Dairy Interventions for Mitigation and Adaptation (DaIMA)

Funding Proposal

Annex 2: Feasibility Study

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List of Abbreviations

ACMI	Africa Carbon Market Initiative
ACF	Agricultural Credit Facility
AE	Accredited Entity
AFBS	Animal Feed Inventory and Balance Sheet
AFOLU	Agriculture, forestry, and other land use
AGAG	Animal Production and Genetics unit
AGB	above ground biomass
AI	Artificial Insemination
AMA	Accreditation Master Agreement
ANITRAC	Animal Identification & Traceability
ARCAFIM	Africa Rural Climate Change Adaptation Financing Mechanism
ASAL	arid and semi-arid lands
ASDP	Agricultural Sector Development Programme
ASIS	Agricultural Stress Index System
AU–IBAR	African Union Inter-African Bureau for Animal Resources
AWPB	Annual work plan and budget
BAU	Business-as-usual
BCR	Benefit Cost Ratio
BDS	Business Development Services
BUR	Biennial Update Report
CAHW	Community-based animal health workers
CAMARTEC	the Centre for Agricultural Mechanisation and Rural Technology
CAO	Chief Administrative Officer
CAPEX	Capital Investment
CASSCOM	County Agricultural Sector Steering Committee
CAVA	Climate and Agriculture risk Visualization and Assessment
CBPP	Contagious Bovine Pleuropneumonia
CC	Climate Change
CCM&A	Climate Change Adaptation and Mitigation
CECM	Country Executive committee Members
CIFA	Community Initiatives Facilitation & Assistance
COP	Conference of Parties
COWSO	Community-based water supply organizations
CP	Crude protein
CPC	County Project Coordinator
CPIT	County Programme Implementation Team
CPST	County Programme Steering Team
CRED	Centre for Research on the Epidemiology of Disasters
CSA	climate-smart agriculture

C-SDTP	Climate smart Smallholder Dairy Transformation Project, Tanzania
DaIMA	Dairy Interventions for Mitigation and Adaptation
DALFO	District Agricultural, Livestock and Fisheries Officer
DAR	Directorate of Animal Resources, Ministry of Agriculture, Animal Industry and Fisheries, Uganda
DBR	Development Bank of Rwanda
DCU	District level coordination and implementation unit
DDA	Dairy Development Authority, Uganda
DED	District Executive Director
DFI	Development Finance Institutions
DFT	District Facilitation Team
DLG	District Local Government, Uganda
DM	Dry matter
DMI	Dry matter intake
DVO	District Veterinary Officer
DVS	Directorate of veterinary services
EAC	East African Community
EAC-CCMP	East African Community Climate Change Master plan
EC	Eddy Covariance
ECF	East Coast Fever
EE	Executing Entities
ENPV	Economic Net Present Value
ENSO	El Niño Southern Oscillation
EU	European Union
Ex-ACT	Ex-Ante Carbon Balance Tool
FAO	Food and Agriculture Organization
FASTA	Forecasting African Storms Application
FDA	Rwanda Food and drugs authority
FMD	Foot-and-Mouth Disease
FMO	Dutch Entrepreneurial Development Bank
FONERWA	Rwanda Green Fund
FX	foreign exchange
GALS	Gender Action Learning System
GCF	Green Climate Fund
GCM	general circulation models
GDFF	Green Dairy Financing Facility
GDP	Gross Domestic Product
GHACOF	Greater Horn of Africa Climate Outlook Forum
GHG	Green House Gasses
GLEAM	Global Livestock Environmental Assessment Model

GoT	Government of Tanzania
HAC	High Activity Clay
HCP	High Carbon Price
IC	Investment Committee
ICPAC	IGAD Climate Prediction and Applications Center
ICPALD	IGAD Center for Pastoral Areas and Livestock Development
IDDRS	IGAD Drought Disaster Resilience and Sustainability Initiative
IFAD	International Fund for Agricultural Development
IFC	International Financial Cooperation
IGAD	Inter-Governmental Authority on Development
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INReMP	Integrated Natural Resource Management Project
INRM	integrated natural resource management
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
IRCCS	IGAD Regional Climate Change Strategy
IRR	Internal Rate of Return
ITCZ	Inter Tropical Convergence Zone
KAGRC	Kenya Animal Genetic Resources Centre
KALRO	Kenya Agricultural and Livestock Research Organization
KASEP	Kenya Agricultural Sector Extension Policy
KDB	Kenya Dairy Board
KeLCoP	Livestock Commercialization Project, Kenya
KLMP	Kenya Livestock Master Plan
KMD	Kenya Meteorological Department
LCP	Low Carbon Price
LDMP	Livestock Development Master Plan
LDSIP	Livestock Development Strategy and Investment Plan
LEAP	Livestock Environmental Assessment and Performance
LEW	Livestock Extension Workers
L-FFS	Livestock Farmer Field Schools
LGA	Local Government Authorities
LITA	Livestock Training Agency
LN	Liquid Nitrogen
LSD	Lumpy Skin Disease
M&E	Monitoring and Evaluation
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MAINL	Mainland
MCCs	Milk collection centres

MCP	Milk collection points
ME	Metabolizable energy
MFI	Microfinance institutions
MFPED	Ministry of Finance, Planning and Economic Development
MSME	Micro, Small and Medium Enterprises
MINAGRI	Ministry of Agriculture and Animal Resources
MINECOFIN	Ministry of Finance and Economic Planning
MIS	Management Information System
MLF	Ministry of Livestock and Fisheries, Tanzania
MoALD	Ministry of Agriculture and Livestock Development, Kenya
MoALFC	Ministry of Agriculture, Livestock, Fisheries and Cooperatives, Kenya
MoF	Ministry of Finance
MoFPED	Ministry of Finance, Planning and Economic Development
MCD	Modified CAMARTEC designs
MoH	Ministry of Health
MoLG	Ministry of Local Government, Uganda
MoLG	Ministry of Local Government, Uganda
MoU	Memorandum of Understanding
MRV	monitoring, reporting and verification
MSP	Multi-stakeholder platforms
MWE	Ministry of Water and Environment, Uganda
NAFSS	National Feed Security System
NAGRIC&DB	National Animal Genetic Resources Centre and Data Bank
NAIC	National Artificial Insemination centre
NaLiRRI	National Livestock Resources Research Institute
NAMA	Nationally Appropriate Mitigation Action
NAP	National Adaptation Plan
NARO	National Research Organization, Uganda
NARP	National Agricultural Research Policy
NBFI	Non-banking Financial Institutions
NCCAP	The National Climate Change Action Plan, Uganda
NCCRS	National Climate Change Response Strategy, Uganda
NDA	National Drug Authority
NDC	Nationally Determined Contributions
NGOs	Non-governmental Organization
NLC	National Land Commission
NMHS	National Meteorological and Hydrological Service
NTAC	National Technical Advisory Committees
NVL	National veterinary laboratory
OPEX	Operational Capital

PASP	Climate-Resilient Post-Harvest and Agribusiness Support Project, Rwanda
PCO	Project Coordination Office
PCT	Project Coordination Team
PCU	Programme Coordination Units
PET	Pictorial Evaluation Tool
PFS	pastoralist field schools
PLEWS	Predictive Livestock Early Warning Information System
PMU	Project Management Unit
PRISM	Partnership for Resilient and Inclusive Small Livestock Markets Programme
PS	Permanent Secretary
PSC	Programme Steering Committee
PSTA5	Strategic Plan for Agriculture Transformation 5
PTF	Programme Task Force
PV	Photovoltaic
PyAEZ	Python Package for Agro-ecological zoning
QBMPS	Quality-based milk payment systems
RAB	Rwanda Agricultural Board
RCM	regional climate models
RCoE	Regional Centres of Excellence
RCVD	Rwanda Council of Veterinary Doctors
RDDP-2	Rwanda Dairy Development Project Phase 2
RE	renewable energy
ReLIV	Resilient Livestock Value Chains, Uganda
REMA	Rwanda Environment Management Authority
RH	Relative humidity
RIF	Refugee Investment Facility
RK-FINFA	Rural Kenya Financial Inclusion Facility
RSB	Rwanda Standards Board
RSC	Regional Steering Committee
RVF	Rift Valley Fever
RVF	Rift Valley Fever
SACCO	Savings and Credit Cooperative Organizations
SBCC	Social and Behaviour Change Campaigns
SCPIT	Subcounty Programme Implementation Team
SDLD	State Department for Livestock
SME	Small and Medium Enterprise
SNV	Dutch Development Organisation
SOC	Soil Organic Carbon
SOP	Standard Operating Procedure
SPIU	Single Programme Implementation Unit

SSP	Shared socioeconomic pathways
SSTC	South-South and Triangular Cooperation
SUA	Sokoine University of Agriculture
TA	Technical Assistance
TAB	Technical Advisory Board
TAC	Technical Advisory Committee
TADB	Tanzanian Agricultural Development Bank
TALIRI	Tanzania Livestock Research Institute
TAMISEMI	President Office-Regional Administration and Local Government
TANAPA	Tanzania National Park Authority
TAWIRI	Tanzania Wildlife Research Institute
TBS	Tanzanian Bureau of Standards
TCSAP	Tanzania Climate Smart Agriculture Program
TCSAP	Tanzania Climate Smart Agriculture Program
TDB	Tanzania Dairy Board
TLMI	Tanzania Livestock Modernization Initiative
TNZ	Thermoneutral zone
ToC	Theory of change
TOSCI	Tanzania Official Seed Certification Institute
TVLA	Tanzania Veterinary Laboratory Agency
TVLA	Tanzania Veterinary Laboratory Agency
TVLA	Tanzanian Veterinary Laboratories Agency
UDB	Uganda Development Bank
UHT	Ultra-High Temperature
UNMA	Uganda National Meteorological Agency
UR-CAVM	University of Rwanda, Faculty of Veterinary Medicine and Animal Sciences
VP1	First Vice President Office in Zanzibar
VPH	Veterinary Public Health
VPO	Vice President Office, Tanzania
WMO	World Meteorological Organisation
WOAH	World Organisation for Animal Health
WOHA	World Organization for Animal Health
ZARDI	Zonal Agricultural Research and Development Institutes, Uganda
ZBS	Zanzibar Bureau of Standards

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EXECUTIVE SUMMARY

1. The East African dairy sector is highly vulnerable to climate change (CC). Climate change poses risks from both the potential impacts of weather hazards and human responses to modulate their effects. Kenya, Rwanda, Tanzania, and Uganda face significant challenges related to climate change, including extreme weather events, and changing precipitation patterns[1]. Smallholders dominate farming in East Africa, which is highly dependent on livestock for livelihoods[2]. In the dairy sector, climate change impacts include increasing heat stress, prolonged and more recurrent droughts, and intensified heavy rains and floods, and other extreme weather events that reduce productivity of dairy cows. Indirect effects include changes in disease patterns and occurrences, decreasing animal feed and water availability, and pasture quality[3]. At the same time, the sector also contributes to GHG emissions, in particular methane[4], but has a high potential for reducing these emissions and for sequestering carbon[5].

2. For these reasons, the Programme must be cross-cutting and address both mitigation and adaptation. Adaptation needs are based on climate hazards, exposure, vulnerability and adaptive capacity, and the mitigation needs based on GHG emissions profiles of the dairy sector[6]. The analysis of livestock and dairy exposure to observed and projected weather hazards is further supported by geospatial datasets on flood and drought prone areas.

CLIMATE HAZARDS

3. *Annual precipitation* generally declined over most of East Africa during the 1950s (-6.7mm/yr.) and the 1960s (-21.8mm/yr.) and has increased during the 1970s (+16.0mm/yr.)[7]. There are also statistically significant differences (p-value 0.05) on *seasonal precipitation* trends across central Uganda between January and March, extending to the north of Kenya and northern Tanzania between April and June where seasonal precipitation has declined at a rate of -4 to -8 mm/yr. over 1981-2016. On the other hand, a precipitation increase (+4 to +6 mm/yr.) has been observed in the southeast of Tanzania during the austral summer (January to March) over 1981-2016.

4. *Temperature*. The annual average daily maximum temperature (mean Tmax) has increased significantly (p-value 0.05), particularly across Kenya, Uganda, and Tanzania. In Uganda (Eastern and Northern region) and Kenya (north of Lake Turkana County), for example, the annual mean Tmax has increased by +0.030 to +0.035°C/yr., equivalent to +1.1 to +1.3°C during 1981-2016. In addition to having the highest mean Tmax increase over time, the north Rift Valley in Kenya has the warmest mean Tmax year-round among the targeted Programme areas. There is also a significant change in average daily minimum temperature (mean Tmin) in Kenya and Tanzania, but not in Rwanda or the west of Uganda. As for mean Tmax, most of the mean Tmin increase is observed in the east of Uganda and the northwest of Kenya where temperatures have increased by +0.035ºC/yr., equivalent to +1.3ºC during 1981-2016.

5. *Mean relative humidity.* Kenya's Rift Valley has the lowest average annual relative humidity (mean RH <50 percent), while Uganda's central and south, particularly areas bordering Lake Victoria, have the highest mean RH (75-85 percent). The Kenyan and Tanzanian coastlines are characterized by high mean RH (70 to 80 percent) year-round due to incoming moisture from the Indian Ocean. A statistically significant (p-value 0.05) decrease in mean RH between -0.10 and -0.25 percent/year has been observed in most areas

[1] Ayugi, B. et al. (2022). Projected changes in meteorological drought over East Africa inferred from bias-adjusted CMIP6 models. Natural Hazards, 113(2), 1151-1176.
[2] Shikuku, K. M., Winowiecki, L., Twyman, J., Eitzinger, A., Perez, J. G., Mwongera, C., & Läderach, P. (2017). Smallholder farmers' attitudes and determinants of adaptation to climate risks in East Africa. Climate Risk Management, 16, 234–245.
[3] Godde, C. et al. (2021). Impacts of climate change on the livestock food supply chain; a review of the evidence. In Global Food Security (Vol. 28).
[4] Due to its structure, methane traps more heat in the atmosphere per molecule than carbon dioxide (CO2), making it 80 times more harmful than CO2 for 20 years after it is released. Source: UNEP, 2022. Available online here.
[5] Mottet, A., Henderson, B., Opio, C., Falcucci, A., Tempio, G., Silvestri, S., Chesterman, S. and Gerber, P.J., 2017. Climate change mitigation and productivity gains in livestock supply chains: insights from regional case studies. Regional Environmental Change, 17(1), pp.129-141.
[6] Based on the Climate Impact Potential Assessment presented in the report
[7] Ongoma, V., & Chen, H. (2017). Temporal and spatial variability of temperature and precipitation over East Africa from 1951 to 2010. Meteorology and Atmospheric Physics, 129, 131-144.

of Uganda and Rwanda over 1981-2016. In addition, east and northeast Kenya have experienced a statistically significant decrease (p-value 0.05), while central and south Tanzania have experienced the largest decline (-0.10 to -0.15 percent/year).

6. *Rainfall variability*. The region's climatic seasons are influenced by a coupled transboundary ocean-atmosphere phenomenon called the Inter Tropical Convergence Zone (ITCZ). A long rainy season occurs from March to May (MAM), and a short rainy season from October to December (OND) when the ITCZ migrates southwards. There is high rainfall variability in OND due to large-scale oceanic-atmospheric patterns such as the El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD), which frequently coincides with ENSO events. The relationship between the 3-month Standardized Precipitation Index (SPI-3) and ENSO is significant for understanding precipitation variability in East Africa. SPI-3 categorizes precipitation conditions, indicating whether they are normal (-0.99 and +0.99), moderately dry (-1.49 to -1.0) and moderately humid (+1.0 to +1.49), severely dry (-1.99 to -1.5) and severely humid (+1.5 to +1.99), and extremely dry (≤ -2.0) and extremely humid (≥ +2.0). During the strong El Niño of 1997-1998, SPI-3 values indicated very humid conditions, while the subsequent strong La Niña of 1999-2000 resulted in severe dry conditions over East Africa. The impacts of ENSO are also apparent, since peak ENSO events occur between October and March, coinciding with the short (October to November) and long (March to May) rainy seasons in East Africa, further amplifying precipitation anomalies in the region.

7. *Dry-spells and very wet days*. The average annual number of dry days (R≤1mm/day) in East Africa exceeds 300 days in the north of the Rift Valley and northeast of Kenya. Conversely, the annual number of dry days decrease toward Lake Victoria (including Mount Elgon in Uganda and Kenya) and the tropical rainforest near the Democratic Republic of Congo (DRC). On average, Tanzania records 180 dry days/yr. along its border with Uganda and Rwanda and over 280 days within its interior. The Indian Ocean coastline has witnessed an increase in dry days by +1.0 days/yr. (equivalent to +36 dry days on annual average since 1981). The east of Uganda experienced a decreasing number of dry days by -0.50 days/yr. (equivalent to +18 wet days on average every year since 1981). The trends on very wet days (R≥20mm/day) show statistically significant differences (p-value <0.05) along the Great Rift Valley in Kenya and Tanzania, with an annual average increase of +0.15 days/yr. over the 1981-2016, equivalent to an additional +5 very wet days on annual average since 1981. On the other hand, neither the interior of Kenya, Tanzania nor Uganda show an increase or decrease in the number of very wet days on annual average since 1981.

8. *Extreme temperatures*. Most of the change in the number of very warm days (Tmax ≥35ºC) on annual average is reported in the north Rift Valley, where the number of very warm days has increased by +1.2 to +2.8 days/yr. (equivalent to 40 to 100 additional very warm days on annual average since 1981). In addition, the north of Uganda has witnessed an increase in very warm days at a rate of +0.8 days/yr. although this increase is not statistically significant.

Projected climate change[8]

9. *Annual precipitation*. Some parts of East Africa may experience an enhancement in precipitation in the far future under various Representative Concentration Pathways (RCPs)[9]. It is expected that the arid and semi-arid regions will receive less precipitation, while the highlands and lake regions may receive more rainfall. Dry seasons in Kenya, Tanzania, and Uganda may experience an increase in precipitation. Future projections indicate an increase towards the east of Kenya under RCP 2.6 (+100mm), heightened under RCP 8.5 (+100 to +200mm) in the far-future (2070-2099). In Rwanda, a precipitation decline is expected under RCP 2.6 (-0.20mm/yr.) and an increase under RCP 8.5 (+0.18mm/yr.). In Uganda, climate projections show a -0.30mm/yr. precipitation decline under both RCPs.

[8] Future climate projections were based on two representative concentration pathways (RCPs) namely RCP 2.6 (low emission scenario) and RCP 8.5 (high emission scenario). Climate and Agriculture Risk Visualization and Assessment (CAVA) is an approach to climate information with a focus on agriculture. Its goal is to provide long-term, climate services by democratising access and simplifying the use of past and future climate and impact data. CAVA analytics uses the W5E5 merged dataset over the 1976-2005 period to bias-correct the outputs of atmospheric models. More information is available here: https://fao-cava.predictia.es/

[9] Ayugi, B. et al. (2022). Projected changes in meteorological drought over East Africa inferred from bias-adjusted CMIP6 models. Natural Hazards, 113(2), 1151-1176.

10. *Mean maximum temperatures*. Under RCP 2.6, mean Tmax are expected to peak in the mid-term (2040-2069); whereas under RCP 8.5, the highest mean Tmax increase is expected by the end of the century (2070-2099). Under RCP 8.5, mean Tmax may increase by up to +4.5ºC in central parts of East Africa by the end of the century (2070-2099). The rate of increase in both RCPs is slower (+1 to +2ºC depending on the RCP) towards the ocean since water can hold more heat than air, thereby taking longer to warm up than continental parts. Accordingly, Kenya and Tanzania's coastlines may experience a mean Tax increase of +0.5 to +1.0ºC (RCP 2.6) and +2.0 to +3.0ºC (RCP 8.5), respectively, by the end-of-century (2070-2099) compared to the baseline period (1976-2005). Similarly, because of its large size, Lake Victoria may warm more slowly than its surroundings and, thus, have a lower rate of mean Tmax increase over time. Overall, most models agree on a positive climate change signal for mean Tmax.

11. *Mean minimum temperatures*. Mean Tmin increase over East Africa is expected to follow the same spatiotemporal pattern as mean Tmax. However, the rate of change in mean Tmin is slightly higher to that of mean Tmax. Overall, mean Tmin may increase by +1.5 to +2.0ºC (RCP 2.6) and by +4.0 to +5.0ºC (RCP 8.5) towards the interior and by less than +1.5ºC (RCP 2.6) and +3.0ºC (RCP 8.5) in the Tanzanian and Kenyan coastline by 2070-2099 compared to the baseline period (1976-2005).

12. *Mean relative humidity*. Mean daily relative humidity (mean RH) will change over the century for RCPs 2.6 and 8.5. For RCPs 2.6 and 8.5, annual mean RH (+2 percent) is projected to rise along Kenya and Lake Victoria. Under RCP 8.5, however, the mean RH is projected to decline on a yearly average (-2 to -8 percent) in the central parts of Tanzania, heightened towards the south.

13. *Rainfall variability.* In all countries and across the century, positive SPI-3 values are lower under RCP 8.5 than RCP 2.6, implying fewer wet-years under RCP 8.5. For negative SPI-3 values (dry periods), negative trends are heightened in Rwanda, Uganda, and Tanzania, implying that 3-month precipitation values are increasingly more dispersed from the mean.

14. *Dry spells and very wet days*. Model outputs show a positive agreement in the time of emergence on the number of dry days (R≤1mm/day), slightly earlier and widespread for RCP 8.5 (2030-2050) compared to RCP 2.6 (2040-2060). The positive change (increase in the number of dry days) is general across East Africa, particularly towards the west of Kenya, the entire Uganda and Rwanda, and most parts of Tanzania. Conversely, the time of emergence for negative values (reduction in number of dry days) is foreseen by 2060 onwards for RCP 8.5 and slightly earlier for RCP 2.6, essentially in the east and south of Kenya. In addition, most of the increase in very wet days (R≥20mm/day) is anticipated in the southwest of Kenya under RCP 2.6, where there might be an extra +1 to +2 very wet days on annual average by the end-century (2070-2099). For RCP 8.5, the increase in very wet days is widespread over Uganda, Rwanda, Tanzania, and the southwest of Kenya.

15. *Extreme temperatures*. Very warm days (Tmax ≥35ºC) may increase in frequency and intensity in a warmer global climate. Under the low emission scenario (RCP 2.6), for example, an additional +25 to +75 very warm days on annual average are expected in Uganda, Kenya's Rift Valley, and central Tanzania in the mid-term (2040-2069). Most of the increase in very warm days is projected by the end-century (2070-2099) under RCP 8.5, showing an increase that ranges between +100 to +200 additional very warm days on annual average compared to the baseline period (1981-2010). On the contrary, the cooling effect of large water bodies such as Lake Victoria and the Indian Ocean may substantially modulate the increasing trend in very warm days over time.

EXPOSURE

16. In East Africa, *droughts* tend to be more frequent, longer, and more severe during the boreal spring and summer as precipitation and water storage decrease overall. Haile et al. (2020) show that the drought area in East Africa will increase, with extreme droughts increasing more rapidly than severe and moderate droughts. For example, by the end-century (2080s), severe droughts are expected to increase by 13.5 percent under RCP 8.5. Generally, farmers are capable of coping with mild droughts, but severe droughts can result in large-scale livestock losses, diminished pasture quantity, and increase the prevalence of drought-related diseases on livestock.[10] Water availability and quality may also be affected by droughts in

[10] Huho, J. M., & Mugalavai, E. M. (2010). The Effects of Droughts on Food Security in Kenya. The International Journal of Climate Change: Impacts and Responses, 2(2).

rangeland pasture regeneration, feed production, drinking water, and hygiene in production systems. Overall, droughts may affect the availability and quality of water for pasture regeneration, feed production, drinking and hygienic practices within the production system.

17. *Floods*. East Africa experiences frequent floods due to climate variability and anthropogenic factors that exacerbate livestock's exposure to floods. Among its flood-prone areas, Uganda has the highest number of flood related casualties, particularly in the Northern, Eastern, and Central regions along the White Nile River. Annually, flooding affects between 10,000 and 25,000 people/administrative boundary in these regions of Uganda, with up to 36,000 people/administrative boundary in the Northern region. In Tanzania, floods affect 10,000 to 25,000 people per administrative boundary in Tanga, Morogoro, and Pwani. In contrast, in the central parts of Kenya, fewer than 100 people per administrative boundary have been affected by floods on a yearly basis. Due to increasing population and increasing rainfall in Lake Victoria under RCP 8.5, floods along the White River Nile are likely to increase.

18. *Disasters*. In East Africa, between 1971 and 2023 over 95 million people have been affected by disasters caused by meteorological (storms), hydrological (floods, landslides), and climatological factors (droughts)[11]. There have been 248 disasters since 1971, of which 69 percent are flood-related and 17 percent drought-related; 78 disasters have been recorded in Kenya, followed by 70 in Tanzania, 60 in Uganda, and 40 in Rwanda. Over time, the number of disasters has increased exponentially, from 28 between 1971-1990 to 174 between 2001-2020. The most prevalent disaster is flooding, followed by drought and landslides. Between 1900 and 2023, 176 flood events were recorded along the targeted countries in historical data. Most of these flood events were riverine floods caused by heavy rainfall events.

VULNERABILITY

19. Climate change vulnerability is determined by exposure, demography, social, and political conditions affecting communities' sensitivity and coping capacity. Climate change also poses many challenges and threats to the dairy sector, but by reducing these vulnerabilities, the sector can become more resilient. East Africa's dairy systems are vulnerable to the following factors:

20. *Poverty and income inequality.* Kenyan, Tanzanian, Rwandan and Ugandan societies are marked by important poverty and income inequality. The Human Development index (HDI) 2022 ranking in Kenya (146th), Rwanda (159th), Uganda (159th) and Tanzania (160th) reflect low achievements in some of the key dimensions of human development, while high GINI indices (38.7 in Kenya, 43.7 in Rwanda, 40.5 in Tanzania and 42.7 in Uganda) evidence strong income inequalities. The vulnerable – more particularly poor dairy farmers and women will be the most affected by climate change.

21. *Rangelands and ecosystems degradation*. Feed availability depend on rangelands, which are degraded in some areas of the region. The degraded land represents 27 percent of total rangelands areas in Tanzania, 3.6 percent in Kenya, and 2.1 percent each in Uganda and Rwanda. The main factor leading to rangelands and pasture degradation include soil structure and erodibility, climate (rainfall intensity and temperature), reduction in land vegetation cover and topography (influencing capacity of run-off). Degradation prevents rangelands from delivering ecosystem services such as *provisioning* (production of above ground biomass, such as grass) and *regulating* (such as the capacity of grasslands and rangelands to sequester carbon in the soils[12]). It also negatively impacts the livestock carrying capacity, which highlights the pressure that the land receives in terms of maximum number of animals the ecosystem can sustainably support over time, without causing damages to the environment [see Feasibility Study and its appendix for a detailed assessment of (i) the livestock carrying capacity in the four countries and (ii) potential for soil carbon sequestration.

22. *Limited water availability.* Climate change affects water resources with changes in precipitation patterns leading to water scarcity or excessive water supply in different regions. In food insecure areas, limited access to safe and reliable water resources, and limited water harvesting systems can hinder livestock and dairy production, contributing to food insecurity and increased vulnerability.

[11] Centre for Research on the Epidemiology of Disasters (CRED) database (2023). 2022 Disasters in Numbers. Available at: link

[12] Sub-Saharan Africa has been estimated to have the highest potential for soil carbon storage (0.41 tC/ha/yr) compared to other regions of the world. The potential annual increase is estimated at 0.57, 0.53, 0.52, and 0.51tC/ha/yr, respectively, for Kenya, Tanzania, Rwanda, and Uganda

23. *Inadequate knowledge and skills*. Dairy farmers have limited access to extension services and training programs. Modern dairy management practices, like feeding, breeding, herd management, and disease control, are not known, nor adopted, which hinders productivity and profitability of dairy herds[13].

24. *Limited access to quality inputs*. Feed that reduces enteric emissions, veterinary services, and climate resilient breeding stocks are difficult to access for dairy smallholder farmers. Limited veterinary services lead farmers to prefer local or cross-bred animals that are not as high yielding, whereas exotic breeds are highly susceptible to local disease. Also, limited access to improved breeds impedes genetic progress.

25. *Frequent disease outbreaks.* Foot-and-mouth disease, mastitis, and ECF are common livestock diseases. Disease outbreaks result in high mortality rated, reduced milk production, and increased veterinary services. Poor disease control measures, inadequate quarantine facilities, and limited veterinary services contribute to the prevalence of diseases in the dairy farming sector.

26. *Market access.* East Africa's dairy farmers face inadequate infrastructure (milk collection centres – MCCs) along the dairy value chain. In most areas, the availability of electricity is erratic, which affects the ability to process and cool milk. In addition, price fluctuations and market volatility are common challenges for dairy farmers in East Africa. Most milk prices are determined by bulkers and processors. Incomes margin dairy farmers are adversely affected by seasonal spikes in milk prices. Obtaining higher-value markets is further hindered by limited access to MCCs, dairy cooperatives and business alliances. *More details are provided in the Market Assessment (Annex to the Feasibility Study).*

27. *Limited access to credit and financial services*. Critical aspects of dairy farming, such as infrastructure, animal health, and feed, require adequate access to credit and finance. Small-scale dairy farmers and pastoralists face challenges in obtaining such services, resulting in restricted investments in modern equipment, infrastructure, and improved animal husbandry.

CLIMATE ADAPTIVE CAPACITY OF THE DAIRY SECTOR

28. Approximately 70-90 percent of the East African agriculture is rain-fed, with small-scale farmers relying heavily on seasonal rainfall for food and fodder crops, and pastures. With dairy production subject to significant seasonal (temporal) and spatial variations, dairy farmers face extreme difficulties to plan investments. A livestock and dairy system's resiliency depends on its ability to adapt to different climate conditions and to cope with the impacts of climate change. Identifying adaptation needs facilitates prioritizing actions and allocating resources for addressing critical challenges.

29. The adaptive capacity in the dairy sector in East Africa stems from the following:

i. *Access to climate-smart technologies*. Improved dairy breeds, drought-resistant forage varieties, and efficient milk processing equipment are among climate-smart technologies needed by farmers.

ii. *Capacity building and knowledge transfer*. Farmers' technical knowledge and skills in dairy management can be enhanced by providing training programs, Livestock Farmer Field Schools (L-FFS), and extension services on sustainable feeding practices, breeding strategies, disease control measures, and effective use of water resources.

iii. *Financial and market support*. Affordable financing support farmers' investments in productive assets, infrastructure, and value-added activities. Fair markets and value chain linkages can also enhance farmers' incomes. Agribusiness can provide productivity-enhancing input and output markets for resource-poor smallholder farmers[14]. Entry into rural markets can be facilitated by cooperative selling institutions.

iv. *Strengthening infrastructure*. Improvements in rural infrastructure, such as water harvesting systems, renewable energy, electricity connection and supply, and milk collection and processing facilities, lower transportation costs and improve dairy farmers' market access.

[13] A. Gelan & B.W. Muriithi (2012) Measuring and explaining technical efficiency of dairy farms: a case study of smallholder farms in East Africa, Agrekon, 51:2, 53-74, DOI: 10.1080/03031853.2012.695140
[14] Omondi, I. et al. (2017). Processor Linkages and Farm Household Productivity: Evidence from Dairy Hubs in East Africa. Agribusiness, 33(4)

v. *Climate information*. Informed feed management, breeding, and disease control decisions can be made through climate information, early warning systems, and advisory services. This assists dairy farmers in anticipating and adapting to climate-related risks.

vi. *Policy support and institutional strengthening.* To enable dairy farmers to thrive, it is imperative to develop policies, regulations, and institutions tailored to their needs, as well as strengthen those involved in research and extension. The key adaptation requirements require collaboration between governments, research institutions, dairy cooperatives, and financial institutions.

IMPACT OF CLIMATE CHANGE

30. The East African dairy sector is one of the most vulnerable sectors to climate change, and its impacts will be felt at all levels of the dairy value chain. At the level of the dairy farms, the impacts are as follows: (a) a decline in milk yields, in particular for high milk-yielding breeds; (b) heat stress of dairy cattle; (c) increase in dairy cattle pathogen, diseases, parasite and vector development; (d) decrease in feed production and productivity, due to reduced soil or excess soil moisture and fertility; (e) decrease in pasture quantity and quality due to changes in composition and increased degradation; (f) spoilage of fodder in unprotected storage due to excess moisture. At the level of rangelands, livestock owners face: (i) decreased access to rangelands resources; (ii) ecosystem degradation; (iii) a decrease in rangeland and pasture productivity and forage quality. At the level of the dairy value chain, high temperatures compromise the safety of milk and milk products and increase the risk of milk losses.

31. *Climate change and milk yields*. The Feasibility Study shows that temperature and humidity have a significant impact on milk yield and milk production. Significant milk production losses have been observed in Kenya, Uganda, and Tanzania's coastal regions between 1981 and 2016, where losses range from 4 to 8 kg/day for the Holstein Friesian breed and between 0.5 and 1 kg/day for the Boran breed. Over the period 1981-2016, milk production declined less than 2 kg/day for the Holstein Friesian breed in the high-altitude areas of Kenya, Tanzania, and Rwanda. Future milk production is expected to decrease up to 1 kg/day for Holstein Friesian cows and up to 0.15 kg/day for Boran animals by the end of the century under RCP 2.6, but significantly more under RCP 8.5 (2.5 kg/day for Holstein Friesian cows and less than 0.15 kg/day for Boran cows).[15] Heat stress can also cause reproductive problems (missed mating or insemination).

32. *Ruminant feed/forage supplies are most affected by climate change through changes in cereal, forage, and rangeland productivity*. Feed and fodder are available in the rainy and early dry seasons and sparse in the dry seasons, leading to high seasonal milk production and milk price fluctuations. Even during the rainy seasons, there is not adequate forage (fodder and pasture) to be preserved and stored for using it during the dry season[16]. Availability of rainfall determines rainfed crop production. Feed availability fluctuates throughout the year, challenging livestock production. It can also lead to conflicts between communities, and competition with wildlife in pastoral areas. Pastoral communities are more vulnerable to feed shortages because of droughts, degradation of rangelands, and limited access to grazing lands. Both RCPs predict the greatest yield change in the north of Kenya and Uganda in the mid- and long-terms (2031-2060 and 2061-2090). For example, under RCP 2.6, maize yields, commonly used as a source of feed, are likely to decline by -5 to -15 percent in Uganda and by -20 to -25 percent in Kenya under RCP 8.5. Napier grass yields are likely to decline mostly in Uganda (e.g., North region by more than -30 percent), the north of Kenya by -30 percent, and the southeast of Tanzania (by -20 to -30 percent). Under RCP 8.5, Napier grass yield losses are lower (0 to -10 percent) in the southwest of Tanzania both in the mid-term (2031-2060) and into the future (2061-2090).

33. *Climate change may affect pathogens, vectors, hosts, or reservoirs*, as well as human behaviour. Estimating climate change effects on livestock diseases is difficult due to the complex interactions between climatic and non-climatic factors. Temperature and humidity also play a significant role in pathogen and parasite development. Wind patterns also affect the movement of locusts and pathogens. Pathogen propagation may be limited by hot and dry conditions. Impacts on vectors may be driven by changes in rainfall and temperature regimes which influence disease vector distribution, such as ticks, mosquitoes or

[15] For further details see section 7.2.2. of the Climate Impact Potential Assessment

[16] Mudavadi, O. et al. (2020). Effects of Season Variation on Water, Feed, Milk Yield and Reproductive Performance of Dairy Cows in Smallholder Farms in Eastern Africa. Journal of Agriculture and Ecology Research International.

flies[17]. Vector dynamics are also influenced by soil and vegetation type, and topography. In most cases, vectors and pathogens negatively affect livestock. Zoonotic diseases spread during droughts and feed shortages. More details and references are found in the pre-Feasibility Study.

34. *The above impacts of climate change on milk production at farm level will have a direct impact on national and household food and nutrition security*. At household level, less milk will be available for dairy consumption, with an immediate impact on nutrition and health of young children and women. It will also reduce revenues from sales of milk. In the four countries, small daily revenues from the sales of surplus milk, often 1 to 5 litres per household, are essential for rural poverty reduction. At national level, a reduction of domestic milk production will lead to higher imports from the international market and require monetary reserves. Also a higher dependence on the international market to purchase feed, in particular maize and soybean, will impact the national balance of trade.

GREENHOUSE GAS EMISSION PROFILE OF THE DAIRY SECTOR

35. *Dairy production systems.* In **Kenya**, the dairy production systems are classified as intensive, semi-intensive, and extensive systems. 39 percent of milk is produced by intensive systems (or zero-grazing) and 43 percent by semi-intensive agriculture. Agropastoral and pastoral systems are also important pillars the national economy and for dairy production (18 percent of milk produced by extensive systems). In **Rwanda,** major dairy production systems are intensive/zero grazing, pastoral/open grazing, and semi-grazing. 93% of milk is produced in intensive systems, 4 percent in semi-intensive and 3 percent in extensive. In **Tanzania,** dairy systems are traditional and intensive. Traditional system is characterized by meat-milk production and large herds of cattle grazing natural pastures, producing 91 percent of the country's milk. In **Uganda**, systems are also traditional and intensive. Traditional systems produce 98 percent of the country's milk.

36. *Absolute GHG emissions***.** East Africa represents about 5% of GHG emissions of the global cattle sector, but they are increasing. In particular, enteric methane emissions from the dairy sector dominate the GHG emission inventories of Kenya, Rwanda, Tanzania, and Uganda. Methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2) are released by ruminants (cattle, sheep, goats) during enteric fermentation, methane and nitrous oxide from manure.[18] Enteric methane is not only a short-lived climate pollutant, but it represents a waste in the production process that doesn't result in milk or meat. In addition, cattle manure releases N2O and CH4. Finally, land-use changes and degradation contribute to GHG emissions due to the disruption in carbon stocks.

37. In ***Kenya,*** GHG emissions have increased from 57 $MtCO_2eq$ in 1955 to 94 $MtCO_2eq$ in 2015[19]. Agriculture produces half of all emissions. FAO's GLEAM[20] tool estimated that dairy cattle (4.5 million animals) emit 6.4 $MtCO_2$ eq (based on 2019 data). The dairy sector emits the most CH_4 and N_2O at 93 percent and 6.6 percent respectively. About 82 percent of CH_4 emissions are caused by enteric methane, while 11 percent are caused by manure management. While business-as-usual (BAU) emissions from agriculture are projected to reach 142 $MtCO_2eq$ by 2030, FAO's GLEAM tool estimates that total milk production and enteric CH_4 emissions will respectively increase by 43 and 36 percent by 2050 under current practices, in a baseline scenario carried out at national level.

38. In ***Rwanda***, total GHG emissions were estimated to be 6.7 $MtCO_2eq$ in 2018, of which 3.3 $MtCO_2eq$, or 49 percent from agriculture. During the last decade, agriculture, forestry, and other land use (AFOLU) emissions increased by 34 percent. Methane emissions from the livestock sector represent about 46 percent of total GHG emissions. Enteric fermentation accounts for 74 percent of emissions, followed by

[17] Bett, B., Kiunga, P., Gachohi, J., Sindato, C., Mbotha, D., Robinson, T., Lindahl, J. and Grace, D., 2017. Effects of climate change on the occurrence and distribution of livestock diseases. Preventive veterinary medicine, 137, pp.119-129.

[18] The production of CH4, a potent GHG with a 27 times higher global warming potential than carbon dioxide over the long-term - 100-year time period (IPCC, 2021), significantly contributes to the region's carbon footprint.

[19] Nationally Determined Contribution, communication to UNFCCC, December 2020. unfccc.int/sites/default/files/NDC/2022-06/Kenya%27s First NDC %28updated version%29.pdf

[20] The Global Livestock Assessment Model (GLEAM) is a modelling framework that simulates the interaction of activities and processes involved in livestock production and the environment. It is designed to analyze multiple environmental dimensions, such as feed use, greenhouse gas emissions, land use and land degradation, nutrient and water use and interaction with biodiversity. More information on GLEAM can be found here https://www.fao.org/gleam/en/

CH_4 and N_2O emissions from manure management (15 percent and 11 percent respectively). Dairy systems in Rwanda emit about 3.6 $MtCO_2$-eq in 2020[21]. Crossbred cattle contribute 58 percent to methane emissions in zero-grazing systems, while exotic dairy cattle contribute only 0.2 percent. Zero grazing practices account for 93 percent of these emissions, semi-grazing systems 2 percent, and open grazing 5 percent. FAO's GLEAM model estimates that by 2050 milk production and enteric CH4 emissions will increase by 64 percent and 59 percent respectively, under a baseline scenario.

39. In *Tanzania*, total GHG emissions are estimated to be 286.5 $MtCO_2eq$[22], to which agriculture contributed 49.7 $MtCO_2eq$ or 17 percent. Methane emissions represent 94 percent of total GHG emissions from dairy cattle systems. Enteric fermentation counts for 92 percent of GHG emissions, and manure management by 2 percent. Emissions from the dairy sector are expected to increase by mid-century, in response to the projected dairy herd growth to satisfy the future demand for dairy products, which is expected to grow from 1.4 billion litres of raw milk in 2020, to 2.0 billion litres in 2030, and 8 billion litres in 2050. Projections based on milk demand under a BAU scenario (from 2020 data), will be associated with an increase of enteric methane emissions by 43 percent, escalating from 19 to 27 Mt of CO_2eq between 2020 and 2030. FAO's GLEAM model estimates that enteric CH_4 emissions will increase by 117 percent by 2050, under a baseline scenario.

40. GHG emissions in *Uganda* totalled 95 $MtCO_2eq$ in 2017, of which the AFOLU sector accounted for 79 $MtCO_2eq$[23] or 84 percent. The GLEAM model estimated that the dairy sector in 2019 24.4 $MtCO_2eq$ or 30 percent of the AFOLU sector's emissions. CH_4 emissions from enteric fermentation (78 percent, 19 $MtCO_2eq$) and CH_4 and N_2O emissions from manure management (4 percent or 2 $MtCO_2eq$) dominate GHG emissions from dairy cattle sector and mostly concentrated in the Eastern, Central, Southern and Northeast (Karamoja) regions. FAO's GLEAM model estimates that milk production and enteric CH4 emissions will increase by 80 percent by 2050, under a baseline scenario.

41. *Emission Intensities (EI).* The methane emission intensity, defined as the volume of methane emissions generated per kg of milk, varies widely across intensive, semi-intensive and extensive dairy production systems, with more productive systems having much lower EIs per kg of milk. In East Africa, EIs vary from 1.5 kg CO_2eq./kg milk for exotic dairy breeds in Kenya to 24.2 kg CO_2eq./kg milk for traditional systems in Uganda. This shows the range of performances between (but also within) systems and the potential for improvements, including by increasing the productivity in dairy production and promoting practices from dairy systems with a low emission intensity per kg of milk. Details per country and per dairy production system are presented in section 2.8.3.

42. In *Kenya,* the enteric CH_4 EI is on average 2 kg CO_2eq./kg of milk produced, ranging from 1.4 kg CO_2eq./kg milk in intensive exotic systems to 5 kg CO_2eq./kg milk in extensive indigenous systems. Emissions intensities were on average higher for the indigenous systems (3.5 kg CO_2eq./kg milk) then for exotic systems (1.5 kg CO_2eq./kg milk).

43. In *Rwanda's* dairy herd, dairy herd, crossbreeds account for 63 percent of enteric methane emissions, followed by local breeds contributing 29 percent, and exotic breeds 8 percent. The intensity of enteric CH4 emissions lays between 1.8 (exotic/ crossbreed pasture grazing) and 4.6 kg (local semi-grazing) of CO2eq. per kg of milk. This highlights the importance of mitigation strategies targeting the crossbreeds. Approximately 93 percent of the dairy sector emissions are attributed to zero grazing practices.

44. In *Tanzania,* enteric methane represents about 92 percent of total GHG emissions. About 97 percent of enteric CH_4 emissions are associated with traditional dairy cattle systems, whereas improved dairy systems contribute 3 percent. The intensity of enteric CH_4 emissions varies between 1.9 and 19 kg of

[21] The analysis of the direct GHG emissions was conducted using the Global Livestock Environmental Assessment Model (GLEAM), a geo-referenced model framework that simulates the bio-physical processes and activities along livestock supply chains based on the life cycle assessment and based on the IPCC Tier 2 methodology. More information on GLEAM can be found here https://www.fao.org/gleam/en/

[22] CAIT. (2022). Climate Watch data: Climate Watch. 2022. Greenhouse Gas Emissions. World Resources Institute. https://www.climatewatchdata.org/ghg-emissions

[23] MWE, Uganda National Communication 3, 2022.
See https://unfccc.int/sites/default/files/resource/Final%20TNC%20Uganda.pdf

CO_2eq. per kg of milk. Unlike CH_4 production, CH_4 intensity is notably elevated in the traditional system when compared to the improved system.

45. In *Uganda,* the enteric EI is on average 8.9 kg CO_2eq./kg milk produced. Emission intensities range from 7.7 to 24.2 kg CO_2eq./kg milk in traditional systems, compared to the range of 1.4 to 2.9 kg CO_2eq./kg milk for commercial systems. The highest emission intensity is observed for pastoral systems at 24.2 kg CO_2eq./kg milk.

PROPOSED INTERVENTIONS

46. The Programme's interventions will address the climate change adaptation and mitigation issues across the various dairy production systems and along the dairy value-chain, while addressing the barriers identified in the theory of change. It will scale-up: (i) farm and herd level practices to increase productivity, reduce emission intensity, and decrease absolute emissions compared to a BAU scenario; (ii) farm level solutions for manure management and nutrient recycling, to improve circularity, resilience and reduce emissions; (iii) landscape-level interventions to improve the resilience and services of rangelands ecosystems, particularly soil carbon sequestration, and water and biomass supply for animal feed; and (iv) value-chain level interventions, to reduce milk losses (and corresponding GHG emissions) and increase the use of renewable energy. This holistic and sustainable approach, that will also address enablers such as access to markets, finance, knowledge and services, will lead to lower emissions from the dairy sector when compared to the business-as-usual scenario. A detailed table, linking the climate drivers with interventions and their benefits, can be found in the Feasibility Study.

47. *Interventions at farm and herd levels*. Interventions will focus on the various climate risks and impacts, namely the decrease in milk yields, heat stress of animals, the increase in cattle mortality, the change in dairy cattle diseases, the decrease in feed productivity, the deterioration of fodder in unprotected warehouses due to excess humidity. For all dairy systems, the Programme will encourage the combined adoption of climate-smart adaptation and mitigation practices, including the enhancement of animal genetic resources (artificial insemination with locally-adapted improved and indigenous livestock breeds, sexed semen), improved herd health (e.g. vaccination against East Coast Fever), animal welfare, water access, recycling, harvesting and reuse for cattle watering. In intensive and semi-intensive systems, in addition to the above, interventions will improve the availability of forage grasses and legumes, feeding practices, and use of conserved silage and complementary feed. In intensive systems, interventions will include the establishment of forage grasses and legumes (Calliandra, Leucaena, etc.), the use of conserved silage and urea-molasses multi-nutrient blocks (UMMB), the use of methane inhibitors (e.g. tannins rich Calliandra, lipids), supplementation (use of non-conventional feed resources, e.g. sweet potato vines), precision feeding and improving animal welfare and housing. In extensive systems, activities will include improving pasture management (e.g. rotational grazing), the use improved pasture species and management practices to improve forage quality and quantity, and use of multipurpose leguminous trees.

48. *On-farm solutions for manure management and nutrient recycling*. These interventions will address the CH4 and N2O emissions on dairy farms and limits related to the cost and availability of mineral fertilizers. Interventions include promoting simple circular manure management practices to reduce nutrient losses and GHG emissions (covering, compaction, composting, liquid-solid separation, production and addition of biochar). The Programme will also invest in biogas solutions to produce renewable energy for cooking and electricity, as well as nutrient-rich biofertilizer.

49. *Interventions at the landscape level* will address the negative impact of CC on ecosystem degradation (rangeland and pastures) that result in reduced soil carbon sequestration, reduced feed and water availability and livestock carrying capacity, decreased quantity and quality of pasture, all of which leads to a drop in milk yields. The interventions will focus on improved rangeland management, through participatory learning and promoting sustainable grazing practices. Land management activities will rehabilitate degraded rangelands to increase soil carbon sequestration, promote access to fodder and address the natural barrier to rangeland degradation. In the four countries, soil carbon impacts were identified as a strategy for carbon sequestration activities such as grazing intensity management, mowing frequency, organic inputs and fertilizers used in fodder production, and improved agroforestry systems associated with mixed crop-livestock production systems.

50. *Interventions at the dairy value chain level* will include the upgrading or equipping milk collection centres (MCCs), milk collection points (MCPs) and processing centres. This will increase the supply of milk through formal aggregation and processing channels and create a stable market outlet for dairy farmers. Interventions will also aim to reduce milk losses and its carbon footprint, and reduce GHG emissions through the use of photovoltaic (PV) systems as a renewable energy (RE) source for milk collection, cooling and processing.

51. *Interventions to improve the enabling environment.* The focus will be on (i) a climate-sensitive policy and regulatory environment (institutional framework, dairy value chain governance, farmer awareness campaigns) for the dairy sector; (ii) strengthening proximity public and private services to the dairy sector, in particular expanding access to veterinary services and innovative gender-inclusive advisory services combined with input supply services; (iii) strengthening dairy cooperatives, MCCs and MCPs to encourage farmers to adopt the above- mentioned pathways. Improved Measurement, Reporting, and Verification (MRV) capabilities will provide more precise Tier2-emissions data and improve the quality of national inventories, as well as policies, planning, and investment decisions. Through regional cooperation, knowledge sharing and joint learning, coordinated strategies will be adopted and efforts of the individual countries will be amplified.

ADDITIONALITY

52. The Programme is a unique comprehensive framework to address simultaneously climate change impacts in, and GHG emissions from, the dairy sector. It will contribute to the National Determined Contributions (NDC's), Nationally Appropriate Mitigation Actions (NAMA), National Adaptation Plan for Agriculture (NAP-Ag), the National Agriculture Policies, and contribute to National Development Plans on climate-smart dairy livestock value chains. Through the introduction of climate-smart agricultural practices and technologies, the Programme is intended to trigger resilient low-carbon development of the dairy sector, with a focus on methane.

53. Sources of methane from the dairy sector are among the key categories of anthropogenic GHG emissions from AFOLU identified in national inventories (e.g., national communication, Biennial update reports) in East Africa. It is evident that the long-term low-emission national development strategies in East Africa cannot be achieved without addressing the main source of methane emissions, meaning the dairy sector[24]. Besides, the dairy sector is currently affected by several climate change impacts, including long drought and floods, thus necessitating more investment in adaptation and resilience of the dairy herd. Rapidly reducing methane emissions from agriculture will contribute to achieve near-term gains in global efforts in this decade for decisive action and is regarded as the single most effective strategy to keep the goal of limiting warming to a 1.5˚C temperature increase within reach.

54. In this regard, the Programme is a flagship and pioneering investment vehicle to support the Global Methane Pledge (GMP). The GMP was launched at COP 26 in November 2021 in Glasgow. Participants joining the Pledge agreed to take voluntary actions to contribute to a collective effort to reduce global methane emissions at least 30 percent from 2020 levels by 2030, which could eliminate over 0.2˚C warming by 2050. Participants also committed to moving towards using the highest tier IPCC good practice inventory methodologies, in effect making assessments of emissions as specific and detailed as possible. They also committed to working to continuously improve the accuracy, transparency, consistency, comparability and completeness of national GHG inventory reporting under the UNFCCC Charter and Paris Agreements, and to provide greater transparency in key sectors. The GMP aims to catalyse global action and strengthen support for existing international methane emission reduction initiatives to advance technical and policy work that will serve to underpin Participants' domestic actions. It also recognizes the essential roles that private sector, development banks, financial institutions and philanthropy play to support implementation of the Pledge and welcomes their efforts and engagement.

55. In line with the GMP, the additionality of the Programme is to enhance, through a large-scale investment programme, the long-term institutional capacity to provide effective services that improve

[24] Graham, M.W., Özkan, Ş., Arndt, C., González-Quintero, R., Korir, D., Merbold, L., Mottet, A., Ndung'u, P.W., Notenbaert, A. and Leitner, S.M., 2024. Toward compatibility with national dairy production and climate goals through locally appropriate mitigation interventions in Kenya. *Agricultural Systems*, *220*, p.104098.

efficiency, climate resilience, and reduce GHG emissions by improving the enabling environment. The capacities will be focused on preparing and implementing climate-smart policies at the national and regional levels, encouraging favourable trade policies across East Africa to unlock climate smart solutions, GHG MRV, climate risk analysis, and ensuring the dairy sector contributes fully to the NDCs of the participating countries.

TARGET AREAS

56. Programme areas are pre-identified based on the integration of: (i) climate risk hot-spots; (ii) absolute methane emissions from the dairy sector; (iii) soil carbon sequestration potential in pastures and grasslands; (iv) milk production by district/county; and (v) complementarity with other international financing institutions (IFI)-funded interventions, more particularly from IFAD.

57. *Climate risk.* A climate risk hot-spot mapping was conducted by overlaying the sum of climatic hazards, exposure, vulnerability and subtracting the adaptive capacity. The mapping shows that most of the region has a high risk to climate hazards under both RCP 2.6 and RCP 8.5 in the mid-term (2040-2069) and far future (2070-2099).

58. In **Kenya**, the project will be implemented in 12 counties selected based on (1) emissions; (2) milk production and (3) overlap with two IFAD-funded projects. In **Rwanda**, the Programme will target 27 out of 30 districts, as selected in conjunction with the Rwanda Dairy Development Project, phase 2, which will co-finance the Programme. Districts were selected based on (1) poverty, food insecurity and malnutrition incidence; (2) impact of climate change; (3) potential for women, youth, school children and value chain actor involvement. The percentage of milk produced from improved breeds was also considered. In **Tanzania**, the Programme will be implemented in geographic alignment with the IFAD-funded Climate smart Smallholder Dairy Transformation Project (C-SDTP) in Southern Highlands, Eastern Zone and Zanzibar. Districts were chosen based on (i) importance of dairy production in the area; (ii) prevalence of smallholder systems; (iii) existence of off-takers, or potential for local market; (iv) other development partners' interventions; and (v) vulnerability to climate change. In **Uganda**, 35 districts (about one third of the country) were selected within the cattle corridor and align with the Resilient Livestock Value Chains Project. Districts were selected based on (1) poverty, food insecurity and malnutrition incidence; (2) herd size; (3) opportunities for women and youth involvement and (4) based on climate vulnerability.

COUNTRY OWNERSHIP

59. The Nationally Determined Contributions (NDCs), National Adaptation Plan (NAP) in the case of Kenya, and other national CC strategies outline the countries approaches to reduce GHG emissions and adapt to climate change. The proposed Programme is fully aligned with these national strategies, which propose measures such as: climate-resilient crops and livestock production, CC resilient animal breeds, improved husbandry, and windrow composting to reduce enteric fermentation emissions from livestock, and more efficient manure management systems. In addition, the Programme will support the Ministries responsible for the dairy sector to review and formulate national policies, strategies, and regulations that are essential for a sustainable transformation of the dairy sector aligned with the NDCs.

SYNERGY WITH OTHER PROJECTS

60. At regional level, the Programme will be complementary with the GCF-funded Africa Rural Climate Adaptation Finance Mechanism (ARCAFIM, FP220, IFAD being the AE) for East Africa region. At the national level, synergies will be developed with IFAD-funded initiatives, and key stakeholders will be involved in coordination and implementation. In **Kenya**, implementation will be supported by the Kenya Dairy Board (KDB), the Kenya Agricultural and Livestock Research Organization (KALRO), the Kenya Animal Genetic Resources Centre (KAGRC), amongst others. The Programme will be closely linked to the Integrated Natural Resource Management Programme (INRMeP) and the "Transforming Livelihoods through Climate Resilient, Low Carbon, Sustainable Agricultural Value Chains in the Lake Region Economic Bloc" proposed by FAO to the GCF. It will also build on the lessons learnt of the GCF-funded "Towards Ending Drought Emergencies: Ecosystem Based Adaptation in Kenya's Arid and Semi-Arid Rangelands" (FP113) and from the IFAD-financed Kenya Livestock Commercialization Project (KeLCoP). In **Uganda**, implementation will be supported by the Dairy Development Authority (DDA), the National Animal Genetic Resources Centre and Data Bank (NAGRC & DB), National Research Organization (NARO), Ministry of

Local Government (MoLG). Synergy will be with the IFAD-funded Resilient Livestock Value Chain Project (ReLIV). In **Rwanda**, implementation will build on the existing networks established through an ongoing project, implemented by the Rwanda Agriculture and Animal Resources Board (RAB), namely Rwanda Dairy Development Project, phase 2 (RDDP-2), as well as the Rwanda Environment Management Authority (REMA). Knowledge from the Transforming Eastern Province through Adaptation (GCF FP167) will also be used for landscape restoration interventions. In **Tanzania**, the Programme is an integral part of the Climate smart Smallholder Dairy Transformation Project (C-SDTP). Implementation will be supported by the Tanzania Dairy Board (TDB), the Tanzania Livestock Research Institute (TALIRI). It will also leverage lessons learnt from the "Building climate resilience in the landscapes of Kigoma region" (GCF FP218). As DaIMA will be aligned with RDDP-2, C-SDTP, ReLIV and INReMP, IFAD's strategic objectives, more particularly its pro-poor, youth and gender-sensitive approach and investment strategy will be fully mainstreamed into DaIMA.

DAIRY INTERVENTIONS FOR MITIGATION AND ADAPTATION

61. The dairy sector faces significant challenges related to climate change in East Africa, including in Kenya, Rwanda, Tanzania, and Uganda. Dairy farming contributes substantially to GHG emissions in national inventories, with the impacts of CC threatening its sustainability. Inefficiencies at the dairy farm level result in excessive GHG emission intensities per kg of milk. In addition, many dairy farmers face barriers to accessing markets, procuring local feed and fodder, obtaining extension and financial services, and managing risks. Low genetic potential of livestock, herd management challenges, animal diseases, inadequate extension services, limited knowledge of climate-smart practices and technologies, rangeland degradation and gender disparities further harm the dairy sector in these countries.

62. The Programme aims to address the following challenges: (i) strengthening climate resilience, (ii) reducing emissions across the dairy value chain; (iii) the reduction of GHG emissions per kg of milk; and (iv) improving the livelihoods of dairy farmers in East Africa. This requires a holistic approach to improving all aspects of the dairy sector, from improving policy, institutional and service delivery environments to building the capacity of smallholder farmers. It also includes measures to facilitate access to finance and innovative technologies with mitigation and adaptation benefits. As a result, dairy farmers and processors will be motivated to adopt more efficient, climate-resilient practices that will increase incomes, reduce production costs, and help combat climate change. Central to this transformative approach is the symbiosis of private sector support and financial access within the dairy sector. This integration aims to foster market growth while promoting climate resilience and reducing GHG emissions.

63. The paradigm shift envisioned by the Programme is a more efficient, climate-resilient dairy industry that contributes to national and regional economic growth, improved smallholder farmers' livelihoods, and reduced GHG emissions. To achieve the above vision, the Programme aims to achieve the following three Outcomes:

64. **Outcome 1: Systemic and institutional capacities in the livestock dairy sector are strengthened to enable smallholder dairy farmers and local value chain actors to reduce CH4 methane and other GHG emissions.** Outcome 1 aims to foster an enabling environment for the transformation of the East Africa's dairy sector towards increased productivity, climate resilience and lower emission intensity. To achieve this, several outputs must be achieved.

65. The Programme will establish a climate-responsive policy and regulatory environment for the dairy sector (Output 1.1) by reviewing regulatory frameworks, supporting value chain governance initiatives, and work on food safety and dairy consumption. Through improved public services (Output 1.2.) through the expansion of proximity veterinary services and innovative extension services, both male and female farmers will be supported to address animal health, feed quality, manure, and herd management issues. This will help scaling up climate-smart practices and addressing the lack of knowledge and perception regarding adaptation. Enhanced measurement, reporting and verification (MRV) capacities (Output 1.3.) will generate detailed Tier 2 emissions data to improve national inventories, and inform evidence-based policies, planning and investment. Robust MRV and modelling will address data gaps and strengthen climate scenarios and assessments. Certification for low-carbon production and facilitating access to the carbon markets (Output 3.3) will create financial incentives for mitigation efforts. Regional cooperation and knowledge sharing (Output 1.4.) will ensure coordinated strategies, amplify each country's efforts, and promote joint learning. This collaboration will be essential to overcome national institutional and knowledge barriers.

66. **Outcome 2: Smallholder dairy farmers and private sector value chain operators can adopt a low-emission, climate-resilient, and sustainable practices for increased production and access pathway through increased production and market knowledge and tools.** Outcome 2 aims to improve the incomes and productivity of smallholder dairy farmers, dairy cooperatives and SMES by promoting sustainable and climate-resilient low-emission pathways for future growth. The three Outputs leading to this Outcome will also have a positive effect on gender equality, increased food security and nutrition for rural/urban consumers (CB1) and women empowerment and inclusion of marginalized groups (CB2).

67. Output 2.1 supports dairy cooperatives to ensure that smallholder dairy farmers have a stable market for their produce, reduce losses, and are interested in adopting the pathway innovations. Renewable energy solutions at cooperative level will also be supported. The promotion of integrated pathway-specific solutions (Output 2.2.) will include the introduction of better dairy cattle breeds, improved herd composition and animal health, increased availability of high-quality feed and fodder, better manure management for biogas production and nutrient recycling. This will increase productivity, improve circularity and reduce GHG emission intensity at animal, herd and farm levels. This Output helps to remove technological and natural barriers by improving on-farm infrastructure and overcoming limitations related to animal nutrition, disease, mortality, and genetic potential. Improved pasture management (Output 2.3), through participatory learning and the promotion of sustainable grazing practices and land management practices will rehabilitate degraded rangelands, increase access to fodder and address rangeland degradation. Together, the three Outputs contribute to broader replication through increased productivity and income for smallholder dairy farmers, increased carbon sequestration in soils, resulting in reduced greenhouse gas emissions. This aligns with the desired paradigm shift towards a more productive, climate-resilient, and low-emission dairy sector, supported by sustainable practices and gender-transformative growth. In particular, the project will create equal opportunities for women and men and aim to: (i) Increase women economic empowerment through access to finance and skills; (ii) Increase women participation, voice and decision making in farmer organization and cooperatives (iii) Reduce and balance workloads with increased resilient production and greater efficiency of dairy production and post-harvest technologies; (iv) Influence positive gender norms and to prevent Gender based violence through the GALS methodology (v) Policy engagement to address gender barriers related in the sector. The result is a transformative change in the East Africa’s dairy sector, which benefits not only dairy farmers, but also the wider community and environment.

68. **Outcome 3: Financial institutions make available appropriate investment resources to make the necessary transition to low-carbon, climate-resilient, and sustainable dairy production and strengthen value chain linkages and improved productivity.** By improving access to finance for climate-smart technologies and practices, Component 3 aims to facilitate access to finance for medium-sized farmer-allied dairy value chain actors, including aggregators and processors, agro-input and technology providers, and mature dairy farmers’ cooperatives.

69. By improving access to finance for climate-smart technologies and practices, Component 3 aims to facilitate the larger-scale transition to sustainable, low-carbon, climate-resilient dairy value chains. To achieve this outcome, dairy value chain actors (including agri-input and technology providers, groups of SHF, aggregators and processors) will be supported in overcoming technological and financial barriers to increase their productivity and green their operations.

70. To support the achievement of the programme objectives and impact, DaIMA will under Component 3 establish a Green Dairy Financing Facility (GDFF) that will operate in the four targeted countries. GDFF aims to enhance access to finance for the target group and support the implementation of climate-smart technologies and practices, thereby facilitating the transition to climate-resilient, sustainable, and low-carbon dairy value chains. This component will specifically address the financial and technological barriers identified in the ToC as key obstacles in greening the sector’s operations. Under Component 3, medium-sized farmer-allied dairy value chain actors, including aggregators and processors, agro-input and technology providers, and farmers’ cooperatives, will be eligible to access DaIMA-supported financing. Businesses identified by Component 2 as suitable for GDFF financing will be proactively encouraged to apply for support under Component 3.

71. The impact statement and the outcomes outlined in the Theory of Change (ToC) are subject to the following assumptions holding true including: (i) dairy farmers' and pastoralists' willingness to adopt new technologies and practices that increase income and climate resilience of their production system; (ii)

government commitment to livestock GHG emission reductions in line with international commitments and national strategies; (iii) socio-cultural barriers not preventing women and youth from participating in L-FFS and practicing new techniques; (iv) farmer organizations and cooperatives having good governance and financial management systems in place; (iv) financial service providers willingly serving clients with characteristics different from conventional ones; (v) dairy cooperatives, SMEs, processors and other stakeholders being capable and willing to take loan-related risks; (vi) technologies adopted having established local supply chains, distribution networks and after-sale support services; and (vii) sustained demand for carbon credits from international buyers so farmers have access to finance for investments during and after the program. Results are also conditional to risks.

72. *Beneficiaries and targeting*. The Programme will directly benefit to 2.5 million individuals, at least 40 percent of whom women, 30 percent of whom are youth and 5 percent are marginalized groups (including people with disabilities). As the geographic and social targeting of DaIMA is fully aligned with the IFAD projects in the four countries (RDDP-2, ReLIV, INReMP, and C-SDTP), the pro-poor targeting approach, which will also include women and youth, is fully mainstreamed into DaIMA. These beneficiaries will mainly be reached through Component 2, but also through Component 3. The majority are dairy farmers in intensive and semi-intensive systems who currently sell or aim to sell milk in formal and informal markets. These smallholder dairy farmers have generally between 1 to 5 dairy cows (6 to 10 kg of milk/cow/day) in zero-grazing/intensive or semi-zero grazing/semi-intensive systems. They are the main target group and can be considered as rural poor. They are the essential segment of producers who need to be scaled to support the formalization of the dairy sector and foster sustainable intensification based on sound investments and viable business development (see Feasibility Study and Market Studies). Dairy value chain support will also benefit medium and large commercial farmers (6 or more dairy cows, 5-9 kg of milk/cow/day in semi-intensive systems, 12 or more kg/cow/day in intensive systems). Under Output 2.3, the Programme will also benefit (i) pastoralists and agro-pastoralists, and (ii) medium- and large-scale extensive farmers through the rehabilitation/ improved management of 178,362 hectares of rangelands. Entry points to reach dairy farmers will also benefit from the Programme’s support, including dairy cooperatives and milk collection centres (MCCs), L-FFS and Pastoralist field schools (PFS), farmers and community-based organisations.

73. *Implementation arrangements*. As Accredited Entity (AE) for the Programme, IFAD will be responsible for overall management, which includes Programme appraisal, fiduciary and technical oversight, fund management, quality monitoring, and reporting to the GCF, resulting in the Programme completion and final evaluation. This role extends to IFAD's various offices, including its headquarters in Rome and regional office in Nairobi, as well as its country offices in Kenya, Rwanda, Tanzania, and Uganda. A Regional Steering Committee (RSC) will ensure regional alignment and added value of the Programme. In each country, Government will implement the Programme through its designated Executing Entities. National Programme Steering Committees (PSCs) and Programme Implementation Units (PIUs) will be established in each country to oversee (for the former) and coordinate (for the latter) the implementation of the Programme. International and national entities, including ministries of agriculture and specialized entities (e.g. the International Livestock Research Institute - ILRI) will provide specialized services to the national implementation teams.

74. In the four countries, the Executing Entities will be: in **Kenya,** the National Treasury and Economic Planning with subsidiary agreements to the Ministry of Agriculture and Livestock Development (MoALD) and the Development Bank of Kenya (DBK); in **Tanzania**, the Ministry of Finance (MoF) with subsidiary agreements to the Ministry of Livestock and Fisheries (MLF) and the Tanzanian Agriculture Development Bank (TADB); in **Rwanda**, the Ministry of Finance and Economic Planning (MIECOFIN) with subsidiary agreement with the Rwanda Agriculture Board (RAB) within the Ministry of Agriculture and Animal Resources (MINAGRI) and the Development Bank of Rwanda (DBR); in **Uganda,** the Ministry of Finance, Planning and Economic Development (MoFPED) with subsidiary agreements to Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and Uganda Development Bank (UDB).

INTRODUCTION

75. Most African countries have contributed among the least to global GHG emissions causing climate change (IPCC, 2022)[25], yet have already experienced widespread losses and damages. East Africa is already facing loss of lives and impacts on human health, reduced economic growth, water shortages, reduced food production, biodiversity loss, and adverse impacts on human settlements and infrastructure because of human-induced climate change. Limiting global warming to 1.5°C is expected to substantially reduce damages to African economies, agriculture, human health, and ecosystems compared to higher levels of global warming (high confidence) (IPCC 2022)[26]. Agriculture is the main component of economies in Africa and future climate warming will likely have a substantial impact on food security in Africa and is anticipated to coincide with low adaptive capacity as climate change intensifies anthropogenic stressors, as 85% of Africa's poor live in rural areas and mostly depend on agriculture for their livelihoods (Adams, 2018[27;] Mahmood et al., 2019[28]).

76. Livestock, across the region, underpin food systems that provide high-quality and nutritious food to many, including the most vulnerable. Livestock products, such as dairy, supply more than 17% of daily per capita protein consumption (FAO, 2021). They also contribute to the livelihoods of millions of smallholders supporting more than two-thirds of smallholder incomes (Goopy et al., 2018)[29]and, in mixed farming systems, help to reduce the impact of climate or economic shocks leading to crop failure, by diversifying income generation. Livestock is fastest growing sector in agriculture and the largest source of agricultural GHG emissions in East Africa and represent the best opportunity for mitigation in the region.

77. This Feasibility Study (FS) is prepared to support the Funding Proposal (FP) of the International Fund for Agricultural Development (IFAD) led Green Climate Fund (GCF) programme "Dairy Interventions for Mitigation and Adaptation (DaIMA) in East Africa: Promoting Low Carbon and Climate Resilient Livestock in East Africa", comprising Kenya, Rwanda, Uganda, and United Republic of Tanzania.

78. The FS is informed by ten thematic pre-feasibility studies (listed below) which were prepared during design, and that will be referred to as when necessary. The FS is structured to first provide a climate analysis of the region (Chapter 1) then an overview of the dairy sector in the 4 countries, including emissions and climate change impacts (Chapter 2). It details the Theory of Change (Chapter 3), explains the programme area selection (Chapters 4) and reports beneficiaries calculations (Chapter 5). The FS provides detailed justification of the Programme interventions (Chapter 6), depicts implementation arrangements (Chapter 7) and elaborates on activities and sub-activities (Chapter 8). Chapters 9 and 10 summarizes financial management and monitoring and evaluation (M&E), which both have dedicated Annexes in the FP package.

Pre-feasibility Studies	Objective	Relevance to Feasibility Study
1. Typology of production systems	Understand current production systems typology and potential evolution (incl. productivity, economics, challenges)	Dairy sector context in the 4 countries

[25] IPPC 2022: Sixth Assessment report. Impacts, Adaptation and Vulnerability Fact sheet Africa.
[26] ibid
[27] Adams, L., 2018: Unlocking the potential of enhanced rainfed agriculture. SIWI, Stockholm. Available at: https://www.siwi.org/wp-content/uploads/2018/12/Unlocking-the-potential-of-rainfed-agriculture-2018- 49 FINAL.pdf
[28] Mahmood, R., S. Jia and W. Zhu, 2019: Analysis of climate variability, trends, and prediction in the most active parts 36 of the Lake Chad basin, Africa. Scientific Reports, 9(1), 6317, doi:10.1038/s41598-019-42811-9
[29] FAO. 2022. Ibid.

Pre-feasibility Studies	Objective	Relevance to Feasibility Study
2. Climate rationale for mitigation: Emissions baseline and business-as-usual pathways	Understand current baseline greenhouse gas emissions from the dairy sector in each country	Rationale for mitigation in the dairy sector in the 4 countries
3. Climate rationale for adaptation: Main climate change risks and climate vulnerability assessments	Understand the climate context in the 4 countries as well as the impact of climate change on the dairy sector without any interventions. Suggest a "menu" of possible climate-change adaptation options	Rationale for climate-resilient investments for the dairy sector
4. Pathway-specific assessment of adaptation and mitigation options at farm/production level (Study 4 was blended with Study 2)	Provide a "menu" of possible mitigation solutions at farm-level that can be promoted by the programme	Investment options to be considered for the Programme
5. Pathway-specific/production-system specific formulation of interventions at country level	Identify appropriate mitigation solutions solutions per country	Country-specific investment options
6. Pasture rehabilitation and management, including forage/fodder	Understand current conditions of rangelands and pastures in the four countries, analyse actual feed balance, assess current practices and policies, identify barriers to adoption	Investment options to enhance rangelands management and enhance soil carbon sequestration
7. Market Study (presented as Appendix 1 to this report)	Understand dairy sector investment context (value chain, enablers), provide insights for the financing facility (pipeline and feasibility)	Provide the financial & economic business rationale for investment in the dairy sector
8. Design and operationalization of private sector financing facility	Develop design of financing facility and assess feasibility	Rationale and detailed mechanisms for operating the facility
9. Study on land tenure	Establish key production asset availability and related opportunities and risks	Investment risks and barriers assessment
10. Study on renewable energy	Establish current technology use and potential opportunities and barriers for adoption	Investment options to be considered for the Programme. Technical input, CAPEX and OPEX needs

1 CLIMATE ANALYSIS

79. This section is structured around the climatic risk definition (compounded effect of observed and projected climate hazards, exposure[30], vulnerability[31], modulated by the existing adaptive capacity[32]) of the Intergovernmental Panel on Climate Change (IPCC)'s 5th Assessment Report (AR5). In the context of climate change, risks arise from the impacts of weather hazards; human responses; vulnerability of the system to cope with adverse effects; and the ability of the target system to adjust and cope with the impacts of climate change. The document WMO-GCF "Developing a Science Basis for Climate Action (World Meterological Organisation, WMO, 2021[33]) describes how to identify relevant climatic and non-climatic contribution factors. The section is informed by pre-feasibility Study 3, Climate rationale for adaptation: Main climate change risks and climate vulnerability assessments.

1.1 CLIMATE BASELINE INFORMATION

80. The climate over East Africa is shaped by astronomical (amount of heat reaching the earth), atmospheric (distribution of heat along the earth), and geographical factors (interfering on heat distribution such as distance to the sea and physical barriers).

81. A large percentage of the interannual rainfall variability across East Africa is linked to sea surface temperature variability over the Equatorial Pacific and the Indian Ocean through El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD), respectively (Endris et al. 2019[34]). The Walker circulation comprises the east-west atmospheric circulation along the Equatorial belt and, thus, during ENSO, there is an eastward shift of the anomalous circulation in the south Pacific Ocean (Lau & Yang, 2003[35]). The ENSO is one of the strongest drivers of climate variability over East Africa, directly influencing agricultural production, including livestock production (Sazib et al. 2020[36]).

82. During El Niño years, above average sea surface temperatures warm the atmosphere and, thus, result in greater convention and rainfall over the region, essentially between October and January and, conversely, below average rainfall during La Niña years. In addition, the IOD is closely related to rainfall variability over East Africa. Opposite sea surface temperature anomalies (IOD positive phase) result in above average autumn rains over East Africa, as warm sea waters are pushed towards the western parts of the Indian Ocean (Nicholson, 2017[37]). Furthermore, intra-seasonal variability over East Africa is mostly affected by the migration of the Inter Tropical Convergence Zone (ITCZ), where trade winds converge. The north displacement of the ITCZ results in a unimodal rainfall regime in areas far apart from the Equator.

83. The migration of the ITCZ carries air moisture and, consequently, precipitation to the north of the Equator during the boreal summer (June to August) and vice-versa, rains to the south of the Equator during the austral summer (December to February). On the contrary, a bimodal rainfall regime is observed along the Equatorial line, traditionally experiencing two rainfall seasons (March to May and October to November) over the course of the year. The above ocean-atmospheric factors are then shaped by local geographical factors, including the Turkana channel, the East African highlands, the Lake Victoria, and the influence of coastal sea surface temperatures, as described by Nicholson (2017[38]). For example, precipitation along the northwestern parts of Kenya declines due to the Turkana low-level jet stream that supports rainfall formation at the jet's exist, and vice-versa (deficit rainfall) towards the northwest of Kenya (Óscar et al. 2022[39]).

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[30] Presence of livelihoods, ecosystems, and assets
[31] Degree to which a system, livelihood might be negatively affected
[32] Capacity to respond to actual climate effects

[33] WMO. (2021). Developing the Climate Science Basis for Climate Action. Available at: https://library.wmo.int/idurl/4/53280
[34] Endris, H. et al. (2019). Future changes in rainfall associated with ENSO, IOD and changes in the mean state over Eastern Africa. Climate dynamics, 52, 2029-2053.
[35] Lau, K. M., & Yang, S. (2003). Walker circulation. Encyclopedia of atmospheric sciences, 2505(2510), 00450-4.
[36] Sazib, N. et al. (2020). Assessing the impact of ENSO on agriculture over Africa using earth observation data. Frontiers in Sustainable Food Systems, 4, 509914.
[37] Nicholson, S. E. (2017). Climate and climatic variability of rainfall over eastern Africa. Reviews of Geophysics, 55(3), 590-635.
[38] Ibid.
[39] Óscar, L. et al. (2022). Characteristics of the Turkana low-level jet stream and the associated rainfall in CMIP6 models. Climate Dynamics, 1-17.

84. The East African highlands block the low-level easterly flow over the southern Indian Ocean and steer the winds across the Equator into the southwest monsoon flow (Slingo et al. 2005[40]). As a result, the East African highlands lead to increased convergence and, thus, rainfall over Equatorial Africa, particularly affecting the eastern parts of Uganda and northwestern Tanzania that see an increase in rainfall reinforced by the air moisture from the Lake Victoria. Lastly, the coastal areas of Kenya and Tanzania are predominantly affected by the easterly flow, indicating a net outflow of water vapor from the region and, thus, experiencing a precipitation decline heightened during the neutral and negative IOD phases.

85. The climate (atmospheric factors) is the main driver behind a diversity of agro ecologies in East Africa. These agro ecologies in turn determine the ability of a system to support given agricultural systems, including the livestock systems and cattle breeds. East Africa is dominated by a tropical savannah climate, separated by a corridor of arid steppe and desert climates parallel to the Indian Ocean coastline and northwest of Kenya, as well as in the central parts of Tanzania. Tropical rainforest conditions are found in the Lake Victoria and temperate climates are present along the highest altitude areas of the Great Rift Valley bordering Kenya and Tanzania. Kenya is the driest among the four targeted countries, with a total annual rainfall ranging between 400 to 600mm in the northwest of Lake Turkana and in areas bordering Somalia. Conversely, Uganda and Rwanda have the highest total annual precipitation, ranging between 1000 and 1600mm. These conditions lead to a mosaic of climates and, consequently, to a wide range of agroecological zones in East Africa, as can be seen in Figure 1 below:

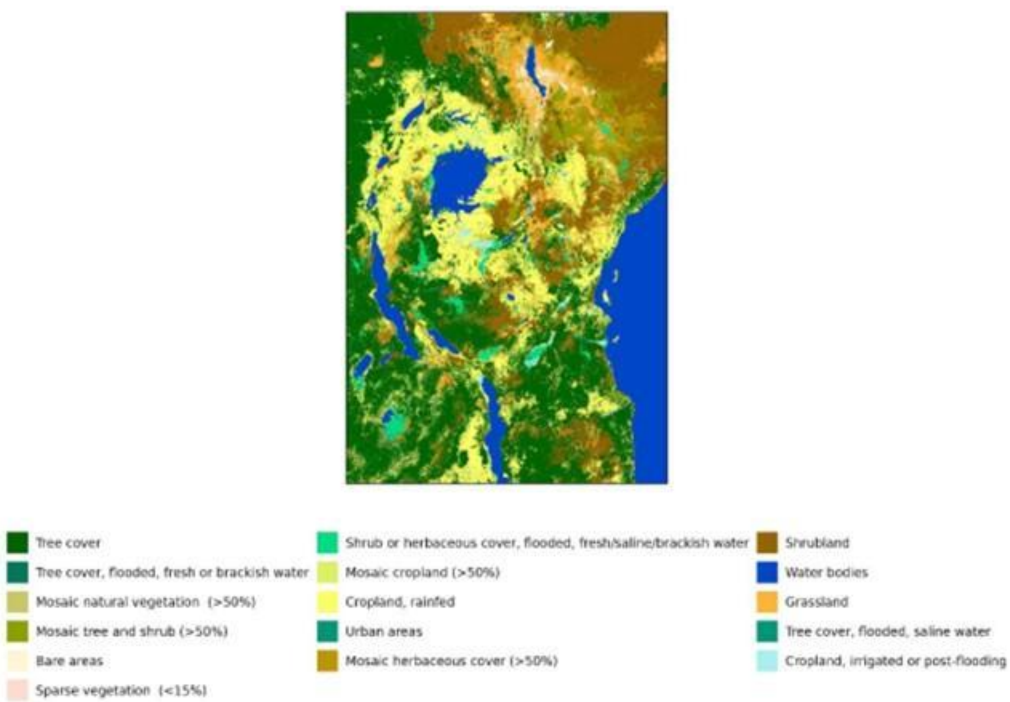


Figure 1: Land cover map for East Africa in 2020

[40] Slingo, J. et al. (2005). The meteorology of the Western Indian Ocean, and the influence of the East African Highlands. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 363(1826), 25-42.

1.2 CLIMATE HAZARDS (PAST CLIMATE)

86. For the analysis of past climate, this Feasibility Study uses the W5E5 dataset for the 1981-2016 period (36-year dataset for daily precipitation, daily maximum and minimum temperatures, and relative humidity at around 50km resolution) (Cucchi et al. 2020[41]). W5E5 is currently used in many impact assessment studies, and it has been adopted by the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) as the official product for the bias-correction of atmospheric models. The W5E5 merges two datasets, the ERA5 reanalysis dataset (at 0.25º spatial resolution) over the ocean with the WFDE5 over the land (at 0.50º spatial resolution). To support the analysis of historical climatic trends, this study's results are supported by a scientific literature review. The analyses performed in this document are prepared using the CCAVA tool. The tool allows the user to access different reanalysis products for the historical period, where trends can be calculated by applying a simple linear regression for the historical period.

1.2.1 Precipitation

[41] Cucchi, M. et al. (2020). WFDE5: bias-adjusted ERA5 reanalysis data for impact studies. Earth System Science Data, 12(3), 2097-2120.

87. At the regional level, several studies show a decreasing pattern on total annual rainfall over East Africa during the 1951-2010 period. Most of the precipitation decline over East Africa is observed in the 1950s (-6.7mm/yr.) and in the 1960s (-21.8mm/yr.), whereas a precipitation increase is reported in the 1970s (+16.0mm/yr.) (Ongoma & Chen, 2017[42]). Over the last three decades (1980-2010), total annual precipitation remains relatively stable. At the country level, this study reports a decline in total annual precipitation in Kenya (-1.87mm/yr.) and Uganda (-0.59mm/yr.), equivalent to an average loss in total annual precipitation of -67 and -21mm over the 1981-2016 study period. On the other hand, an increase in total annual precipitation is observed in Rwanda (+1.05mm/yr.) and Tanzania (+0.52mm/yr.), corresponding to an average gain in total annual precipitation of +38mm and +19mm during the 1981-2016 period (Figure 2). Because of a very high inter-annual rainfall variability, none of these countries display statistically significant changes (p-value 0.05). Similarly, but not statistically significant different, is the change in the north and southeast Kenya experiencing a total annual rainfall reduction of about -2.5 to -5.0mm/yr. over the 1981-2016 period. The observed precipitation decline also extends to the coastline of Tanzania, where losses in total annual precipitation amount to more than - 7.5mm/yr. (equivalent to -270mm in total annual precipitation) over the 1981-2016 period. Conversely, in Tanzania, the highest total annual precipitation increase (p-value < 0.05) is reported along the strip bordering Uganda (+5mm/yr. over the 1981-2016 period), just like in West Kenya and East Uganda.

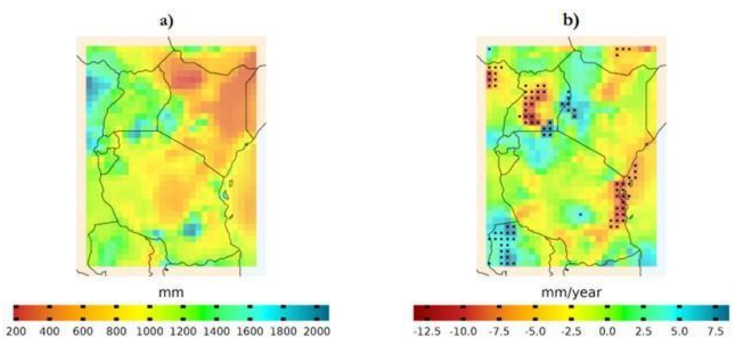
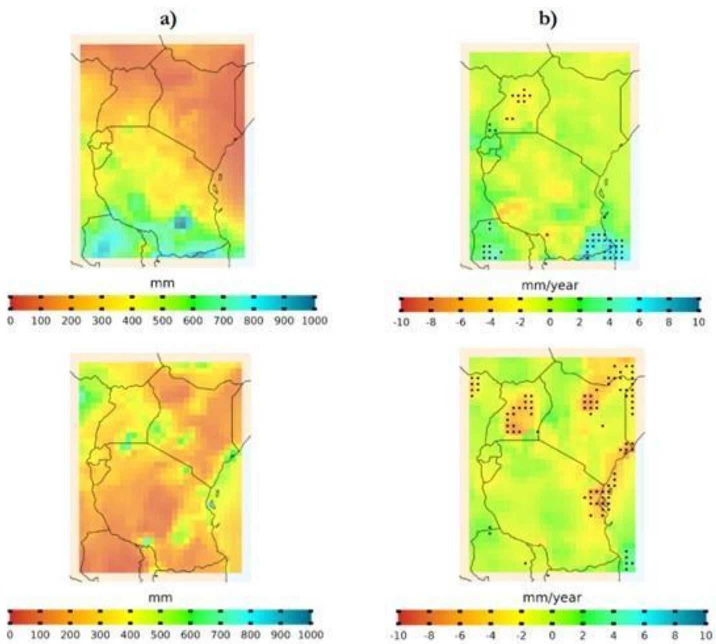


Figure 2: Average total annual precipitation (mm) and (b) annual change (mm/yr.) over the 1981-2016 period using the W5E5 dataset

For the annual change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance.

[42] Ogega, O. M. et al. (2020). Heavy precipitation events over East Africa in a changing climate: results from CORDEX RCMs. Climate Dynamics, 55(3-4), 993-1009.

88. Analysis on seasonal precipitation trends shows statistically significant differences (p-value < 0.05) across central Uganda between January and March, extending to north Kenya and northeast Tanzania between April and June where precipitation has declined at a rate of -4 to -8mm/yr. over the 1981-2016 period (Figure 3b). In addition, during the austral summer (January to March), southeast Tanzania has recorded a precipitation increase, ranging between +4 to +6mm/yr. (p-value 0.05). Spatial changes are reported between October and December. For example, while west and north Kenya, north Tanzania and east Uganda reported a precipitation increase of +4 to +6mm/yr. (statistically significant difference), large areas of Tanzania showed a precipitation decline of -2 to -4mm/yr. between October and December over the 1981-2016 period, especially along the southeast coastline of Tanzania where precipitation decline showed a statistically significant different (p-value < 0.05) trend over the 1981-2016 period. These findings are aligned with scientific literature, displaying increasing precipitation trends between January and February along southeast Tanzania, and an overall increasing trend between October and December in west Kenya, north Tanzania, and east Uganda (Gebrechorkos et al. 2019[43]). In alignment to this study's findings, Gebrechorkos et al. (2019[44]) showed a precipitation decline in southeast Tanzania between October and December over the 1981-2016 period.



[43] Gebrechorkos, S. et al. (2019). Long-term trends in rainfall and temperature using high-resolution climate datasets in East Africa. Scientific reports, 9(1), 11376.
[44] Ibid

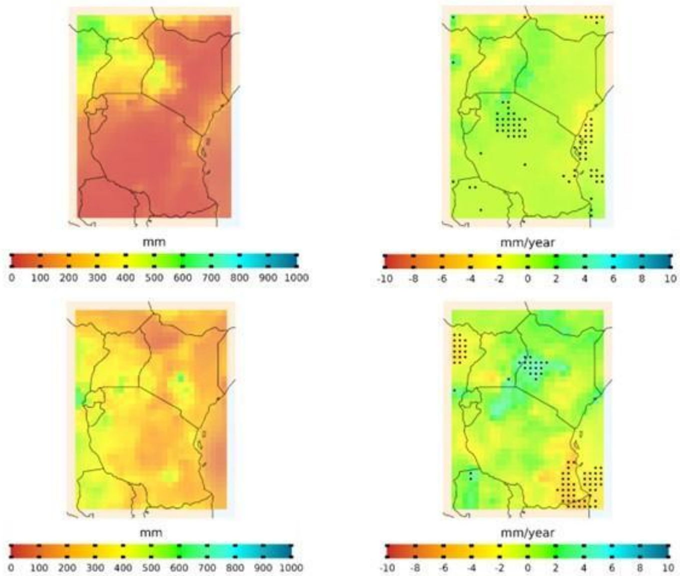


Figure 3: (a) accumulated seasonal precipitation (mm) and (b) seasonal change (mm/yr.) over the 1981-2016 period using the W5E5 dataset

From top down: January-March; April-June; July-September; and October-December. For the seasonal change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance.

1.1.1 Temperature

89. *Mean Maximum Temperatures*. There is a significant change on average daily maximum temperature (hereafter mean Tmax) over East Africa, particularly across the entire Kenya, and most of Uganda and Tanzania (Figure 4b). For example, in east Uganda (Eastern and Northern region) and northwest Kenya (north of the Lake Turkana County), the mean Tmax trend is of +0.030 to +0.035ºC/yr., equivalent to a +1.1 to +1.3ºC increase over the 1981-2016 period. On top of having the greatest mean Tmax increase over time, the north Rift Valley in Kenya is considered the warmest area among the targeted countries, where mean Tmax ranges between 34 to 36ºC year-round (Figure 4a). Although the rate of change is statistically significant different (p-value <0.05) in most parts of Tanzania, the mean Tmax increase is lower (+0.015 to +0.020ºC/yr.) to that observed in Kenya and Uganda (Figure 4b). On the contrary, W5E5 results indicate that west Tanzania (e.g., Katavi, Rukwa, and Songwe) has hardly experienced a mean Tmax increase over the 1981-2016 period. The spatiotemporal changes on mean Tmax are consistent with literature, showing a higher rate of mean Tmax increase (+1.0 to +1.5ºC) over the west of Kenya and the east of Uganda during the 1981-2016 period, as well as in north Tanzania compared to Kenya's and Tanzania's coastline which have experienced a lower mean Tmax increase over time (Gebrechorkos et al. 2019[45]).

[45] Ibid

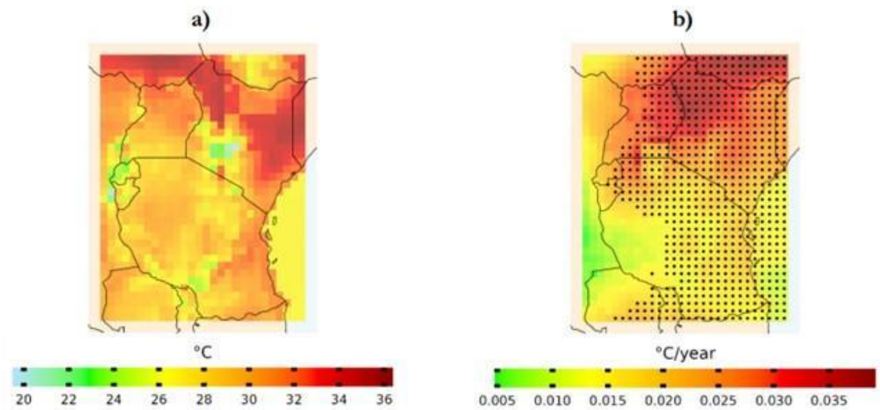


Figure 4: (a) Mean maximum daily temperatures (°C) and (b) annual change (°C/yr.) over the 1981-2016 period using the W5E5 dataset

For the annual change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance

90. *Mean minimum temperatures*. There is a statistically significant change in average daily minimum temperature (hereafter "mean Tmin") over Kenya and Tanzania; however, not in Rwanda nor in the west of Uganda (Figure 5b). As for mean Tmax, most of the mean Tmin increase is observed in east Uganda and northwest Kenya where temperatures have increased at a rate of +0.035ºC/yr., equivalent to +1.3ºC during the 1981-2016 period. Although statistically significant different, the change in mean Tmin over Lake Victoria is considerably lower to that of its surroundings due to the high specific heat value of water compared to air. In most parts of Tanzania, mean Tmin has increased at a rate of +0.020 to +0.030ºC/yr., equivalent to +0.72 to +1.08ºC during the 1981-2016 period. As for mean Tmax, Rwanda does not display statistically significant changes in mean Tmin over time, except for eastern parts. Overall, mean Tmin has increased by +0.5 to +1.0ºC in Rwanda since 1981, country characterized by having mean Tmin values lower (12-14ºC) to those observed in nearby countries (>18ºC) (Figure 5a). Lastly, the areas recording the highest annual mean Tmin (>22ºC) are those in Kenya's Rift Valley, just like the areas along the Indian Ocean coastline.

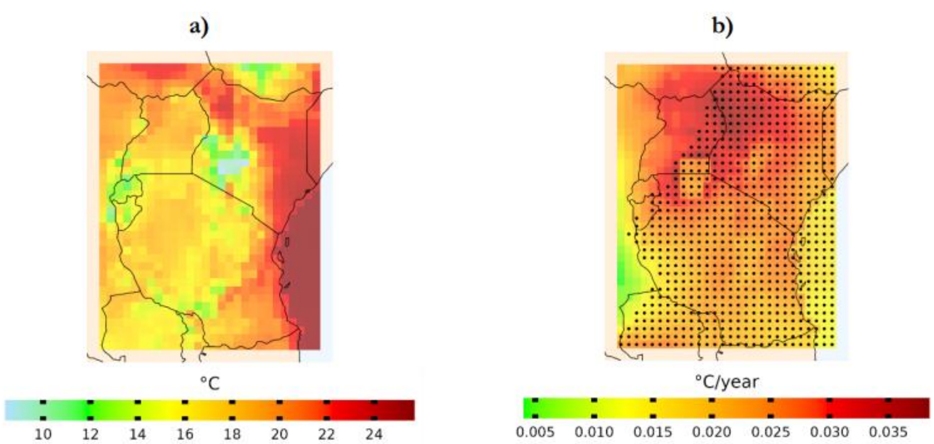


Figure 5: (a) Mean minimum daily temperatures (°C) and (b) annual change (°C/yr.) over the 1981-2016 period using the W5E5 dataset

For the annual change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance

1. *Mean relative humidity*. Even though relative humidity is one of the major factors affecting animal health and production of livestock systems, it has not received much research attention. Therefore, the following analysis investigates the changes in mean daily relative humidity (hereafter mean RH) across the targeted countries.

2. Figure 6a shows that Kenya's Rift Valley has the lowest mean RH (≤50%), while central and south Uganda, particularly areas bordering the Lake Victoria have the highest mean RH on annual average (75 to 85%). Due to the incoming moisture from the Indian Ocean, the coastline of Kenya and Tanzania is characterized by a high mean RH (70 to 80%) year-round. The eastern side of Tanzania's Arc Mountain range also displays a high mean RH (70 to 75%). In addition, changes in RH are statistically significant in most parts of Uganda and Rwanda, where RH has decreased by -0.10 to -0.25%/yr. over the 1981-2016 period (equivalent to -2.5 to - 9.0% decline in mean RH) (Figure 6b). In Kenya, the decrease is statistically significant different in the northeast and east, whereas in Tanzania, central and southern regions have experienced the largest mean RH decline (-0.10 to -0.15%/yr.) over time. On the contrary, Tabora, Lindi and Mtwara regions in Tanzania, and the north of the Rift Valley and the coastline of Kenya show minimal declines over the 1981-2016 period.

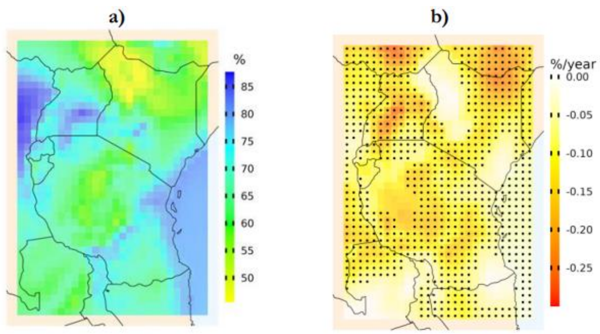


Figure 6: (a) Mean daily relative humidity (%) and (b) annual change (%/yr.) over the 1981-2016 period using the W5E5 dataset

For the annual change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance

1.2.2 Extreme weather events

3. *Dry-spells and extreme precipitation*. The average annual number of dry days (R≤1mm/day) in East Africa exceeds 300 days in the north Rift Valley and in the northeast of Kenya and, conversely, declines to less than 160 days towards the Lake Victoria (including Mount Elgon) and tropical rainforests nearby the Democratic Republic of Congo (Figure 7a). In Tanzania, the number of dry days on annual average ranges between 180 days along the border with Uganda and Rwanda to more than 280 days along the interior. Very few statistically significant differences in the number of dry days on annual average are reported in East Africa, except for the Indian Ocean coastline where there has been an increase in the number of dry days by +1.0 days/yr. (equivalent to +36 dry days on annual average since 1981) and east Uganda where there has been a decrease in the number of dry days by -0.50 days/yr. (equivalent to +18 wet days on annual average since 1981) (Figure 7b). Although not statistically significant, different large areas of Tanzania and Kenya have experienced a slight increase (represented with light green and yellow colours) in the number of dry days on annual average over the 1981- 2016 period.

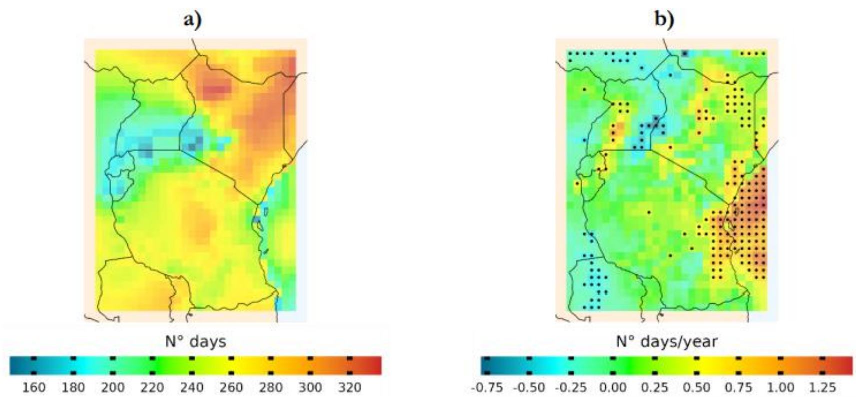


Figure 7: (a) Average number of dry days (R≤1mm/day) and (b) annual change (days/yr.) over the 1981-2016 period using the W5E5 dataset

For the annual change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance.

4. The 3-month Standardized Precipitation Index (SPI-3) is critical for understanding whether precipitation over a period is normal (SPI values between -0.99 to +0.99), moderately dry and or humid (SPI values between - 1.49 to -1.0 and +1.0 to +1.49, respectively), severely dry and or very humid (SPI values between -1.99 to - 1.5 and +1.5 to +1.99, respectively), and extremely dry or humid (SPI values ≤-2.0 and ≥+2.0, respectively). SPI-3 analysis provides accurate meteorological and agricultural drought analysis over an area and illustrates well the influence of precipitation anomalies on short-term water availability, which is important for rainfed agricultural activities. In this study, the magnitude of wet and dry years is displayed in Figure 8. The 1997-1998 period, considered as very humid (SPI >+1.5), has been followed by a severe dry period (SPI <-1.5) in 1999-2000. Therefore, the linkages between El Niño and La Niña phenomena with precipitation variability over East Africa cannot be ruled out, especially because the years 1997-1998 and 1999-2000 have been considered as very strong El Niño and strong La Niña years, respectively. It also reflects the ENSO impacts, since peak ENSO events occur during October to March periods coinciding with the short (October to November) and long (March to May) rainy seasons over East Africa.

5. The magnitude of SPI-3 and temporal behaviour over East Africa is, to some extent, similar (Figure 8). The interannual SPI-3 variability over East Africa is high, characterized by at least one dry and or humid year on average every 5-years. Overall, this variability has been highest over the 80s and 90s and has declined in recent years, especially in Kenya and Rwanda (Figure 8 a, b). On average, all four countries in study have a standard deviation higher or lower than +0.5 or -0.5 over the 1981-2016 period, respectively, and thus implying that SPI-3 precipitation values are spread out from the mean. High interannual precipitation variability is important in Uganda, where SPI-3 values lower than -1 have been constantly breached over the 1981-2016 period. Lastly, Kalisa et al. (2020[46]) study's using the Climate Research Unit (CRU) data precipitation records from 1920 to 2016 show a series of recurrent short dry periods becoming more recurrent since the 1980s (e.g., 1981-1982, 1983-1984, 1988-1990, 1991-1992, 1993-1994, 1996-1997 and 2001-2002).

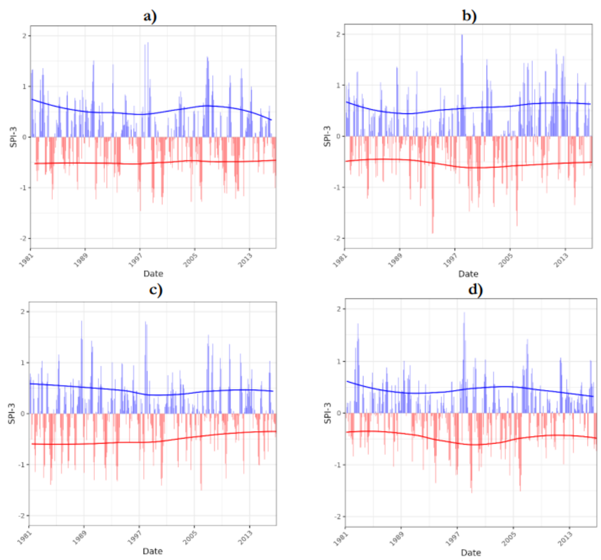


Figure 8: Spatiotemporal analysis of SPI-3-month over the 1981-2016 period in (a) Kenya, (b) Rwanda, (c) Uganda and (d) Tanzania

6. There is not a clear spatial pattern in the number of very wet days (R≥20mm/day) over East Africa, except for the Indian Ocean coastline that has experienced very wet days on annual average over the 1981-2016 period (Figure 9a). The trends show statistically significant differences along the Great Rift Valley in Kenya and Tanzania, with an annual average increase of +0.15 days/yr. over the 1981-2016, equivalent to an additional +5 day very wet days on annual average since 1981 (Figure 9b). However, neither the interior of Kenya, Tanzania nor Uganda show an increase or decrease in the number of very wet days on annual average since 1981. Our results agree with literature, suggesting that the entire East Africa received less than 20 very wet days on annual average during the 1981-2017 period (Ojara et al. 202147). In addition, a recent study on annual trends for precipitation indices, such as the number of extreme and very wet days (R≥50mm/day and R≥20mm/day), over East Africa showed a decrease between 1981 to 2010 (Nimussima et al. 2019[48]).

[46] Kalisa, W., Zhang, J., Igbawua, T., Ujoh, F., Ebohon, O. J., Namugize, J. N., & Yao, F. (2020). Spatio-temporal analysis of drought and return periods over the east african region using standardized precipitation index from 1920 to 2016. Agricultural Water Management, 237, 106195. https://doi.org/10.1016/j.agwat.2020.106195

[47] Ojara, M. A. et al. (2021). Trends and zonal variability of extreme rainfall events over East Africa during 1960–2017. Natural Hazards, 109(1), 33-61.

[48] Alex, N., K. Jesse and N. Neoline. 2019. Evaluation of past and future extreme rainfall characteristics over Eastern Uganda. Journal of Environmental & Agricultural Sciences. 18:38-49.

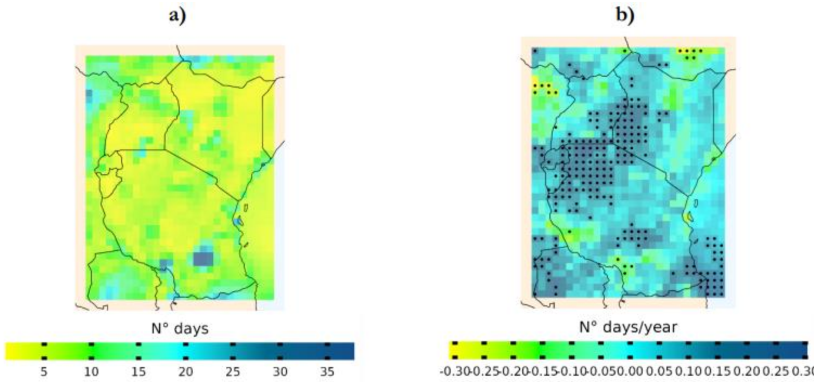


Figure 9: (a) Average number of very wet days (R≥20mm/day) and (b) annual change (days/yr.) over the 1981-2016 period using the W5E5 dataset

For the annual change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance.

7. *Extreme temperatures.* According to the W5E5 dataset, most of the change (p-value 0.05) in the number of very warm days (Tmax ≥35ºC) on annual average is reported in the north Rift Valley, eastern and northeast Kenya, where the number of very warm days on annual average has increased by +1.2 to +2.8 days/yr. (equivalent to 40 to 100 additional very warm days on annual average since 1981) (Figure 10b). Besides experiencing the highest positive trend over time, north Kenya records the highest number of very warm days on annual average, ranging between 150 to 250 days on annual average depending on the location (Figure 10a). Although not statistically significant different, north Uganda has observed an increase in very warm days at a rate of +0.8 days/yr. over the 1981-2016. The rest of the studied areas did not report any major changes (denoted in green colours) in the number of very warm days on annual average over the 1981-2016 period.

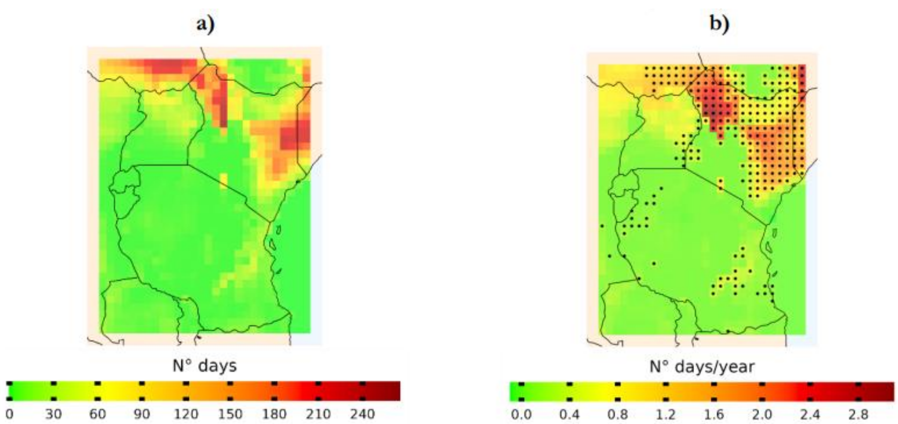


Figure 10: (a) Average number of very warm days (Tmax≥35°C) and (b) annual change (days/yr.) over the 1981-2016 period using the W5E5 dataset

For the annual change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance.

8. Over the 1981-2016 period, tropical night conditions (Tmin ≥20ºC) are considerably higher (more than 250 days on annual average) in Kenya's Rift Valley, just like in Kenya's and Tanzania's Indian Ocean coastline compared to the interior and high-altitude areas of Rwanda (0 to 50 days on annual average) (Figure 11a). While statistically significant differences for Tmax ≥35ºC are limited to Kenya, for Tmin ≥20ºC these differences expand across Tanzania, where trends show an increase in tropical nighttime conditions by +1.0 to +1.5 days/yr. over the 1981-2016 period (Figure 11b). Although not statistically significant different in all areas, the greatest change is observed in north Uganda and Kenya where tropical nighttime temperature conditions have increased by +3.5days/yr., equivalent to an additional 125 tropical nights in areas typically experiencing 50 to 150 tropical nights on annual average over the 1981-2016 period.

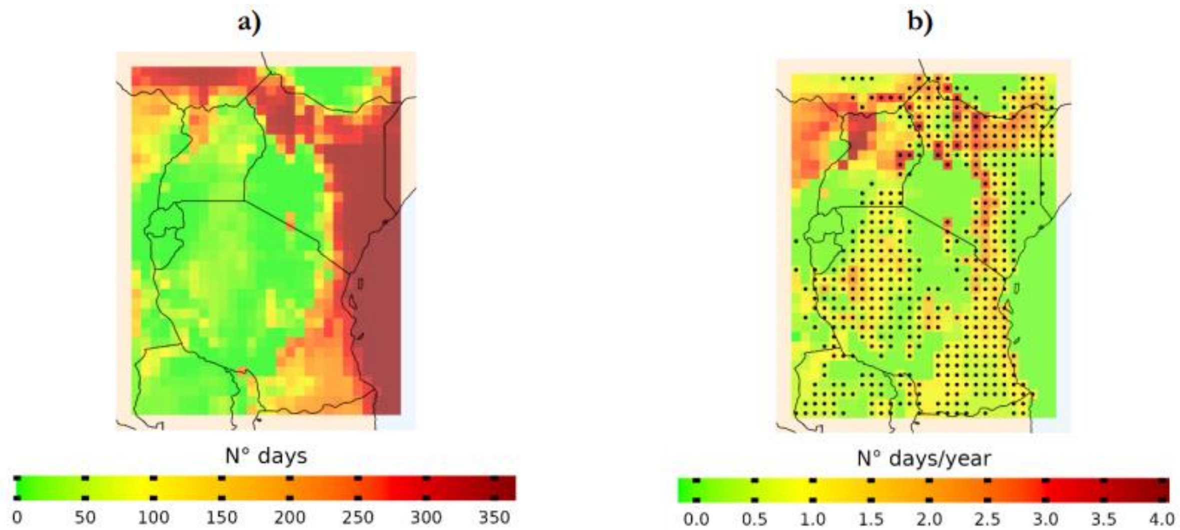


Figure 11: (a) Average number of tropical nights (Tmin≥20°C) and (b) annual change (days/yr.) over the 1981-2016 period using the W5E5 dataset

For the annual change (b) a linear regression is applied to each pixel, and, thus, a statistically significant change is represented with a black dot. Conversely, pixels with an absence of a black dot indicate a lack of statistical significance.

1.3 CLIMATE HAZARDS (FUTURE CLIMATE)

9. The FAOs CAVA analytics tool allows the user to access regionally dynamically downscaled (CORDEX CORE) CMIP-5 models (general circulation models (GCMs), namely MOHC-HadGEM2-ES, MPI-M-MPI-ESMLR, NCC-NorESM1-M downscaled with regional climate models (RCMs), namely REMO2015 at around 25km resolution (interpolated at 50km) for two representative concentration pathways (RCPs), namely RCP 2.6 (low emission scenario) and RCP 8.5 (high emission scenario). For future climate projections, CAVA analytics uses the W5E5 merged dataset over the 1976-2005 period for bias-correcting the outputs of atmospheric models. The calculation of the agreement of the climate change signal as defined by the IPCC is among the several statistical indices that CAVA analytics can perform.

10. Additionally, CAVA analytics can calculate climatic thresholds (seasonality and extremes) and agroclimatic indices that are of interest for climate impact potential assessments in agriculture. In this document, the CAVA analytics tool has been used to downscaled 3 GCMs with one RCM. This is because the region of interest is large and performing operations in all six available simulations (3 GCMs and 2 RCMs) is computationally intensive. However, we highlight that most of the variation resides in the GCMs and not in the RCMs as widely reported in literature. Thus, even if this document focuses on 3 GCMs and 1 RCM, most of the inter-model variation over time is captured. In addition, when a linear regression is applied to future projections in CAVA analytics, design-based inference is used for the calculation of p-values. The scientific problem is that there are multiple models, all equally plausible. Therefore, calculating the significance of trends is much more challenging. While a linear regression on the ensemble member could mask statistical signals, a multivariate version of linear regression through resampling of model residuals via PIT-strap resampling helps us elucidate statistical signals over time (Wang et al. 2012[49]).

[49] Wang B, Liu J, Kim HJ, Webster PJ, Yim SY (2012) Recent change of the global monsoon precipitation (1979–2008). Clim Dyn 39:1123–1135

1.1.2 Precipitation

11. Future precipitation changes show an enhancement in some parts of East Africa in the far future under different shared socioeconomic pathways (SSPs) (Ayugi et al. 2022[50]). However, the arid and semi-arid regions are expected to receive a lower volume of precipitation, whereas the highlands and the lake regions may receive larger amounts of precipitation. Seasonal climatological precipitation over East Africa displays a precipitation increase during the dry season in Kenya, Tanzania, and Uganda.

12. More advanced statistical analysis performed in CAVA analytics using CORDEX-CORE simulations indicate an overall reduction in total annual precipitation over Uganda (0 to -100mm) in the mid-term (2040-2069) for RCP 2.6, as well as in south Tanzania (0 to -200mm) in the far-future (2070-2099) for RCP 8.5 relative to the baseline period (1976-2005) (Figure 12). In some parts of Uganda and south Tanzania, GCMs and RCMs highly agree in the sign of the climate change signal and, thus, demonstrate a high model agreement in the direction of precipitation change. These results are in harmony with those of Gebrechorkos et al. (2023) using CMIP-6 data that show a decline in total annual precipitation of up to -4.5% in south Tanzania by 2050 and 2080. Conversely, with regards to the positive changes in total annual precipitation, future projections indicate an increase towards the east of Kenya under RCP 2.6 (+100mm), heightened under RCP 8.5 (+100 to +200mm) in the far-future (2070-2099) relative to the baseline period (1976-2005). Most of the change in east Kenya is statistically significant different especially in the far-future (2070-2099). The positive changes in total annual precipitation are captured in the multivariate analysis in, displaying both a statistically significant trend over time as well as a very high model agreement (dark blue colors).

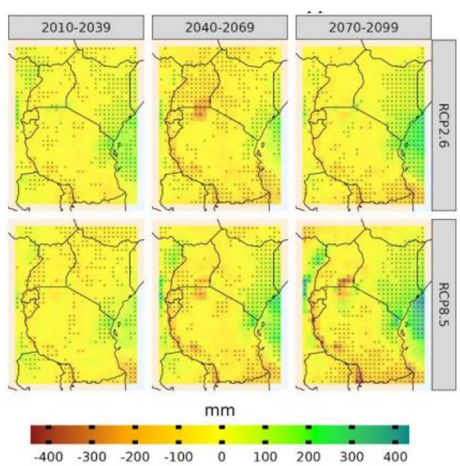


Figure 12: Climate change signal in total annual precipitation (mm) over the 21st century from historical period (1976-2005)

The black cross indicates where at least 60% of the models agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs with REMO2015 is applied.

[50] Ayugi, B. et al. (2022). Projected changes in meteorological drought over East Africa inferred from bias-adjusted CMIP6 models. Natural Hazards, 113(2), 1151-1176.

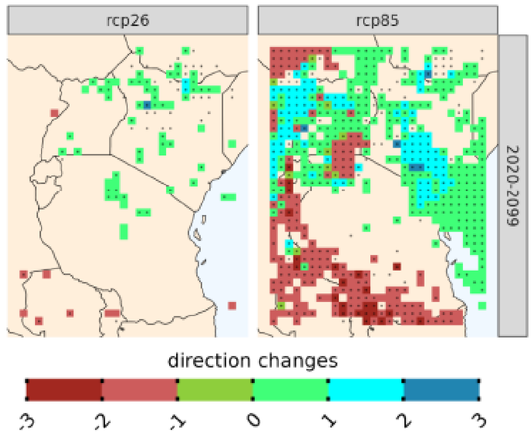


Figure 13: A multivariate linear regression is applied to each pixel for each model through PIT-trap residual resampling on cumulative total annual rainfall for RCPs 2.6 and 8.5 over the 2020-2099

The statistical significance of the multi-model ensemble is calculated through residual resampling (design-based inference). A black dot indicates whether one model (at least) had a statistically significant trend. The colors indicate the direction of change (increase of decrease in precipitation) based on the number of models agreeing on the sign of change. The color of the pixel states the number of models (statistically significant) agreeing on an increase or decrease. For example, -2 in the legend corresponds to an agreement in precipitation decline between two GCMs.

13. Figure 14 shows the trends in total annual precipitation for RCPs 2.6 and 8.5 over the century in Kenya, Rwanda, Uganda, and Tanzania. At the country level, Kenya is likely to experience the highest increase in total annual precipitation. Future climate projections for Kenya indicate an increase in total annual rainfall by +0.89 and +1.32mm/yr., respectively under RCPs 2.6 and 8.5, equivalent to +80 to +120mm on annual average. The former represents a significant enhancement (ranging between +10 to +20%) relative to the annual average rainfall observed at national level (600 to 700mm). More in-depth temporal analysis for Kenya suggests that monthly precipitation during January, June and July is lower (-17, -24 and -23%, respectively) than the reference period, but higher than in the other months (Gebrechorkos et al. 2023[51]). In Rwanda, GCMs show a decrease under RCP 2.6 (-0.20mm/yr.) and an increase under RCP 8.5 (+0.18mm/yr.). However, in both RCPs there is not a significant trend on total annual precipitation over time. In Uganda, for example, future climate projections show identical values for both RCPs, with a precipitation decline of -0.30mm/yr. across the century and, thus, representing a minimal loss (-27mm) in total annual precipitation by the end-century. However, Gebrechorkos et al. (2023[52]) suggests a decrease in seasonal precipitation during the boreal winter ranging between -2.7 to -16% and between -0.9 to -7.8% in January and December, respectively. In Tanzania, the rate of precipitation declines under RCP 8.5 doubles that of RCP 2.6 (-0.21 and -0.39mm/yr., respectively), equivalent to a precipitation reduction of -5% in the worst-case scenario (RCP 8.5) by the end-century.

[51] Gebrechorkos, S. H., Taye, M. T., Birhanu, B., Solomon, D., & Demissie, T. (2023). Future changes in climate and hydroclimate extremes in East Africa. Earth's Future, 11, e2022EF003011. https://doi.org/10.1029/2022EF003011
[52] Ibid

14. Figure 15 shows the precipitation trend disaggregated by GCM over the 2020-2099. This approach allows us to discern whether there is an agreement and disagreement between GCMs separately and compute the precipitation trend over a much longer time-period. Under RCP 2.6, GCM results show statistically significant differences (increase by +5 to +15mm/yr. over the 2020-2099 period) merely in the northwest of Kenya and northeast of Uganda using NCCNor-ESM1 (member 3: low sensitivity to GHG); whereas, under RCP 8.5, large spatiotemporal differences and outcomes are produced between different GCMs. For example, while MOHC-HadGEM2-ES (member 1: high sensitivity to GHG) and MPI-M-MPI-ESM-LR (member 2: medium sensitivity to GHG) project a statistically significant increase in total annual rainfall over Uganda, NCCNor-ESM1 projects a slight decrease under RCP 8.5. However, under RCP 8.5, all GCMs agree on an increase in total annual precipitation (ranging between 0 to +15mm/yr.) over Kenya and Uganda and a decrease (ranging between 0 to -10mm/yr.) in Tanzania's southeast and southwest crescent. These results are aligned with literature, showing a significant increasing trend (up to +12 mm/yr.) in Kenya and Uganda by 2050 and 2080 under SSP5-8.5 (Gebrechorkos et al. 2023[53]).

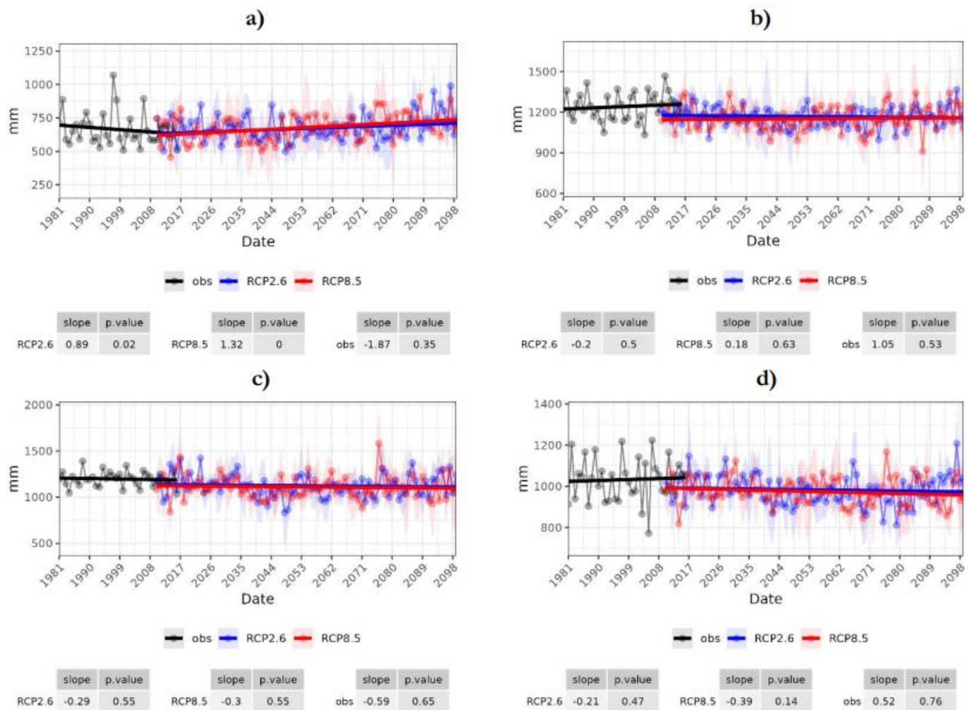


Figure 14: . Total annual rainfall (mm) over the 21st century from historical period (1981-2016) in (a) Kenya, (b) Rwanda, (c) Uganda, and (d) Tanzania

[53] Ibid

For future simulations, the significance of trends is calculated on a multi-model ensemble mean of 3 bias-corrected GCMs downscaled with REMO2015.

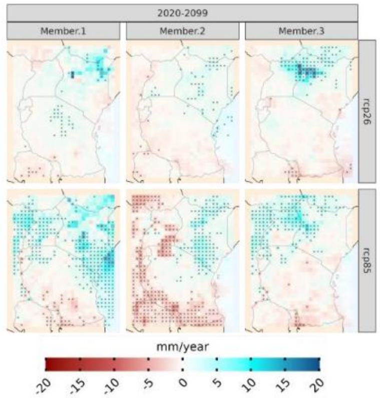


Figure 15: A linear regression is applied through residual resampling on total annual rainfall for each climate model (3 GCMs downscaled with REMO2015) over the 2020-2099 for RCPs 2.6 and 8.5

The black dot indicates the statistical significance of linear trends. The intensity of colour within the pixel indicates the degree of change.

1.3.1 Temperature

15. *Mean maximum temperatures*. While mean daily maximum temperatures (hereafter "mean Tmax") may reach its highest increase in the midterm (2040-2069) under RCP 2.6; conversely, under RCP 8.5, the highest mean Tmax is expected by the end-century (2070-2099) (Figure 16). In both RCPs, the rate of increase is lower (1 to 2ºC depending on the RCP) towards the ocean because water can hold much more heat than the air and, consequently, water takes more time to warm up than the air. Therefore, the coastline of Kenya and Tanzania may experience an increase of +0.5 to +1.0ºC and +2.0 to +3.0ºC, respectively under RCPs 2.6 and 8.5 by the end-century (2070-2099) relative to the baseline period (1976-2005). Conversely, towards the central parts of East Africa, mean Tmax may increase by as much as +4.5ºC under RCP 8.5 by the end-century (2070-2099) relative to the baseline period (1976-2005). Given its relatively large size, the Lake Victoria may warm at a slower pace than its surroundings. These differences are heightened under RCP 8.5 by the end-century, showing a considerably lower rate of mean Tmax increase in the Lake Victoria than in the nearby areas. Overall, there is a strong model agreement in the sign of climate change for mean Tmax, represented with a black cross in Figure 16.

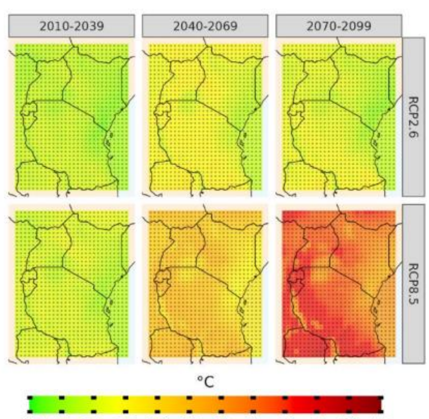


Figure 16: Climate change signal in mean daily temperatures (mean Tmax; °C) over the 21st century from historical period (1976-2005)

The black cross indicates whether at least 60% of the models agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015

16. *Mean minimum temperatures.* Figure 17 shows the mean daily minimum temperature (hereafter mean Tmin) increase in East Africa over the 2010-2099 period for RCPs 2.6 and 8.5. The spatiotemporal behaviour of mean Tmin increase over East Africa is identical to that of mean Tmax. However, the rate of change in mean Tmin is slightly higher to that of mean Tmax. Overall, mean Tmin may increase by +1.5 to +2.0ºC (RCP 2.6) and by +4.0 to +5.0ºC (RCP 8.5) towards the interior and by less than +1.5ºC (RCP 2.6) and +3.0ºC (RCP 8.5) in Tanzania's and Kenya's coastline by 2070-2099. Large water inland bodies such as the Lake Victoria are likely to warm at a slower pace (up to +1.5ºC) than the surrounding areas of Uganda, east Rwanda, and north Tanzania. As for mean Tmax, most models agree in a positive sign of the climate change signal for mean Tmin, implying a high reliability on model outputs for different time-horizons and RCPs.

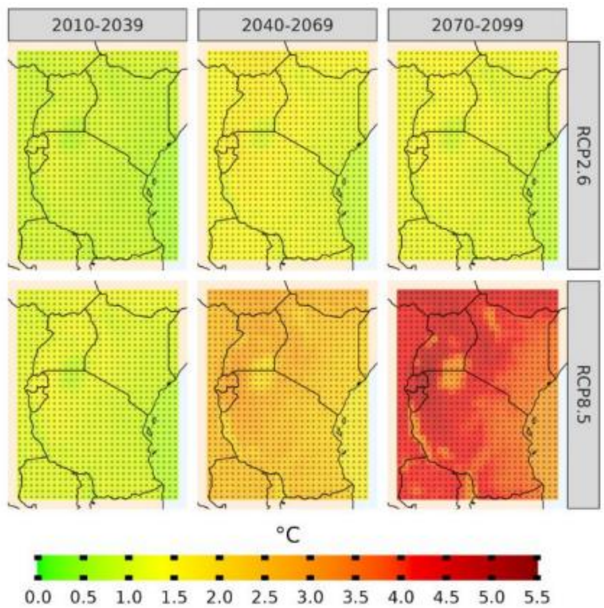


Figure 17: Climate change signal in mean annual minimum daily temperatures (mean Tmin; °C) over the 21st century from historical period (1976-2005) downscaled with REMO2015

The black cross indicates whether at least 60% of the model agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs

17. *Mean relative humidity*. Figure 18 shows the changes in mean daily relative humidity (hereafter mean RH) over the century for RCPs 2.6 and 8.5. Projections show an increase in mean RH on annual average (+2%) along Kenya and Lake Victoria by the end-century (2070-2100) for RCPs 2.6 and 8.5. On the contrary, under RCP 8.5, a notable decline in mean RH on annual average (-2 to -8%) is projected along central parts of Tanzania, heightened towards the south by the end-century. On the contrary, mean RH along the Lake Victoria might continue to increase (+2%) by the end-century, largely because warming temperatures may result in high levels of evaporation from the Lake Victoria under RCP 8.5.

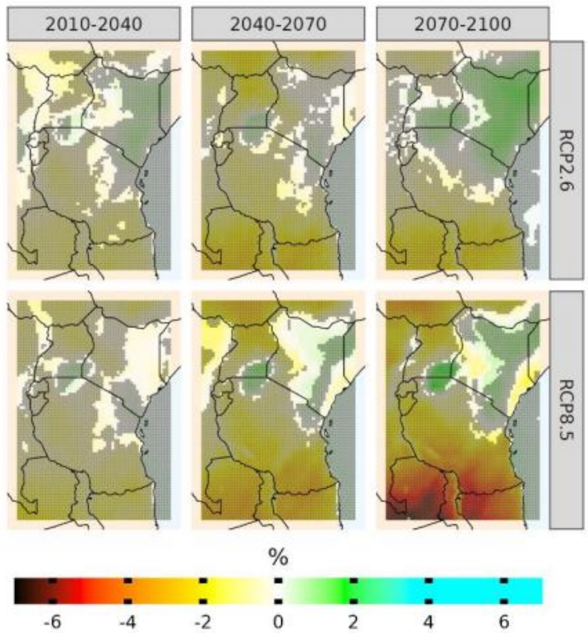


Figure 18: Climate change signal in mean annual daily relative humidity (RH; %) over the 21st century from historical period (1976-2005)

The black cross indicates whether at least 60% of the model agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015.

1.3.2 Extreme weather events

18. *Dry-spells and extreme precipitation*. As described by Rojas et al. (2019[54]), the time of emergence is defined as the moment when the magnitude of the ensemble mean precipitation change becomes greater than the uncertainty due to the noise and natural variability. Although not the only relevant climatic variable, precipitation variability also plays a significant role in the agricultural and livestock sector and, therefore, it is paramount to analyze its changes over time. Figure 19 shows the changes in the emergence of number of dry days (R≤1mm/day) over the century in East Africa. Model outputs show a positive agreement in the time of emergence, slightly earlier and widespread for RCP 8.5 (2030-2050) compared to RCP 2.6 (2040-2060). The positive change (increase in the number of dry days) is general across East Africa, particularly towards west Kenya, the entire Uganda and Rwanda, and most parts of Tanzania. Conversely, the time of emergence for negative values (reduction in number of dry days) is foreseen by 2060 onwards for RCP 8.5 and slightly earlier for RCP 2.6, essentially in east and south Kenya.

[54] Rojas, M. et al. (2019). Emergence of robust precipitation changes across crop production areas in the 21st century. Proceedings of the National Academy of Sciences, 116(14), 6673-6678.

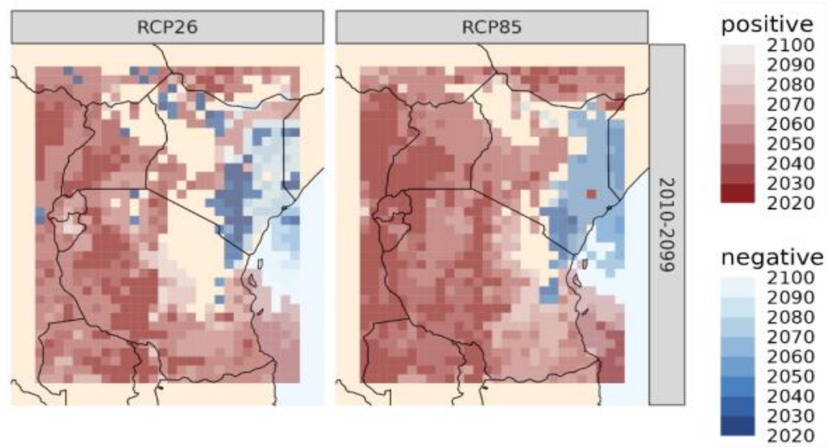


Figure 19: Time of emergence for the number of dry days (R≤1mm/day) over the 21st century. For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015

19. In addition, to complement Figure 19, Figure 20 shows the climate change signal in the number of dry days (R≤1mm/day) on annual average over the century. There is a high model agreement in the climate change signal for both RCPs. While the number of dry days (R≤1mm/day) is expected to increase by +5 (RCP 2.6) to +25 days (RCP 8.5) by the mid-century (2040-2069) along west Kenya, across Uganda and Rwanda, and most parts of Tanzania, these changes are heightened under RCP 8.5 by the end-century (2070-2099). For example, the Lake Victoria and surrounding areas may experience an increase of +30 to +40 days on annual average, while southwest Tanzania show an increase of +25 to +35 days by the end-century under RCP 8.5. On the contrary, east Kenya is the only area, among those in study, likely to experience a decrease in the number of dry days, essentially under RCP 2.6 by the end-century. In the former climate scenario, climate models agree on a decrease (-5 to -10 days) in the number of dry days on annual average by the end-century in east Kenya.

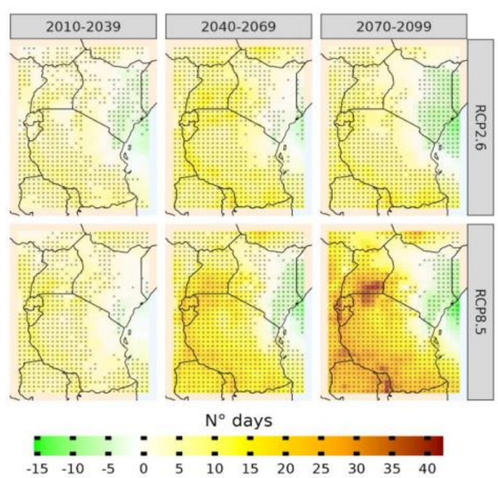


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Figure 20: Climate change signal in the number of dry days (R≤1mm/day) on annual average over the 21st century from historical period (1976-2005)

The black cross indicates whether at least 60% of the model agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015

20. Furthermore, the drying tendency compared to the reference period over East Africa is supported by the scientific community. For the annual reference evapotranspiration, for example, Gebrechorkos et al. (2023[55]) suggest a higher increase along south Tanzania compared to Rwanda, Kenya's north Rift Valley, and east Tanzania. These evapotranspiration analyses at regional level are complemented by SPI-3-month analysis at country level (Figure 21). Our results show a similar spatiotemporal trend in positive SPI-3, with lower SPI-3 values under RCP 8.5 compared to RCP 2.6, implying lower number of wet-years in RCP 8.5 in all countries and across the century. For negative SPI-3 values (dry periods), negative trends are heightened in Rwanda, Uganda, and Tanzania, but not in Kenya by the end-century in RCP 8.5 compared to RCP 2.6. In Rwanda, Uganda, and Tanzania SPI and, thus, standard deviation increases for both positive and negative SPI values under RCP 8.5 over time, implying that precipitation values are increasingly more dispersed from the mean. Overall, future SPI-3-month values are consistent with historical SPI-3-month values, ranging between +0.5 and -0.5. However, SPI-3-month anomaly analysis reveals noteworthy drought (wetness) events during the mid-future (far-future) in SSP3-7.0 and SSP5-8.5 scenarios relative to the baseline period (1985-2015) (Ayugi et al. 2022[56]). In-depth analysis at sub-national level suggests an increase in positive SPI-3 (wetter periods), displaying a strong relationship with latitude and, thus, being highest towards the north of Kenya and Uganda, while lowest in south Tanzania. Lastly, strong evidence of severe drought events (SPI -1.5) is projected across the entire domain under SSP3-7.0 and SSP5-8.5 during the mid-century (Ayugi et al. 2022[57]).

[55] Gebrechorkos, S. et al. (2019). Long-term trends in rainfall and temperature using high-resolution climate datasets in East Africa. Scientific reports, 9(1), 11376.
[56] Ayugi, B. et al. (2022). Projected changes in meteorological drought over East Africa inferred from bias-adjusted CMIP6 models. Natural Hazards, 113(2), 1151-1176.
[57] Ibid

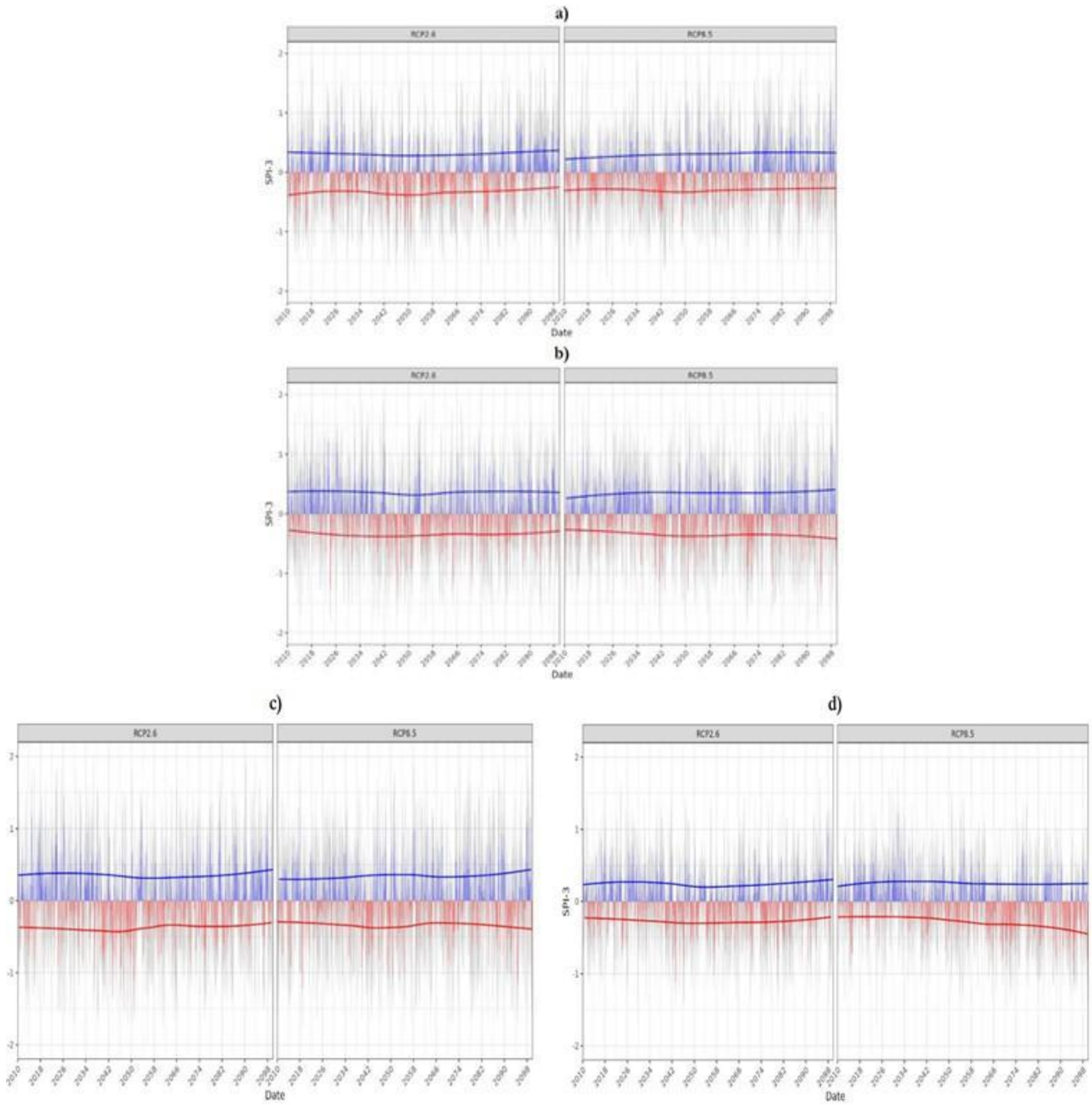

Figure 21: Spatiotemporal analysis of SPI-3-month over the century under RCPs 2.6 and 8.5 in (a) Kenya, (b) Rwanda,(c) Uganda and (d)Tanzania

21. Most of the increase in very wet days (R≥20mm/day) is anticipated in southwest Kenya under RCP 2.6 where there might be an extra 1 to 2 very wet days on annual average by the end-century (2070-2099) (Figure 22). For RCP 8.5, the increase in very wet days is widespread over Uganda, Rwanda, Tanzania, and southwest Kenya. Besides of having a high model agreement, the increase in the former areas is notable, ranging between 2 to 6 additional very wet days on annual average by the end-century (2070-2099) under RCP 8.5. This increase is substantial because the entire East Africa received less than 20 very wet days (R≥20mm/day) on annual average during the 1981-2017 period (Ojara et al. 2021[58]). Conversely, a non-statistically significant different decrease (-2 to -4 days) in number of wet days is expected along the Lake Victoria and southeast Tanzania over time under both RCPs. Even though the number of heavy rainfall events (R≥20mm/day) may decrease over the Lake Victoria, noteworthy the increase in extreme rainfall events (R≥50mm/day) over the century, especially under RCP 8.5 where projections show an increase in extreme rainfall (+6 to +7 days on annual average) (Figure 23). These results are aligned with literature, showing an increase of about +5 days on very intense precipitation (99th percentile) in the future (2071-2099) relative to the baseline period (1977-2005) under RCP 8.5, particularly along the Lake Victoria (Ogega et al. 2020[59]).

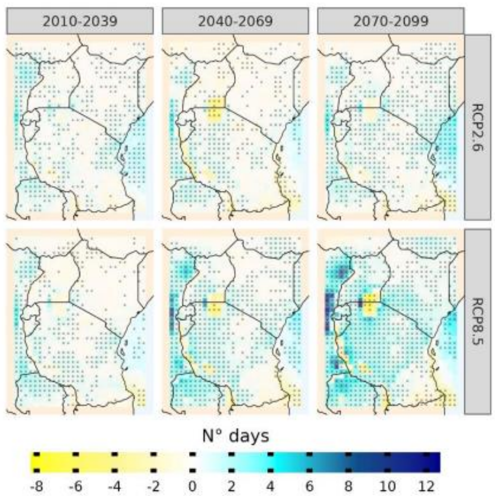

Figure 22: Climate change signal in the number of heavy rainfall events (R≥20mm/day) on annual average over the 21st century from historical period (1976-2005)

The black cross indicates whether at least 60% of the model agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015.

[58] Ojara, M. A. et al. (2021). Trends and zonal variability of extreme rainfall events over East Africa during 1960–2017. Natural Hazards, 109(1), 33-61.

[59] Ogega, O. M. et al. (2020). Heavy precipitation events over East Africa in a changing climate: results from CORDEX RCMs. Climate Dynamics, 55(3-4), 993-1009.

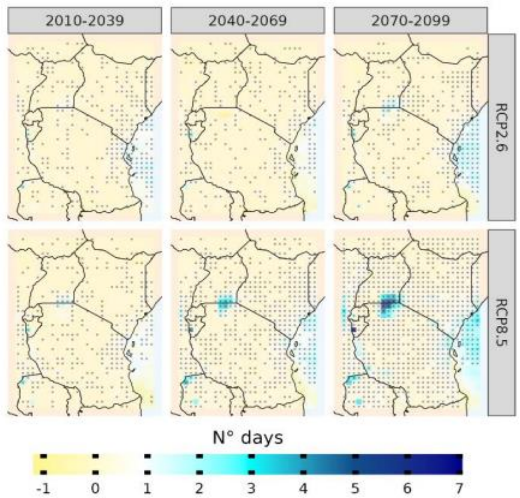

Figure 23: Climate change signal in the number of extreme rainfall events (R≥50mm/day) on annual average over the 21st century from historical period (1976-2005)

The black cross indicates whether at least 60% of the model agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015.

22. *Extreme temperatures*. Other relevant climatic extreme indices, such as very warm days (Tmax ≥35ºC), may gain in frequency and intensity in a warmer global climate (Figure 24). Under the low emission scenario (RCP 2.6), for example, an additional +25 to +75 very warm days on annual average are expected in Uganda, Kenya's Rift Valley, and central Tanzania in the mid-term (2040-2069). Most of the increase in very warm days is projected by the end-century (2070-2099) under RCP 8.5, showing an increase ranging between +100 to +200 additional very warm days on annual average compared to the baseline period (1981-2010). On the contrary, the cooling effect of large water bodies, including the Lake Victoria and the Indian Ocean, may substantially modulate the increasing trend in very warm days over time.

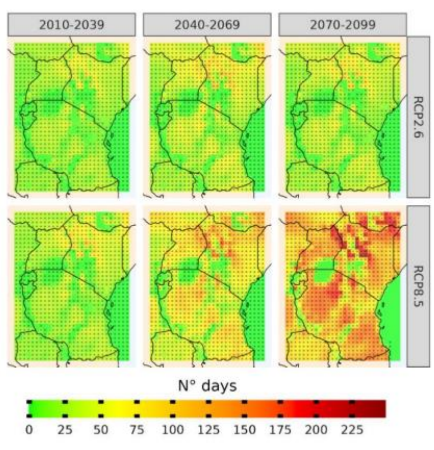

Figure 24: Climate change signal in the number of very warm days (Tmax≥35°C) on annual average over the 21st century from historical period (1976-2005)

The black cross indicates whether at least 60% of the model agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015

23. Figure 25 displays large spatial differences in the rate of change in tropical nighttime conditions (Tmin ≥20ºC), particularly under RCP 8.5 and, to a minor extent, in RCP 2.6 by the end-century (2070-2099). The highest rate of increase is reported in Uganda and Tanzania where the number of tropical nighttime conditions may increase by more than +200 days on annual average by the end-century (2070-2099) in RCP 8.5. The reason behind such an increase in Uganda and Tanzania is because these areas experienced less than 50 days on annual average in the baseline period (1981-2016) and, thus, are more likely to display a significant increasing trend under a much warmer climate compared to areas along Kenya's coastline and north Rift Valley that have recorded more than 250 days with tropical nighttime conditions in the baseline period (as reported in Figure 25, past climate).

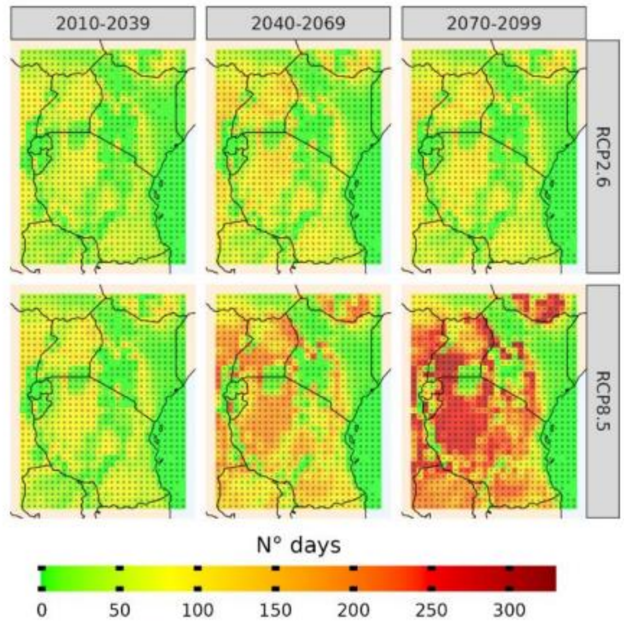

Figure 25: Climate change signal in the number of days with tropical nighttime conditions (Tmin≥20°C) on annual average over the 21st century from historical period (1976-2005)

The black cross indicates whether at least 60% of the model agree in the sign of the climate change signal (positive or negative). For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015

1.4 CLIMATE EXPOSURE

24. According to the Centre for Research on the Epidemiology of Disasters (CRED) database, a total of 95 million people in East Africa have been affected by meteorological (storms), hydrological (floods and landslides), and climatological (droughts) disasters between 1971 and 2023. A total of 248 disasters have occurred since 1971, of which 69% and 17% are flood and drought-related, respectively. Kenya has recorded the highest number of disasters (78), followed by Tanzania (70), Uganda (60), and Rwanda (40) (Figure 26). The number of disasters has exponentially increased over time. While the number of disasters amounted to 28 over the 1971-1990 period, the number of disasters has risen to 174 over the 2001-2020 period. Flood is the disaster increasing the most over time, followed by drought and landslides.

25. Furthermore, while flood is the most recurrent and deadliest disaster, drought tends to affect the highest number of people (Figure 26). Since 1971, a total of 8010 casualties have been reported along the targeted countries, of which 49% have been attributed to floods and 39% to drought. However, since 2001, the number of weather-related casualties has experienced a notable increase, reporting 6514 casualties over the 2001-2023 period. The deadliest natural disaster is the drought-induced famine in Uganda (2465 casualties), making it the second deadliest event in 2022 after the European heatwaves (CRED, 2022[60]). Overall, 88% of the people affected along the targeted countries is affected by drought (approximately 83.5 million), mostly in Kenya where drought has affected 59 million people since 1971.

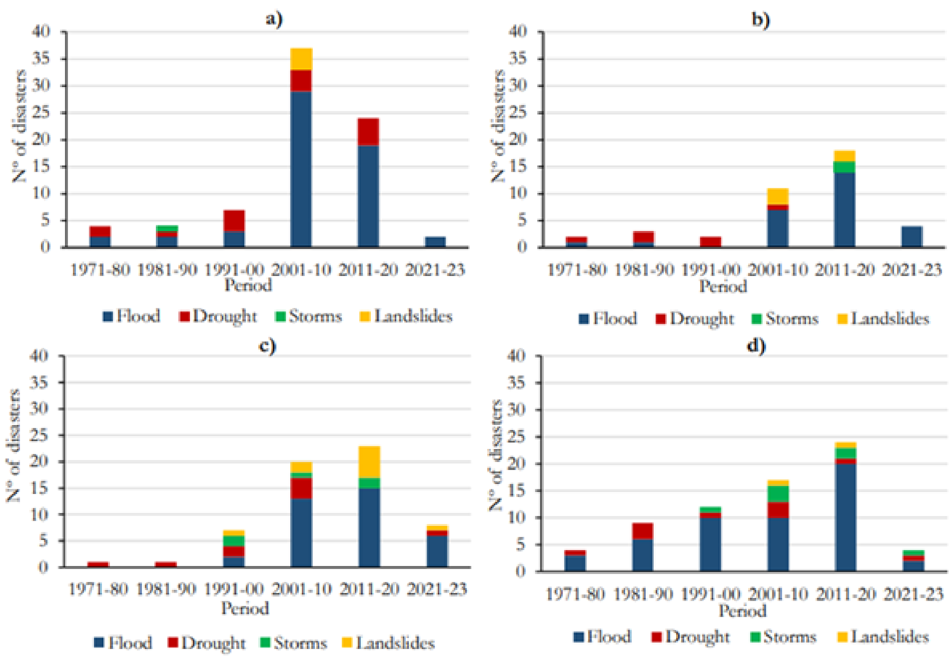

Figure 26: Number of disasters (disaggregated by hazard type) observed in (a) Kenya, (b) Rwanda, (c) Uganda and (d) Tanzania from 1971 until 2023. Prepared using the CRED database

[60] CRED. (2023). 2022 Disasters in Numbers. Available at: link

26. Drought and flooding events in East Africa have exposed the layers of poverty, underdevelopment, and political marginalization in the region's arid and semi-arid lands inhabited by pastoral communities. As a result, East Africa has been the primary focus of various drought studies in recent years. Studies reveal that droughts tend to be more frequent, longer, and more severe in the boreal spring and summer in East Africa, as the overall precipitation and water storage declines. On the contrary, a decrease in drought frequency is observed during the boreal autumn season (October-November) (Haile et al. 2019[61]).

27. Figure 27 shows the historical drought frequency for pastureland's season 1 and 2 over the 1984-2020 period in East Africa using data from FAOs Agricultural Stress Index System (ASIS). Historical satellite observations indicate that vast areas of Kenya have experienced severe drought (30% of the pastureland) on regular basis (once every three years) in seasons 1 and 2 over the 1984-2020 period. Mara and Arusha regions in Tanzania also show a high drought frequency, exceeding 15% in seasons 1 and 2 over the 1984-2020 period. The rest of the pastureland in Tanzania, Uganda, and Rwanda has been less prone to severe droughts, with less than 10% of the years affected by severe drought (>30% of pastureland). To support our analysis, 28a shows the annual physical exposition to drought based on: (i) a global monthly gridded precipitation dataset obtained from CRU, (ii) a GIS modelling of global SPI based on Brad Lyon (IRI, Columbia University) methodology, (iii) a population grid for the year 2010, provided by LandScanTM Global Population Database. The results indicate a higher number of people physically exposed (over 1000 people every 25km^2) on annual average to drought in areas bordering the Lake Victoria, as well as in Rwanda where the population density is highest (100 to 250 and >250 people/km^2, respectively). The exposure to drought also extends to southwest Kenya, particularly along the cities of Kisumu, Nakuru and Nairobi. On the other hand, the population exposure to drought is lowest (less than 10 people every 25km^2) in Kizigo, Rungwa, and Usungu Game Reserve (Tanzania), and in the north and east of Kenya where population density is lowest.

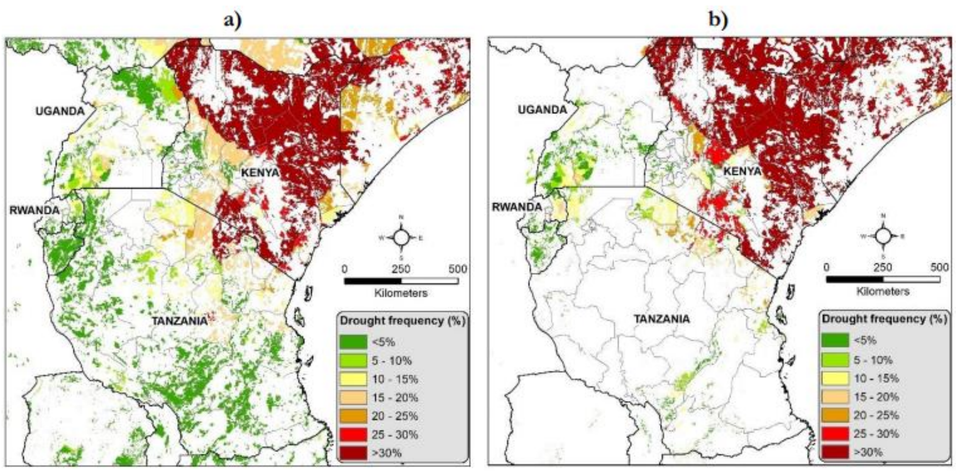

Figure 27: Historical drought frequency (%) over the 1984-2020

The map shows the frequency of severe drought in the areas where 30% of the pastureland has been affected by drought in season 1 (a) and season 2 (b). The maps have been prepared using data from FAOs Agricultural Stress Index System (ASIS)

[61] Haile, G.et al.(2019). Droughts in East Africa: Causes, impacts and resilience. Earth-science reviews, 193, 146-161.

28. The future changes in drought under different climate scenarios is described in Table 1**: Projected changes (%) in drought in East Africa according to Haile et al (2020)**. Haile et al. (2020)[62] show that the drought area in East Africa is going to increase, with the areas affected by extreme drought increasing more rapidly than severe and moderate droughts, particularly under RCP 8.5. For example, by the end-century (2080s), severe droughts are expected to increase by 13.5% whereas moderate drought is likely to rise by 11.6% under RCP 8.5. The number of drought events is also expected to gain in frequency for all climate scenarios, particularly in the mid and end-century.

Table 1: Projected changes (%) in drought in East Africa according to

	RCP 2.6			RCP 4.5			RCP 8.5		
	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s
Projected change in drought area (%)	9	17	16	7.7	22	36	14.5	41.5	39
Change in moderate drought (%)	7.5	12	12	6	13	17	10	17	11.6
Change in severe drought (%)	1.4	3.8	3.5	1.4	6	11	3.4	12.3	13.5
Number of drought events	3	4	4	2	4	5	3	5	3

29. Floods are one of the most common and severe natural hazards in East Africa, driven by climate variability and anthropogenic factors. According to a search of literature of more than 34 research papers, the physical and sociocultural environment have the highest number of identified anthropogenic factors accountable for floods (Balikuddembe et al. 2023[63]). While some of the physical environment factors (out of the nine human induced flood factors) include: (i) inadequate and poor maintenance of drainage systems, (ii) proximity of roads, houses, and other infrastructure to floodplains, (iii) lack of flood proof infrastructure, (iv) shape, size or capacity of dams, levees and embankments to floods, (v) inadequate or non-compliant urban and physical planning, among others; the major sociocultural factors (out of the eight anthropogenic factors attributed to varying sociocultural dynamics) include: (i) low flood risk perception and resilience, (ii) socioeconomic vulnerability, (iii) reliance on flood-induced economic activities, (iv) traditional norms, beliefs and practices, e.g., grass burning in nomadic communities, (v) population growth, (vi) land ownership, and legal or regulatory and governance policies, among others. These anthropogenic drivers of floods are diverse, multifaceted, and interrelated that have contributed to floods before and during their reoccurrences between 1990 and 2021.

[62] Haile, G. et al. (2020). Projected Impacts of Climate Change on Drought Patterns Over East Africa. Earth's Future, 8(7).
[63] Balikuddembe, J. et al. (2023). A Haddon matrix-based analysis of the anthropogenic drivers of floods in 10 Eastern African partner countries of the Belt and Road Initiative 1990–2021. International Journal of Disaster Risk Reduction, 92, 103683.

30. The compounded effect of exposure and people affected by flood on annual average along the targeted countries, based on a probabilistic regional flood risk assessment developed for the Horn of Africa Partnership for Early Warning and Early Action, is displayed in Figure 28. Estimated number of people exposed to drought (b) and number of people affected/administrative boundary by flooding in Kenya, Uganda, Rwanda, and Tanzania. The areas in East Africa with highest number of people affected by flood are in Uganda, particularly in the Northern, the Eastern, and Central regions following the course of the White Nile River. In these regions of Uganda, the number of people affected on annual basis is in the range of 10000 to 25000 people/administrative boundary, increasing up to 36000 people/administrative boundary in the Northern region of Uganda. In Tanzania, the provinces of Tanga, Morogoro, and Pwani have the highest number of people affected by floods (10000 to 25000 people/administrative boundary) on annual average. On the contrary, central parts of Kenya record the lowest number of people affected by flood on annual basis (less than 100 people/administrative boundary). The number of people exposed to floods along the White River Nile is likely to increase because of rising population and increasing number of very heavy rainfall (R≥50mm/day) in Lake Victoria under RCP 8.5, as displayed in Figure 28. Lastly, the research literature suggests that, while East African pastoralists have been able to track climate variability very well in the past, their strategies based on centuries of exposure to intra and inter-annual droughts and to floods, are not working now, partially due to their incapacity to implement coping strategies (Galvin et al. 2004[64]).

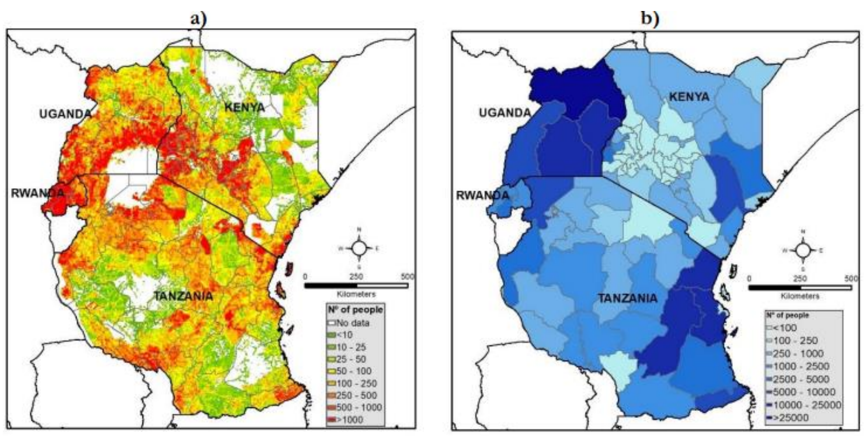

Figure 28: Estimated number of people exposed to drought (b) and number of people per affected/administrative boundary affected by flooding in Kenya, Uganda, Rwanda, and Tanzania

1.5 CLIMATE VULNERABILITY

The main causes of vulnerability in dairy sector in East Africa are:

31. *Climate variability and climate change*. According to historical records, the region is subjected to high climate variability. This is largely due to the key drivers of climate in the region. The swings from drought years to floods is unpredictable and this variability is projected to increase. Climate change induces changes such as unpredictable weather patterns, prolonged droughts, and increased incidences of extreme weather events may lead to water scarcity, reduced pasture availability, and increased vulnerability and exposure to diseases, ultimately affecting the productivity and health of dairy animals.

[64] Galvin, K. A.et al.(2004). Climate variability and impacts on East African livestock herders: the Maasai of Ngorongoro Conservation Area, Tanzania. African Journal of Range and Forage Science, 21(3), 183-189.

32. *Rangelands and ecosystems degradation.* Feed availability depend on rangelands, which are degraded in some areas of the region. The degraded land represents 27 percent of total rangelands areas in Tanzania, 3.6 percent in Kenya, and 2.1 percent each in Uganda and Rwanda. Main factor leading to rangelands and pasture degradation include soil structure and erodibility, climate (rainfall intensity and temperature), reduction in land vegetation cover and topography (influencing capacity of run-off). Degradation prevent rangelands from delivering ecosystem services such as *provisioning* (production of above ground biomass, such as grass) and *regulating* (such as the capacity of grasslands and rangelands to sequester carbon in the soils[65]), besides negatively impacting the productivity and quality of the pasture, and therefore the livestock numbers and productivity.

33. *Land tenure*. In Kenya, Tanzania and Uganda, the main risk for intensive/zero-grazing is tenure insecurity, i.e. occupancy rights or land ownership. Access to natural capital, more particularly women's ownership, management and control of land and land-based resources are key barriers to sustainability, and adoption of climate resilient and low-carbon practices.

34. *Limited access to credit and financial services.* Dairy farming requires significant investment in infrastructure, animal health, and feed. Many small-scale dairy pastoralists face challenges in accessing credit and financial services to expand their operations and improve their productivity. This restricts their ability to invest in modern equipment, infrastructure, and improved animal husbandry practices.

35. *Inadequate knowledge and skills*. Many dairy farmers in East Africa have limited access to agricultural extension services and training programs. This knowledge gap prevents pastoralists from adopting modern and sustainable practices in dairy management, including proper feeding, breeding, and disease control. Limited knowledge on improved techniques and technologies hinders pastoralists' productivity and profitability. Technology adoption factors have positive and statistically significant effects on the level of livestock efficiency (Gelan & Muriithi, 2012[66])

[65] Sub-Saharan Africa has been estimated to have the highest potential for soil carbon storage (0.41 tC/ha/yr) compared to other regions of the world . The potential annual increase is estimated at 0.57, 0.53, 0.52, and 0.51tC/ha/yr, respectively, for Kenya, Tanzania, Rwanda, and Uganda

[66] A. Gelan & B.W. Muriithi, 2012. "Measuring and explaining technical efficiency of dairy farms: a case study of smallholder farms in East Africa," Agrekon, Taylor & Francis Journals, vol. 51(2), pages 53-74.

36. *Limited access to quality inputs*. Small-scale dairy farmers in East Africa often face challenges in accessing quality animal feed, veterinary services, and breeding stocks. Poor-quality feed results in inadequate nutrition for the animals, leading to low milk production, and increased susceptibility to diseases. Because of limited veterinary services, pastoralists prefer local or cross-bred animals that are not as high yielding because improved exotic breeds are highly susceptible to local diseases. Limited access to improved breeds also hampers genetic progress and milk productivity.

37. *Frequent disease outbreaks*. East Africa is prone to outbreaks of livestock diseases such as foot-and-mouth disease, mastitis, and east coast fever. These diseases lead to high mortality rates, reduce milk production, and increase veterinary expenses. Frequent movements of livestock in search of pastures and water combined with trade movements lead to herd mixing. Poor disease control measures, inadequate quarantine facilities, and limited veterinary services increases the vulnerability of dairy farming to disease outbreaks.

38. *Poor infrastructure*. Inadequate infrastructure, such as water harvesting, roads and electricity are a challenge for dairy farmers in East Africa. Poor roads difficult the transportation of milk from farms to markets, leading to milk spoilage and increased losses. Electricity supply in most areas is erratic affecting the milk processing and storage capabilities.

39. *Market volatility and price fluctuations*. Dairy farmers in East Africa often face challenges related to market volatility and price fluctuations. Bulkers and processors mostly determine milk price and do not often favour the farmers. Fluctuations in milk prices due to seasonality, inadequate market linkages, and lack of price transparency can negatively affect pastoralists' morale, incomes, and profitability. Limited access to processing facilities and value addition options further limits the pastoralists' ability to capture higher-value markets.

40. In addition, climate change has the potential to significantly impact food security in vulnerable areas, particularly in those areas already facing food insecurity. The Integrated Food Security Phase Classification (IPC) is a widely used tool for classifying and monitoring the severity of food insecurity in different regions. Some of the key drivers of food insecurity in vulnerable areas of East Africa include:

41. *Decreased agricultural productivity*. Climate change can disrupt agricultural systems through changes in rainfall patterns, increased frequency of extreme weather events (such as droughts, floods, and storms), rising temperatures, and shifts in growing seasons. These factors can lead to reduced crop yields, increased livestock losses, and diminished access to water for irrigation, thus aggravating food insecurity in already affected areas.

42. *Loss of natural resources*. Climate change can cause the degradation and loss of natural resources that are crucial for food production, such as fertile soils, freshwater sources, and biodiversity. This loss can further exacerbate food insecurity as it reduces the availability and quality of agricultural inputs.

Table 2: Vulnerability of pastoral, mixed crop animal systems and intensive dairy systems in East Africa

Pastoral systems	Mixed crop livestock systems	Intensive dairy systems
▪ Loss of grazing lands due to land use changes, including artisanal mining. ▪ Land degradation. ▪ Poor financial capital and alternative livelihoods. ▪ Land grabbing. ▪ Conflict over scarce natural resources. ▪ Difficulties associated to tracking animals.	▪ Limited mobility. ▪ Land fragmentation leading to small land sizes. ▪ Soil exhaustion and acidification due to repeated cropping. ▪ Reliance on youth labor. ▪ Limited irrigation due to land size.	▪ Energy intensive especially in mechanization housing and climate control. ▪ Labor and capital intensive. ▪ Large high value of animals that are more susceptible to heat stress and diseases.

43. *Increased food prices*. Climate change impacts on livestock production can contribute to regional food price volatility. In food insecurity areas, where vulnerable populations are already struggling to afford highly nutritious food, rising food prices can limit access to essential dietary requirements, leading to malnutrition and rising food insecurity levels.

44. *Disruption of livelihoods*. In areas heavily dependent on agriculture, climate change-related impacts can disrupt livelihoods. Climate-related shocks and stresses can diminish income-generating opportunities, increase debt burdens, and displace people from their traditional livestock activities, thereby intensifying food insecurity.

45. *Impacts on water availability*. Climate change affects water resources, with changes in precipitation patterns leading to water scarcity or excessive water supply in different regions. In food insecurity areas, limited access to safe and reliable water resources can hinder livestock production, contributing to food insecurity and increased vulnerability to waterborne diseases.

46. *Human displacement and conflicts*. Climate change can be a driver of human displacement, as people are forced to leave their homes in search of better job opportunities. Displaced populations often face increased vulnerability to food insecurity, as they lose their livelihoods, assets, and social support networks. Moreover, competition over scarce resources, including land and water, can lead to conflicts between pastoralists and farmers and, consequently, exacerbate food insecurity.

1.6 ADAPTIVE CAPACITY

47. In the 5th assessment report of IPCC, i.e., the IPCC 2014 report, adaptation is defined as "the process of adjustment to actual or expected climate and its effects in order to either lessen or avoid harm or exploit beneficial opportunities" (IPCC, 2014[67]). In the 6th assessment report of IPCC, a distinction of the adaptation concept has been made between human systems and natural systems. For human systems, adaptation implies adjustments not only to actual climatic impacts but also to expectations of future climate change to avert potential harm. For nature systems, adaptation only means "the process of adjustment to actual climate and its effects" after a certain climatic event has already happened or is happening (O'Neill et al., 2022[68]). Human systems need planned "adaptation", which aims at the consideration of possible climate risks in the future and the consequential anticipatory planning for proper infrastructure and ecosystem resources management to better prepare for potential future climate risks (Cimato and Watkiss, 2018[69]).

48. The adaptation strategies adopted most frequently in pastoral, mixed crop animal systems and intensive dairy systems in the target countries (Table 3) are geared directly at husbandry practices and the maintenance of acceptable yields through measures such as crop management and diversification.

Table 3: Adaptive capacity of pastoral, mixed crop animal systems and intensive dairy systems in East Africa

Pastoral systems	Mixed crop livestock systems	Intensive dairy systems
Mobility of animals which supports pastoralists adjust to spatial and temporal climate variability. Land communal land.	Opportunity to practice circular production/recycling nutrients across the farm. Capacity to use crop residues for fodder.	▪ Easy access to finance. ▪ Economies of scale. ▪ Renders itself to mechanization. ▪ Opportunity for feed production under irrigation.

[67] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp

[68] O'Neill et al., 2022 B.C. O'Neill, M. van Aalst, Z. Zaiton Ibrahim, L. Berrang-Ford, S. Bhadwal, H. Buhaug, D. Diaz, K. Frieler, M. Garschagen, A.K. Magnan, G. Midgley, A. Mirzabaev, A. Thomas, R. Warren Key Risks across Sectors and Regions Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland (2022)

[69] Cimato, Federica; Watkiss, Paul 2018 Overcoming the barriers to climate change adaptation
Climate and Development Knowledge Network. Future Climate For Africa www.futureclimateafrica.org

Indigenous knowledge of breeds and management of pasture. Indigenous breeds that are adapted to the environment and resistant to diseases.	Diversification of income	▪ Possible to modify microclimate. ▪ Good tracking of individual animals.

49. In participating countries, Governments have established policies and institutional frameworks to support adaptation to climate change. These policies and institutional frameworks are at different stages of implementation or operationalization. Among these are:

50. *Weather and climate services* and products are important instruments to strengthen the adaptive capacity, and an essential pillar within the range of measures available to reduce climate risks, support livelihoods, protect assets and improve food security and nutrition. Despite increased recognition of climate services as an important element in the climate change adaptation agenda, there is a gap on ensuring that climate services are user-centred and scaling up investments to bridge the last mile barrier.

51. Livestock *early warning systems* aim to deliver precise information in a timely manner about possible dangers and threats to the livestock sector and to the pastoral communities. These systems monitor important indicators and issue early warnings using a variety of data sources and technologies, empowering communities, and stakeholders to take preventative action to reduce risks and save livestock-based livelihoods. An Early Warning System can also be used to enable the timing of forage planting or rangeland restoration activities that can be adjusted to improve their performance if coupled with Desert Locust Monitoring in East-Africa can also lead to early harvest of forage and forage crops. However, the effect of an Early Warning System might depend on the actions taken by actors in response to the information provided. Livestock Early Warning Systems in east Africa include:

1. Long-and short-range weather forecasting and weather advisories issued by the National Meteorological and Hydrological Service (NMHSs) and the Inter-Governmental Authority on Development (IGAD) Climate Prediction and Applications Center (ICPAC)

- Greater Horn of Africa Climate Outlook Forum (GHACOF) reflects the performance and impacts of the following season, presents the consolidated objective of regional climate outlooks for the next season, and provides regional interaction platforms for decision makers, climate scientists, users of climate information, among others.

2. Forecasting African Storms Application (FASTA) is an early warning system produced and delivered by Kenya Meteorological Department (KMD) and an early warning bulletin produced and delivered by the National Disaster Management Authority in Kenya.

- Animal Feed Inventory and Balance Sheet (AFBS) under the National Feed Security System (NAFSS).
- East Africa Hazards Watch supports the tracking of extreme weather events such as drought, cyclones, pests (desert locust), heavy rainfall, floods, or crop failures. It also includes a rangeland monitoring system that shows warnings about low or delated vegetation performance at a given region. Forage availability forecasts are also available at seasonal basis.
- ICPAC Warning Explorer is based on near-real-time earth observations and weather information and provides automatic 10-day drought conditions warnings for crops and rangelands at the provincial level.
- Pictorial Evaluation Tool (PET) improves the quality and speed of assessments of crop and forage yields and livestock body conditions.
- FAOs Predictive Livestock Early Warning Information System (PLEWS) uses normalized difference vegetation index data and models' it against edible vegetation (based on high resolution satellite imagery and ground truthing), surface water availability and past data.

- FAOs Rift Valley Fever (RVF) Early Warning System uses near-real-time climate and environmental data from satellites and remote sensing tools to provide decision-makers and health officials with timely RVF risks maps. This enables prevention and control of RVF outbreaks in livestock and humans, and the implementation of mitigation measures to reduce RVF impacts on the livelihoods of pastoralists and rural communities.
- FAOs Digital Services Portfolio has developed new apps bringing agricultural advisory services to farmers and pastoralists. For example, the "cure and feed your livestock app" provides real-time information on animal disease control and animal feeding strategies, besides supporting pastoralists reduce losses in assets and optimize productivity.
- Kenya's Livestock Information System provides timely, reliable, and cost-effective market information to enhance the capacity of producers and traders to anticipate and plan for their livestock business transactions.

1.7 IMPACTS OF CLIMATE CHANGE IN EAST AFRICA

52. In the section "impacts of climate change" will be looked at from development themes perspectives. This will include human health, food systems, water resources and water dependent services.

1.7.1 Impacts on agriculture

53. Climate change is negatively impacting crop and livestock agriculture in East Africa. Maize and wheat yields decreased on average 5.8% and 2.3% respectively across sub-Saharan Africa from 1974–2008, due to climate change (IPCC, 2022)[70].Climate change has slowed the growth of agricultural productivity in Africa by 34% since the 1960s, the highest impact of any region. Future warming will negatively affect food systems in Africa by shortening growing seasons and increasing water stress (high confidence) (IPCC, 2022)[71]. Global warming above 2°C will result in reduced yields of staple crops across most of Africa compared to 2005 yields, even if adaptation options are implemented (IPCC, 2022)[72]. Relative to 1986–2005, global warming of 3°C is projected to reduce labour capacity in agriculture by 30-50% in sub-Saharan Africa due to higher temperatures (IPCC, 2022)[73]

54. Climate change threatens livestock production in East Africa (high agreement, low evidence) (IPCC, 2022)[74]. This is through a combination of negative impacts on the availability and quality of animal fodder, availability of drinking water, direct heat stress on animals, the prevalence of livestock diseases and reduced availability of fodder for livestock (IPCC, 2022)[75]. Pastoral populations of East Africa confront multiple risks associated with drought and flood. In a region with diverse climates, drought is considered a normal event, and herders pursue strategies of mobility, livestock loaning, and diversification to modulate its effects. They can cope with mild droughts, but severe droughts may lead to large-scale livestock losses, diminished pasture quantity and quality, and prevalence of drought related livestock diseases such as tick-borne diseases (Huho et al. 2010[76]; Huho & Mugalavai, 2010[77]). Droughts may also impact the availability and quality of water available for rangeland pasture regeneration, feed production, drinking and hygiene within the production systems. What is not a norm for pastoral communities are prolonged floods, particularly when precipitation cycles become inverted, and the dry season rainfall largely exceeds the average annual amount.

[70] IPPC 2022 Chapter 9 Executive summary Chapter 9, Executive Summary; 9.4.5, 9.6.1, 9.8.2.
[71] IPPC 2022 Chapter 9 Executive summary
[72] IPPC 2022 Chapter 9 Chapter 9, Executive Summary; 9.8.2.
[73] IPPC 2022 Chapter 9, Executive Summary; 9.8.2
[74] IPPC 2022 Chapter 9 Executive summary 9 9.8.2.
[75] IPPC 2022 Chapter 9, Executive Summary; 9.4.5, 9.6.1, 9.8.2.
[76] Huho, J. et al. (2010). Drought severity and their effects on rural livelihoods in Laikipia district, Kenya. Journal of Geography and Regional Planning, 3(3).
[77] Huho, J. M., & Mugalavai, E. M. (2010). The Effects of Droughts on Food Security in Kenya. The International Journal of Climate Change: Impacts and Responses, 2(2).

55. Figure 29 shows the annual average number of livestock units affected by floods under projected climate conditions. Future climate conditions for the years 2050-2100 are estimated from the output of the EC-EARTH3-HR GCM (Hazeleger et al. 2012[78]) for RCP8.5 and grid resolution of 0.5° (~55 km at the Equator). This estimation is part of the results of a probabilistic regional flood risk assessment developed for the Horn of Africa Partnership for Early Warning and Early Action. For the baseline period, the annual average number of livestock units affected by floods is highest in Uganda, particularly along the Northern and the Eastern regions where more than 50000 livestock units are regularly affected by seasonal rains and consequent rising water levels of the White Nile River. The Central and Western regions of Uganda also have a high number (>20,000 units) of livestock units affected on annual basis by flood. In Kenya, the highest number of livestock units affected by flood (1000-3,000 units) are found in the east and the northwest, whereas in Tanzania along the northwest and the east (6,000-8,000 units). Under RCP 8.5, the highest number of livestock units affected by flood are expected in the same areas as for the baseline period, though with higher numbers of livestock units affected than in the baseline period. For example, in the Northern region of Uganda, the number of livestock units affected by flood is expected to exceed 65,000 units on annual average over the 2050-2100 period under RCP 8.5.

56. In addition, Figure 30 complements Figure 29 and represents the changes between the baseline and future (2050-2100) periods under RCP 8.5. While areas in green colors show a decrease in the number of livestock units affected on annual average by floods, areas in yellow, orange, and red display an increase. For example, most parts of Kenya and the north of Tanzania report an increase ranging between 0 to 1000 livestock units. These changes are heightened in the counties of Tana River and Garissa (Kenya), where the number of livestock units affected by floods on annual average might increase by 1000 to 2000 units.

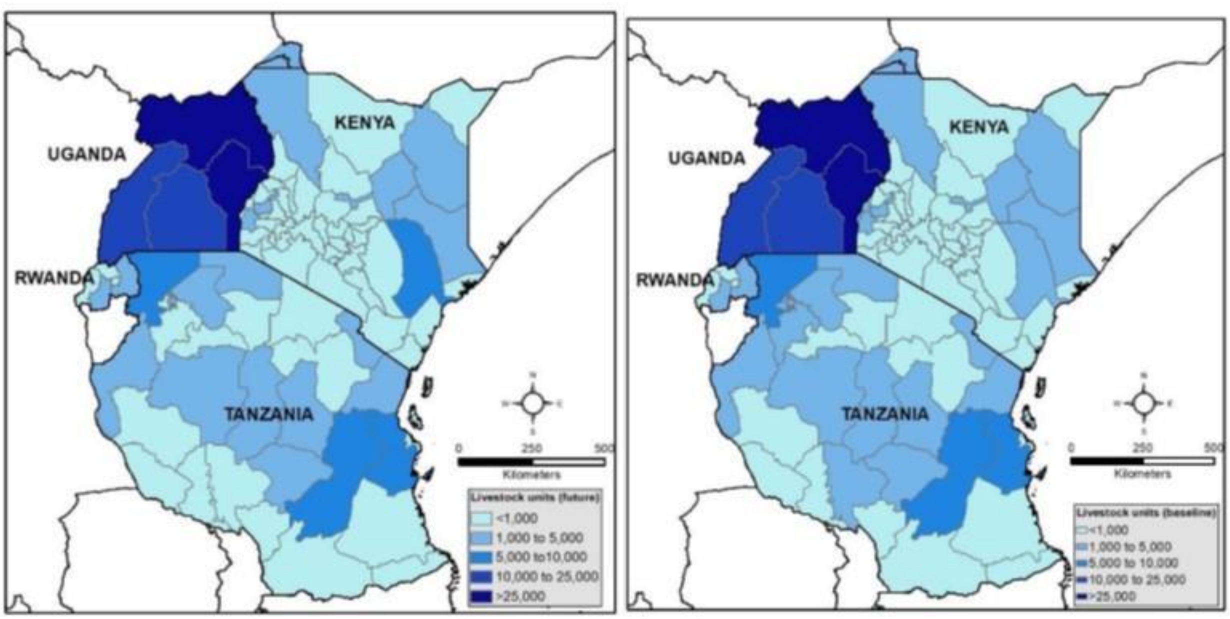

Figure 29: Number of livestock units affected on annual average by floods in the (a) baseline and (b) future (2050-2100) periods under RCP 8.5

[78] Hazeleger, W. et al. (2012). EC-Earth V2. 2: description and validation of a new seamless earth system prediction model. Climate dynamics, 39, 2611-2629.

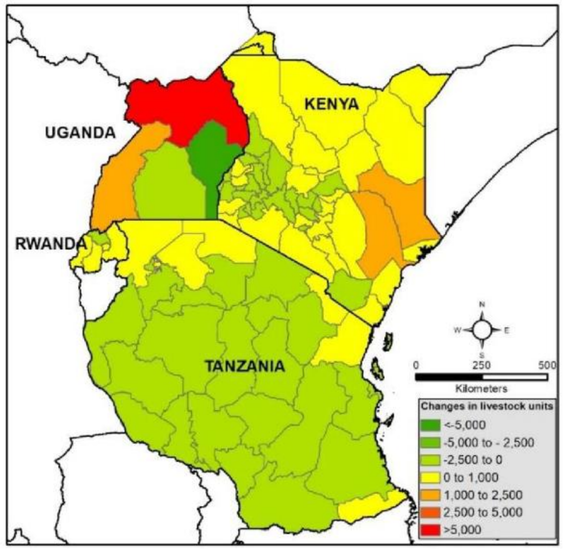

Figure 30: Changes in the number of livestock units affected on annual average by floods between the baseline and future periods (2050-2100) under RCP 8.5

1.7.2 Impacts on food security

57. Several studies document a strong positive correlation between food insecurity and climate change due to a shift in growing seasons compounded by extreme weather events such as droughts and floods (Apollo & Mbah, 2021[79]; FAO, 2020[80]). One estimate suggests climate change could increase the number of undernourished people in East Africa by 50 percent by the 2030s (Funk et al., 2008[81]). Processing, storage, distribution, and consumption are and will be affected by climate change (IPCC, 2022[82]). Droughts induced by the 2015–2016 El Niño, partially attributable to human influences (medium confidence), caused acute food insecurity in various regions, including eastern and southern Africa (IPCC, 2022[83]). Between 2015 and 2019, an estimated 45.1 million people in the Horn of Africa and 62 million people in eastern and southern Africa required humanitarian assistance due to climate-related food emergencies. Children and pregnant women experience disproportionately greater adverse health and nutrition impacts (very high confidence) (IPCC, 2022)[84].

58. Figure 31 shows the Integrated Food Security Classification (IPC) over a 10-year period in East Africa. Most of Kenya, particularly north, south, and eastern parts, have an IPC level of emergency and crisis over a 10- year period, meaning that households have a large food consumption gap which are reflected in above-usual (crisis) and/or very high acute malnutrition and excess mortality levels (emergency). The food insecurity crisis over a 10-year period also extends to the east of Uganda's Northern region, as well as to north Tanzania. On the contrary, Western and Central regions of Uganda, the entire Rwanda, and most parts of Tanzania have IPC phases of stress and/or minimal over a 10-year period, implying that households are able or have minimally adequate food consumption, but are unable to afford some essential non-food expenditures without engaging in stress coping-strategies (Phase 2: stressed). Lastly, none of the project areas have faced famine (Phase 5) over a 10-year period.

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[79] Apollo& Mbah. 2021 Challenges and Opportunities for Climate Change Education (CCE) in East Africa: A Critical Review. Climate 2021, 9(6), 93; https://doi.org/10.3390/cli9060093

[80] Food and Agriculture Organization of the United Nations (FAO), U.N. Economic Commission for Africa (ECA), & African Union Commission (AUC). (2020). 2019 Africa regional overview of food security and nutrition. FAO. ttps://www.fao.org/documents/ card/en/c/ca7704en

[81] Funk, C., Dettinger, M., Michaelsen, J., Verdin, J., Brown, M., Barlow, M., & Hoell, A. (2008). Warming of the Indian Ocean threatens eastern and southern African food security but could be mitigated by agricultural development. Proceedings of the National Academy of Sciences, 105(32) 11081–11086.

[82] IPPC 2022 Chapter 9 Executive summary 9 9.8.

[83] IPCC (2022). Food, Fibre and Other Ecosystem Products (Chapter 5).

[84] IPPC 2022 Chapter 9 Executive summary 9 9.6.1

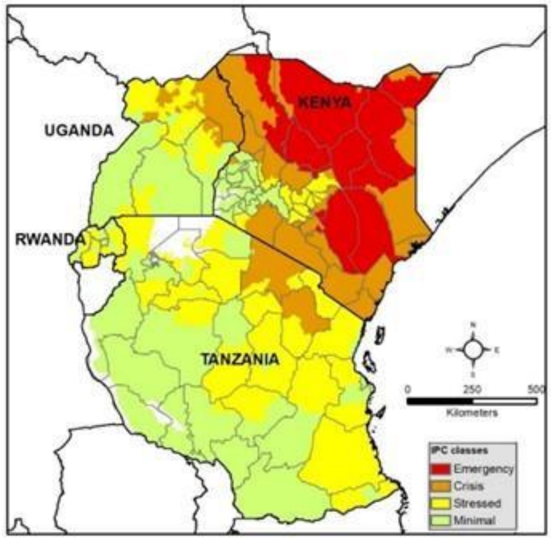

Figure 31: IPC classes (Phase 1: minimal, Phase 2: stressed, Phase 3: crisis, Phase 4: emergency, Phase 5: famine) over a 10-year period in Kenya, Uganda, Rwanda, and Tanzania. Map elaborated from FEWS NET

2 OVERVIEW OF THE DAIRY SECTOR IN TARGET COUNTRIES

59. This chapter presents an overview of the Dairy Sector in Kenya, Rwanda, Tanzania, and Uganda, from the demand of dairy products, the description of the production systems, access to resources and inputs and outputs services while assessing the impacts of climate change on the sector, the emissions of the sector and the barriers to adoption.

2.1 DEMAND FOR MILK

60. Demand for milk in the target countries is driven by population growth and rapid urbanization. In Kenya, the population is expected to increase by 19% in 2030 and 61% in 2050 compared to 2021 figure. The urban population is expected during the same time to increase by 43% and 128%. The milk demand is expected to show a 55% increase by 2030 and a 175% increase by 2050, with an annual growth rate of 2.56%, compared with 2010 (FAO, 2017[85]). In Rwanda, population is expected to increase by 22% in 2030 and 71% in 2050 compared to 2021 (FAOSTAT, 2023). This population growth is theoretically concomitant with the increase in middle-class income generation who are the main consumers of dairy products, hence there shall be increased demand for dairy products. In Uganda, the population in expected to increase by 27% by 2030 and by 91% in 2050 (FAOSTAT, 2023[86]). Milk consumption is expected to increase by 108% in 2030, because of population growth and income growth. In Tanzania, the population is expected to increase by 29% in 2030 and 104% in 2050 (FAOSTAT, 2023[87]) leading a production-consumption gap/deficit of 5.8 million litres in 15 years (Ministry of Livestock and Fisheries, 2017b[88]). The pre-feasibility Market Study (Appendix 1) provides detailed information on the current and projected demand and supply of milk in these countries.

2.2 DAIRY PRODUCTION SYSTEMS

2.2.1 Typology of dairy systems

[85] FAO. 2017a. Africa Sustainable Livestock (ASL) 2050 Country Brief Kenya. Nairobi, Kenya. Available at: https://www.fao.org/3/i7348en/i7348en.pdf
[86] FAOSTAT. 2023. Food and Agriculture Organization of the United Nations Statistical Database. Rome. [Cited 1 August 2023]. Available at: https://www.fao.org/faostat/en/#data/QCL
[87] Ibid.
[88] Ministry of Livestock and Fisheries (2017b). Tanzania Livestock Sector Analysis (2016/2017-2031/2032). United Republic of Tanzania. Kampala, Tanzania. Available at https://www.mifugouvuvi.go.tz/uploads/projects/1553602287-LIVESTOCK%20SECTOR%20ANALYSIS.pdf

61. The typology of dairy production systems in targeted countries, can be categorized using many aspects and criteria, including but not limited to i) integration with crop production; ii) the animal-land relationship; iii) agro-ecological zones (e.g. temperate, tropical, arid); iv) intensity of production; v) type of product (Sere and Steinfeld 1996[89]); vi) size and value of livestock holdings; vii) distance and duration of animal movement (e.g. nomadic, transhumant, sedentary); viii) types and breeds of animals kept; ix) market integration of the livestock business; x) economic specialization; and xi) household dependence on livestock (Eugene, 2017[90]). Additionally, systems based on degree of commercialization are classified as subsistence, partly commercialized if less than 50% of the value of produce is consumed by the household and commercialized if more than 50% of the value of produce is sold outside the farm (Robinson et al 2011[91]).

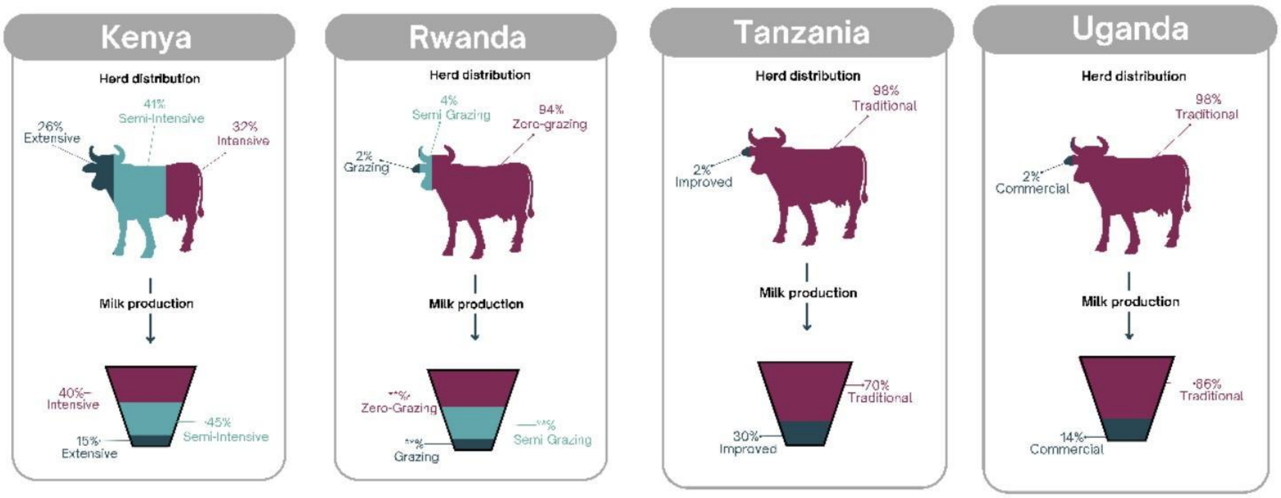

Figure 32: Contribution dairy production systems to milk production in Kenya, Rwanda, Tanzania, and Uganda

2.2.2 Dairy breeds

[89] Seré, C. and Steinfeld, H. 1996. World livestock production systems. FAO Animal Production and Health Paper 127. Rome, Italy: FAO.
[90] Eugene M (2017) Characterization of Cattle Production Systems in Nyagatare District of Eastern Province, Rwanda. Rheol: open access 1: 107.
[91] Robinson, T.P., Thornton P.K., Franceschini, G., Kruska, R.L., Chiozza, F., Notenbaert, A., Cecchi, G., Herrero, M., Epprecht, M., Fritz, S., You, L., Conchedda, G. and See, L. 2011. Global livestock production systems. Rome, Italy: FAO and Nairobi, Kenya: ILRI

62. In East Africa, smallholder dairy farmers keep animals of mixed breed-types; however, productivity levels are low and the countries are not able to meet their national demands for milk production (Majiwa et al., 2013[92]; Makoni et al., 2013[93]; SNV, 2013[94]). Over the last two decades, there have been concerted efforts to improve dairy production in East Africa, with a strong focus on community development (Makoni et al., 2013[95]; Ojango et al., 2016[96]). The level of impact in each country has been variable because of the lack of targeted breeding programs with objectives and strategies relevant to specific production systems.

63. Dairy animals in the targeted region are categorized into three: indigenous breeds, exotic breeds, and crossbreeds. The indigenous breeds are generally low milk yielders which are kept for the dual purpose of milk and meat production. Indigenous breeds are highly adapted to the hostile environmental conditions and are tolerant to endemic diseases. Local cattle groups in Kenya, Tanzania, and Uganda include the large and small East African Zebu, Zenga, and Sanga, whereas in Rwanda, only the Sanga group is found. Furthermore, the exotic breeds include the following either as pure breed or crosses with local breeds: Holstein-Friesian, Jersey, Guernsey, Ayrshire, Brown Swiss, and the Milking Shorthorn a dual-purpose (milk and meet) breed. The choice of an exotic as crossbreeding or pure breed usage is based on milk production, adaptation to the environment and longevity. Table 4 shows the Breed composition of dairy cattle in East Africa and Figure 33 their spatial distribution.

[92] Majiwa E., Kavoi M., and Murage H.. 2013. Smallholder dairying in Kenya: The assessment of the technical efficiency using the stochastic production frontier model. J. Agric. Sci. Technol. 14:3–16. 10.4314/jagst.v14i2.
[93] Makoni, N., Mwai, R., Redda, T., van der Zijpp, A. J., & Van Der Lee, J. 2014. White gold: Opportunities for dairy sector development collaboration in East Africa. No. 14-006. Centre for Development Innovation, Wageningen, The Netherlands. Available at: https://core.ac.uk/download/pdf/29212216.pdf
[94] SNV (Kenya/Netherlands Development Organization). 2013. Dairy Sector Policy Study and Capacity Needs Assessment of Stakeholder Associations. SNV, Nairobi, Kenya
[95] Ibid.
[96] Ojango J.M.K., Wasike C.B., Enahoro D.K., and Okeyo A.M.. 2016. Dairy production systems and the adoption of genetic and breeding technologies in Tanzania, Kenya, India and Nicaragua. Anim. Genet. Resour. 59:81–95

Table 4: Breed composition and contribution to dairy production

	Local Breeds		Exotic	
	% dairy population	**Contribution to total dairy production**	**% dairy population**	**Contribution to total dairy production**
Kenya	54	54	46	46
Rwanda	45	17	55	73
Tanzania	98.7		1.3	
Uganda	94	81	6	19

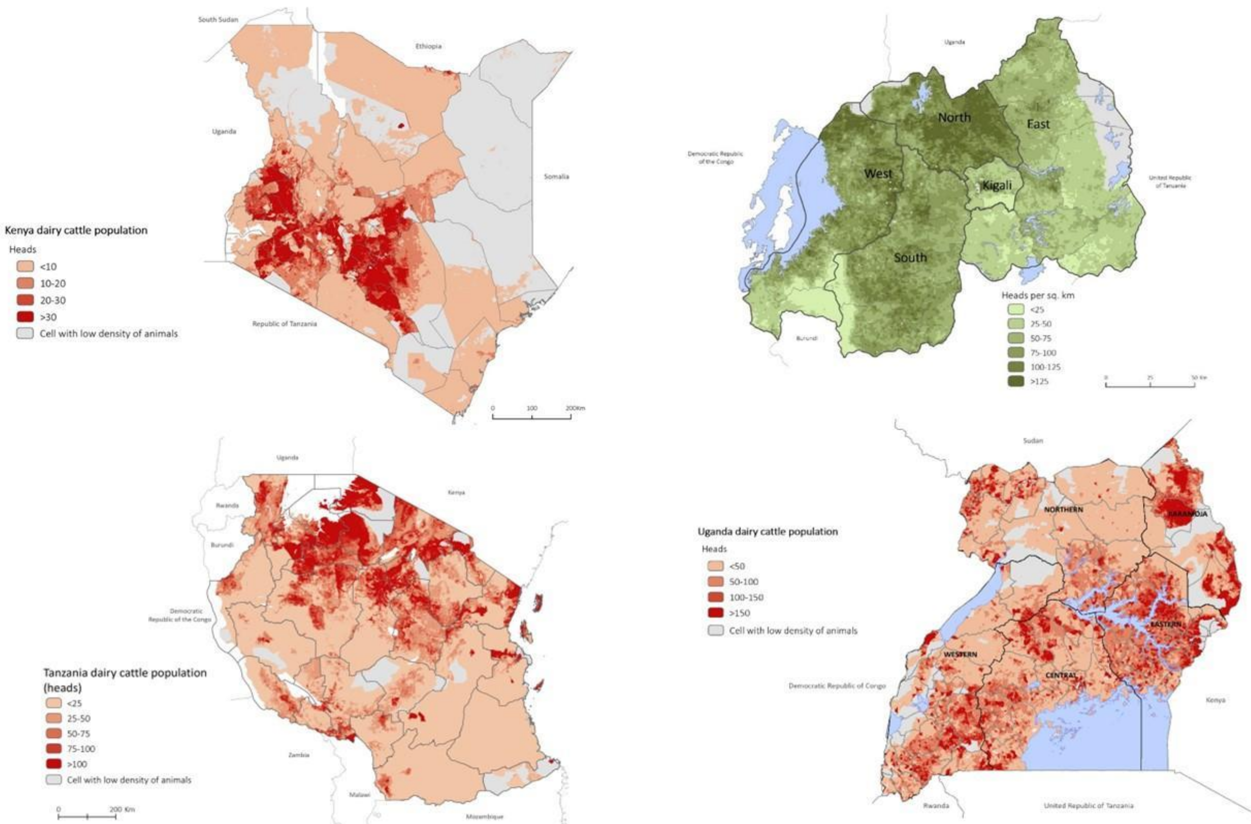

Figure 33: Spatial distribution of dairy cattle in Kenya, Rwanda, Tanzania, and Uganda

2.3 ACCESS TO FEED AND PASTURE (RANGELAND)

64. The region benefits from a diverse range of feed resources, including natural pastures, crop residues, forage crops, agro-industrial byproducts, and concentrates. Natural pastures are a valuable resource, particularly in areas with suitable climatic conditions. Crop residues like maize stover and wheat straw are commonly utilized as supplementary feeds, contributing to the overall diet of dairy animals. Additionally, the cultivation of forage crops like Napier grass, lucerne, and desmodium provides a consistent source of nutritious feed. Agro-industrial byproducts such as molasses, cottonseed cake, and brewers' spent grains offer alternative options to enhance feed quality (Klapwijk et al., 2014[97], Mutimura et al., 2015[98]; Nyiransengimana & Mbarubukeye, 2005[99]; Kamanzi & Mapiye, 2012[100]).

65. Balancing these resources through proper management, nutritional expertise, and sustainable practices is essential for optimizing milk production and ensuring the long-term viability of the dairy sector. However, seasonal fluctuation of feed availability poses challenges to livestock production and precipitates conflicts amongst communities and wildlife competing for feed resources (Lukuyu et al., 2009[101]).

66. In the extensive pastoral and agro-pastoral systems, farmers herd their cattle in the rangelands and fallow farm and supplement very little with crop residues and by-products. Farmers under improved family dairy and commercial dairy production system, practice indoor feeding with conserved forage (hay and silage) and or paddock grazing with concentrate supplementation usually during milking. The low adoption of forage conservation technologies such as hay or silage making leads to the wastage of forage in the periods of surplus production. Balanced feed formulation at farm level remains a challenge despite the availability of locally produced feed ingredients.

67. Concentrate feed producers rely on imports of some raw feed ingredients such as soybean, resulting in a high price fluctuation of commercial feeds. In addition, the weak capacity to control feed quality expose farmers to poor quality feed standards

2.3.1 Current condition of rangelands and pastures

68. Distribution and mapping of rangelands and pastures in Kenya, Uganda, Tanzania, and Rwanda, rangelands are classified as tropical and subtropical grasslands, savannas, and shrublands. Besides, according to Precipitation/Potential evapotranspiration (P/PET), there are three main dryland types in these countries. They are qualified as Arid (P/PET 0.05-0.20), Semiarid (P/PET 0.20-0.50), and dry sub humid (P/PET 0.50-0.65) rangelands. This feasibility study defines rangeland and pasture areas as the "grassland" and "shrubland" classes of the World Cover - a global land cover dataset obtained from the European Space Agency (2021[102]) - with 10 m resolution for the year 2021.

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[97] Klapwijk, C. J., Bucagu, C., van Wijk, M. T., Udo, H. M. J., Vanlauwe, B., Munyanziza, E., & Giller, K. E. 2014. The 'One cow per poor family'programme: Current and potential fodder availability within smallholder farming systems in southwest Rwanda. Agricultural Systems, 131, 11-22. Doi: https://doi.org/10.1016/j.agsy.2014.07.005

[98] Mutimura, M., Lussa, A. B., Mutabazi, J., Myambi, C. B., Cyamweshi, R. A., & Ebong, C. (2013). Status of animal feed resources in Rwanda. Tropical Grasslands 1:109. Doi: https://doi.org/10.17138/TGFT(1)109-110

[99] : Nyiransengimana, E. Mbarubukeye, S.2005 Peri-urban livestock production in Rwanda. Periodical: African Crop Science African Crop Science Conference Proceedings

[100] Kamanzi, M. and Mapiye, C. (2012) Feed Inventory and Smallholder Farmers' Perceived Causes of Feed Shortage for Dairy Cattle in Gisagara District, Rwanda. Tropical Animal Health and Production, 44, 1459-1468. http://dx.doi.org/10.1007/s11250-012-0087-3

[101] Lukuyu B A, Kitalyi A, Franzel S, Duncan A and Baltenweck I .2009. Constraints and options to enhancing production of high quality feeds in dairy production in Kenya, Uganda and Rwanda. ICRAF Working Paper no. 95. Nairobi, Kenya: World Agroforestry Centre

[102] European Space Agency 2021 World cover, , https://worldcover2021.esa.int/downloader

69. In **Kenya**, 67% of the total land area is characterized by arid and semi-arid climate rangeland, commonly referred to as arid and semi-arid lands (ASAL). These ecosystems are home to about 36% of the human population, 70% of the national livestock herd, and 85% of the total wildlife population (Ministry of Agriculture, Livestock, Fisheries and Cooperatives, 2021). Rangelands characterized by humid and sub-humid climate and Temperate and tropical highlands climate represent only 3.4% and 7.1% respectively of the country area. Intensive and semi-intensive dairy production systems are mostly located in the central and western parts of the country (Ochungo et al., 2016[103]).

70. In **Rwanda**, rangelands and pastures represent around 33.8% of the total country area (21.1% in temperate and tropical highlands, and 12.7% in humid and sub-humid climate).

71. In **Tanzania**, rangelands represent 41.7% of the total land area and are used by 20 to 30% of the population. In these ecosystems, grassland-based and mixed crop-livestock systems include large herds of local cattle defined as traditional meat-dairy production systems (CISRO, 2020[104]). It is estimated that 26.2% of the total land area is classified as rangelands in arid and semi-arid climates, 12% in humid and sub-humid, and 3.7% in temperate and tropical highlands climates. According to the National Land Use Framework Plan (National Land Use Framework Plan) for 2013 - 2033, the size of land allocated for grazing is equivalent to 10.3% of the entire arable land area in the country (Northern Tanzania Rangelands Initiative, 2019)[105].

72. In **Uganda,** rangelands and pastures represent 56.6% of the total land area, including 45.7% in humid and sub-humid climates, 6.6% in arid and semi-arid climates, and 4.3% in temperate and tropical highlands. It represents about 35% of Uganda's total land area with varying ecosystem condition and characterized by perennial grasses suitable for livestock grazing. The main issue is, in this area, periodic droughts and profound rainfall variability constrain pastoralists to move their livestock according to seasons to search for water and pasture (Kisamba-Mugerwa, W.,1992[106]).

2.3.2 Carrying capacity and feed balance

73. The concept of rangeland carrying capacity provides an estimate of the maximum number of animals the rangeland can support under certain conditions, without causing damage to the environment or depleting its resources beyond their ability to recover. The methodological approach to calculate the carrying capacity used here consisted of comparing the annual above ground biomass (AGB) available for livestock with the livestock annual forage requirement (Piipponen et al., 2022[107]). The AGB was estimated using the following datasets: the annual total biomass productivity, the mean annual temperature to estimate the shoot to root ratio, the tree multiplier to estimate the sub-canopy vegetation, and the slope multiplier to estimate the risk of land degradation. The annual livestock requirement was estimated based on the livestock numbers per species, the cohort structure, and the dry matter intake per cohort.

[103] Ochungo, P., Lindahl, J. F., Kayano, T., Sirma, A. J., Senerwa, D. M., Kiama, T. N., & Grace, D. (2016). Mapping aflatoxin risk from milk consumption using biophysical and socio-economic data: a case study of Kenya. African Journal of Food, Agriculture, Nutrition and Development, 16(3), 11066-11085.
[104] CISRO 2020. Dairy production in Tanzania https://research.csiro.au/livegaps/findings/livestock-production/dairy-production-in-tanzania/
[105] Northern Tanzania Rangelands Initiative. 2019. Rangelands in Transition: Sustaining Healthy Landscapes for People and Wildlife in Northern Tanzania. Arusha: NTRI
[106] W. Kisamba-Mugerwa, 1992 A Report on the investigations into the manner in which the eviction of people from South Kibale Forest Reserve and Game Corridor
[107] Johannes Piipponen, Mika Jalava, Jan de Leeuw, Afag Rizayeva, Cecile Godde, Gabriel Cramer, Mario Herrero, Matti Kummu 2022 Global trends in grassland carrying capacity and relative stocking density of livestock, Glob Change Biol. 2022;28:3902–3919

74. In the maps of carrying capacity presented in Figure 34, the red patterns indicate that the AGB surplus fall under zero, meaning that not enough resources are available to meet the animal requirements specifically in grazing production systems in which important part of the animal feed comes from grassland biomass. The interpretation of the carrying capacity analysis of rangelands should also consider other indicators, starting with the high seasonality of the biomass availability, the importance of bush and trees in pastoral feed ratios, and the climate risk and frequency of extreme droughts, that can significantly affect the number of livestock that an area can sustain in the East African context.

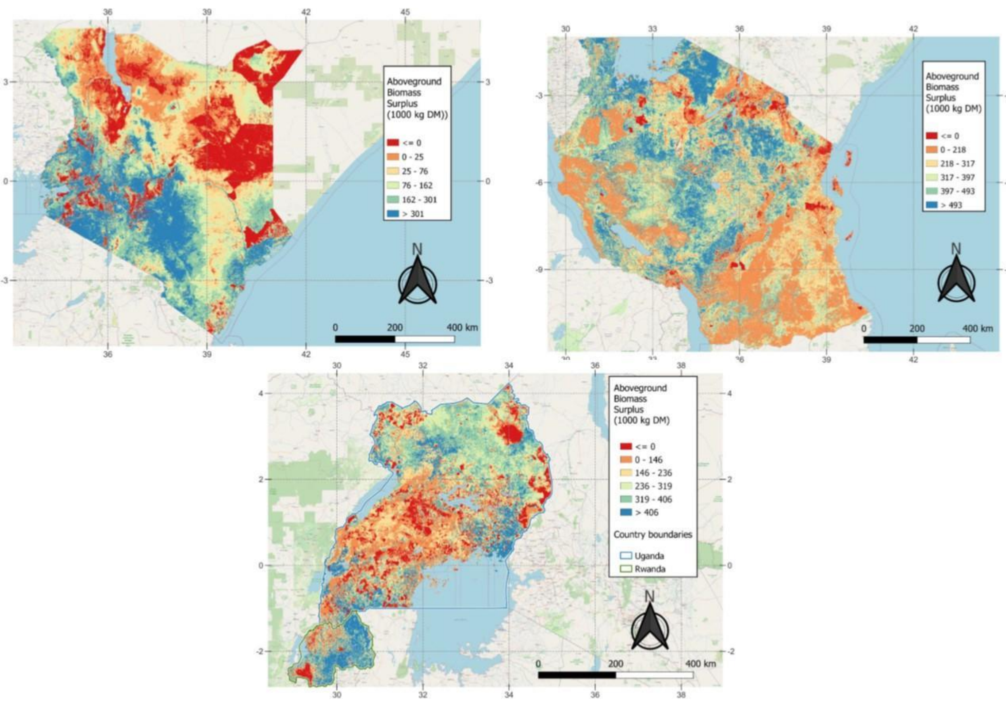

Figure 34: Aboveground biomass surplus for dairy cattle in Tanzania, Kenya, Rwanda/ Uganda for 2021

75. In **Kenya,** the National Feed Inventory and Feed Balance Assessment submitted by the Community Initiatives Facilitation & Assistance (CIFA) in Kenya reported in 2019 that 23 ASAL counties in Kenya presented a higher livestock feed requirement than what is available, indicating overstocking and suggesting the need for destocking, and improved feed accessibility. This assessment was aligned with the Kenya Food Security Steering Group geographical cluster system, which consists of Agropastoral pastoral, Southeast Marginal Agriculture, Pastoral Northwest, Pastoral Northeast, and Coastal Marginal Agriculture. The report indicated important competition for feed resources as well as waste. In 14 ASAL counties, grazing biomass supply more than 50% of the total feed used, and in 9 counties, it is more than 80%. Except for Kitui county, where the contribution of roughage is less than that of grazing biomass (23.6-33.6%), the other counties in the Southeast Marginal Agriculture cluster have significant roughage contributions (54–96%). Except for Embu, Laikipia, Nyeri, and Taita Taveta counties, the contribution of cultivated fodders is minimal. The percentage of cultivated fodders in these three counties ranged from 21 to 62%, with Nyeri having the highest percentage at 56.8 to 62%.

76. In **Rwanda**, due to the country's limited land resources, the zero grazing system is the most dominant across all areas (93% of cows) that is characterized by a low number of animals per farm (1 to 3 cows) and a high level of livestock-crops integration. In this system more than 70% of production expenses are associated with feed as cattle are kept in a shed and fed with forages. The open-grazing system can be differentiated into semi-grazing system mostly found in the Western and Northern highlands where cattle graze freely on low-quality roadside grass and the pasture grazing primarily practiced in Eastern Province (Nyagatare and Gatsibo districts), in drought prone savannah ecosystems, as in the highlands of Western Province (Gishwati basin). The pastures have good quality of grass such as Brachiaria, Kikuyu, and Chloris Gayana with high animal density.

77. In **Tanzania**, most of the ruminant feed resources come from rangelands. The feed resources *available* for livestock nationally are 26%, 13% and 44% of the feed required in an average weather year, including years when rainfall is above-normal average and below-normal average. The lower percentage of available feed resources compared to the animal requirement implies a negative feed balance at the national level (Mbwambo et al., 2016[108]).

78. In **Uganda**, the Department of Animal Production of MAAIF produced in October 2022 the National report on Feed Inventory and Feed Balance Assessment for Ruminants. The national feed balance showed positive values, meaning a feed surplus on both potentially available and available feed. The actual feed balance revealed that all feed required by the national ruminant herd is in surplus by 102.4%, 37.3% and 16.7% in dry matter (DM), metabolizable energy (ME), and crude protein (CP), respectively. Regarding zonal feed balance, negative trends were recorded for Eastern highlands zone, Northern moist farmlands zone, West Nile farmlands zone, Western highlands zone, and Western rangelands zone. The Northern moist farmlands zone (Nabuin ZARDI) showed negative feed balance for DM, ME, and CP based on both potential and actual feed availability. West Nile farmlands also recorded higher rise in potential energy deficits and a negative CP balance. Though a high potential feed surplus is observed in Agro-ecological zones such as Northern farming system, Eastern highlands, Lake Albert Crescent, Western highlands, and Western rangelands, this surplus is decreasing in the actual feed balance. This significant decrease is the result of important waste of animal feeds and ineffective feed management systems. An annual waste estimated at 8.5 Mt, 8.3 Mt, and 6 Mt is recorded, respectively, for Northern farming system, Western Rangelands, and Western highlands.

2.3.3 Level of degradation of rangelands and pastures

79. The United Nations Convention to Combat Desertification defines land degradation as “the reduction or loss of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from a combination of pressures, including land use and management practices” (UNCCD 1994, Article 1). This concept is part of the Sustainable Development Goal 15, with the overall objective to “Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.” The target 15.3 aims to “by 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation neutral world.” The target is monitored through the indicator 15.3.1, the “Proportion of land that is degraded over total land area”, having three sub-indicators, which are the trends in land cover, the trends in land productivity and the trends carbon stocks which is currently represented by soil organic carbon (SOC) stocks.

80. The indicator is calculated by integrating the sub-indicators using a one-out-all-out (1OAO) method, in which a significant reduction or negative change in any one of the three sub-indicators is considered to comprise land degradation. In Figure 35 is presented the trend of the level of degradation of rangelands and pastures in the target countries computed between 2012 to 2020. The results showed that degraded land represent 27% of total rangelands areas in Tanzania, 3.6% in Kenya, and 2.1% each in Uganda and Rwanda.

[108] Mbwambo, N., Nandonde, S., Ndomba, C. and Desta, S. (2016). Assessment of animal feed resources in Tanzania. Nairobi, Kenya: Tanzania Ministry of Agriculture, Livestock and Fisheries and International Livestock Research Institute (ILRI)

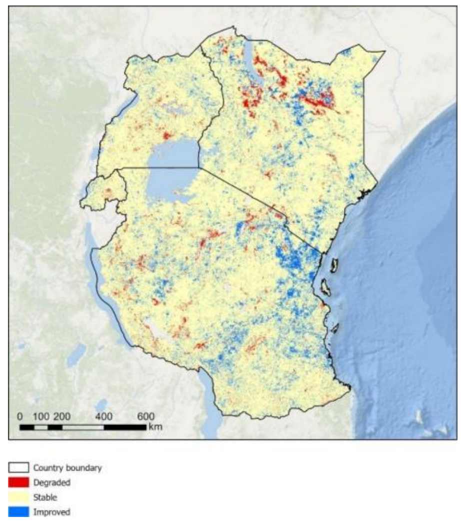

Figure 35: Level of degradation of rangelands and pastures in the four countries

2.4 LAND TENURE

81. Insecure land tenure affects the ability of people, communities, and organizations to make changes to land that can advance adaptation and mitigation. Limited recognition of customary access to land and ownership of land can result in increased vulnerability and decreased adaptive capacity. Land policies (including recognition of customary tenure, community mapping, redistribution, decentralization, co-management, regulation of rental markets) can provide both security and flexibility response to climate change (IPCC, 2019[109]).

82. Historically Kenya, Rwanda, Tanzania and Uganda share many similarities in their land tenure systems and governance in which statutory, customary, and informal governance coexist, with varying and evolving degrees of mutual acceptance, integration, formalization, and harmonization. The intensive/zero grazing, semi-intensive and extensive /open range are highly dependent for their tenure security on ownership or occupancy rights that are unlikely to be challenged. This is because they require a significant investment made sustainable by long-term access to the land. On the other hand, the pastoral nomadic and agro-pastoral semi-nomadic cattle dairy production systems' tenure security is reliant on rights of access, use and mobility.

Table 5: Dairy production systems' tenure Security Risks

[109] IPCC, 2019: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]

Type of production / tenure needs	Intensive	Semi-intensive	Extensive Open graze free ranging	Agro-pastoral semi-nomadic	Extensive Pastoral Nomadic
Ownership / secured occupancy	High	Medium	High	Medium	Low
Governance (Access & use)	Low	Medium	Low	High	High
Governance (Mobility)	Low	Low	Low	Medium	High
Governance (Disputes resolution)	High	High	High	High	High

83. **Kenya** has undertaken in the last decade several structural reforms to improve tenure governance, address historical injustices, and increase transparency, inclusion, and participation in land administration. These reforms have several implications for the different dairy livestock production systems. They increase tenure security for those who hold registered property rights. Improve the governance of shared resources on communal customary land. And promote increased participation of pastoral and semi-pastoral communities acting as right holders in tenure decision-making. As part of this effort, the Government has started mapping rangelands and corridors for inclusion into the national planning processes and to protect and manage their resources.

84. In **Rwanda,** the contemporary shape of the land tenure system is based on the Imidugudu Villagisation Programme (1996) which became Rwanda's guiding spatial planning policy. The Programme systematically sought to resettle rural dwellers into Imigudugu (villages) bringing profound changes to the way land was traditionally managed by reshaping people's access to land, housing and services and making land tenure an instrument for land use policy implementation. The following land tenure reforms aimed to identify and protect individual property rights, and to complete the transition from the previously existing plural tenure governance systems, into one single statutory system. Individuals today can legally hold land under two tenure systems: the Freehold and the Leasehold. The Freehold provides perpetual full ownership rights and is restricted to Rwandans. The Leasehold provides restricted property rights as per the lease conditions up to 99 years and is for Rwandans who registered customary claims and foreigners. This tenure governance system is efficiently increasing tenure security of registered individual plots and regulating access to water through spatial planning, promoting all dairy livestock activities that are intensive. It disincentivizes those dairy livestock production systems that are dependent on movement and shared access to resources, progressively restricting the space for the associated livelihoods.

85. In **Tanzania** all land is public land under the trusteeship of the President. The legal framework for land governance regulates land access, use and management and dispute settlement. Land is grouped under three categories: Village Land, General Land, and Reserved Land. General Land includes all public land which is not Reserved or Village Land - often located in (peri) urban areas - and is administered by the Commissioner for Lands. In urban areas, residents can apply for certificates of rights of occupancy for 33, 66, or 99 years with a prove of tenure record and mapped boundaries. Village Land generally means land within the boundaries of a village registered by the Local Government Act of 1982. The Village Land Act of 1999 and its regulations of 2001 govern Village Land. Certificates of rights of occupancy recorded in the National Land Information System grant right-holders the highest level of tenure security on general land. These certificates provide evidence of the rights, are digitally recorded, and have clear mapped boundaries. Occupancy of uncertified general land is very common and provides in general less tenure security, especially in areas of urban expansion where land values are likely to increase over time. Customary certificates of occupancy granted by villages who have acquired a Certificate of Village and performed demarcation and participatory land use planning grant the highest level of tenure security on Village Land.

86. The **Ugandan** land tenure framework is based on the Constitution, the Land Act, and the National Land Policy. Even though the framework recognizes the same dignity to statutory and customary rights, whether registered or not registered, ensuring customary and other legitimate informal tenure rights are protected has been a challenge. Land can be legally held under four tenure systems: Freehold, Mailo, Customary and Leasehold. Each system regulates the different rights related to the land, including ownership and use.

- Freehold: grants full ownership over land in perpetuity, right to selling, leasing, mortgaging, bequeath, and subdividing land. Land owned in freehold may be subject to conditions, restrictions, and limitations. It is considered the most secure form of tenure, and the safest for long term investments.
- Mailo is a land tenure system predominant in the central region of Uganda. It allows the separation of ownership of land and development on the land by lawful occupants (Bibanja holders) and bona fide occupants. It grants to the holder the same rights as freehold but is subject to the customary or statutory rights of the lawful and bona fide occupants at the time that the tenure was created and their successors in title.
- Customary: The legal definition refers to the ways in which people hold land, either individually or collectively, following customary norms and practices. It grants by law the same level of protection against external interests as freehold, but it is subject to restrictions of use and transfer as per the norms and practices of the community.

2.5 ANIMAL HEALTH AND DISEASE CONTROL

87. With some minor differences, the dairy sector in the 4 countries is facing the same animal disease pressure and challenges. Disease prevalence and distribution vary over time, in different production systems. Effective disease control and prevention measures, including vaccination, vector control, surveillance, and proper animal husbandry practices, are implemented to mitigate the impact of these diseases on the cattle population in East Africa. However, the animal health services in the various countries, have different capacity and are at different stage of development.

2.5.1 Main diseases in the region

The main animal diseases in the region are:

- East Coast Fever: ECF is a tick-borne disease caused by the parasite *Theileria parva*. The disease is transmitted by the brown ear tick (*Rhipicephalus appendiculatus*) and can cause high mortality rates if not treated promptly.
- Foot-and-Mouth Disease (FMD): FMD is a highly contagious viral disease that affects cloven-hoofed animals, including cattle. It is endemic in the region and poses a significant economic burden due to trade restrictions imposed to prevent its spread. Vaccination campaigns and strict biosecurity measures are employed to control and prevent outbreaks.
- Contagious Bovine Pleuropneumonia (CBPP): CBPP is a bacterial respiratory disease caused by Mycoplasma mycoides subsp. mycoides. It can cause severe respiratory distress and high mortality rates in affected animals. Vaccination and surveillance programs are implemented to control and eradicate the disease.

- Anthrax: is a zoonotic disease caused by the bacteria Bacillus anthracis. It affects various animal species, including cattle. The region has sporadic outbreaks of anthrax, particularly in areas with alkaline soils. Vaccination and proper disposal of carcasses are key measures to control the disease.
- Rift Valley Fever (RVF): RVF is a viral zoonotic disease that primarily affects ruminants, including cattle. It is transmitted by mosquitoes and can cause abortions, high mortality rates in young animals, and occasionally affect humans. The region has experienced periodic outbreaks of RVF, and surveillance, vector control, and vaccination are used for prevention and control.
- Lumpy Skin Disease (LSD): LSD is a viral disease that primarily affects cattle and is transmitted by biting insects, especially ticks. Vaccination campaigns and vector control are employed to prevent its spread.
- Mastitis: is a prevalent and economically detrimental udder infection in dairy cattle, poses a significant challenge to the dairy sector. Mastitis causes major losses through decreased milk production, veterinary costs, premature culling of cows usually the high yielding ones, cost of replacement stock as well as discarding and down-grading of milk. With a substantial portion of rural livelihoods dependent on dairy farming, effective mastitis control is imperative. Control measures include farmer training and education, improved milking techniques, regular veterinary care, regular screening for sub-clinical mastitis, and proper sanitation.
- Internal Parasites: there are two types of internal parasites in cattle namely helminths and coccidian. Helminthiasis is a major cause of mortality and sub-optimal productivity in dairy cattle in the region. Coccidiosis causes significant economic losses since it reduces performance, causes death from direct infections or by predisposing cattle to secondary bacterial and viral infections.
- Bovine babesiosis and African trypanosomiasis that are transmitted by ticks and tsetse flies.

2.5.2 Animal disease surveillance

88. Animal disease surveillance is conducted through passive and active surveillance, the former is a continuous surveillance by field actors who are closed to the farmers. The active surveillance includes livestock movement control, border control, abattoir surveillance, livestock and animal origin products permit issuing, farmers association, security organs among others. Passive surveillance allows detecting new sporadic cases.

89. **Kenya** has established a disease-free zones and compartments, quarantine protocols and in partnership with the International Livestock Research Institute (ILRI) in the counties of Marsabit, Turkana, Wajir, Isiolo and Garissa has developed LivHealth E-surveillance App for disease surveillance. The smartphone app for surveillance and reporting of livestock diseases has greatly improved the process of collecting and analysing disease surveillance data in northern Kenya. The LivHealth e-surveillance app has facilitated the recording of symptoms of livestock diseases by community disease reporters. It has also enabled quick and accurate documentation of disease syndromes as well as confirmed disease outbreaks within the communities (ILRI, 2023[110]). Kenya implements an Animal Identification & Traceability (ANITRAC) strategy as a key plank in Kenya's push for the modernization, commercialization, and improved competitiveness of the livestock sub-sector and to enhance disease control and monitor animal movements. The system involves the tagging and registration of livestock to ensure traceability, which helps in disease surveillance and response. ANITRAC aims "to satisfy domestic and international consumer requirements on safety and quality of animals and animal products" which will be partly achieved through "building an efficient and sustainable system for animal identification to achieve farm to fork traceability and secure livestock assets".

90. In **Tanzania** for notifiable diseases, a suspected case is reported to the District Veterinary Officer (DVO) within 24 hours. The DVO visits the farm to investigate the case and report to the Officer in charge of ZVC who in collaboration with the zonal Tanzania Veterinary Laboratory Agency (TVLA) will collect relevant samples. The ZVC will then notify the disease event to the directorate of veterinary services ,DVS, who has a mandate to transmit information internally and internationally. For wildlife, disease information may be captured by a veterinarian or game officer in the respective institutions such as the Tanzania Wildlife Research Institute (TAWIRI), Ngorongoro Conservation Area Authority and Tanzania National Park Authority (TANAPA) and information flow shall be through the respective DVO.

91. In **Uganda,** efforts are continually made to strengthen the veterinary services distribution network and ensure access to animal health services in rural communities throughout Uganda. The veterinary services distribution network in rural areas involves various entities and structures aimed at providing animal health services. The main actors include Government veterinarian/officer, Community-based animal health workers (CAHWS), drug shops, Non-governmental Organization (NGOs), Stockiest, Herdsmen, and Middlemen (animal traders).

92. *Public-Private Partnerships*: The governments in the region collaborate with private veterinary practitioners (through sanitary mandate), farmers' associations, and industry stakeholders to implement animal health programs, disease surveillance, and capacity building initiatives.

93. *International Collaboration:* the countries actively participate in regional and international initiatives for animal health, including cooperation with organizations such as the World Organization for Animal Health (WOHA), Food and Agriculture Organization (FAO), and East African Community (EAC) to align its policies and strategies with global standards. These collaborations enhance capacity building, information sharing, and joint disease control initiatives.

2.6 PROCESSING AND HANDLING FACILITIES

94. High input costs and seasonal milk price fluctuations represent other important obstacles to the development of the sector (Makoni et al., 2014[111]). The inadequate milk marketing infrastructure, with over 80% of the marketed milk in East Africa, destined to the informal market, represents another important issue that undermines the product safety and limits the scope for value chain investment and structuring.

[110] ILRI 2023 Smartphone app improves community livestock disease surveillance in northern Kenya ILRI News 27 February 2023 Tezira Lore

[111] Makoni et al., 2014: White Gold - Opportunities for Dairy Sector Development Collaboration in East Africa Report number: CDI-14-006 Affiliation: Centre for Development Innovation, Wageningen University & Research Centre

95. Post-harvest spoilage and waste are costing the dairy sectors of East Africa and the Near East up to $90 million a year, of which $59.7 million combined loss shared between Kenya Tanzania and Uganda[112]. The inefficient transportation and limited access to infrastructure for collection, storage, and chilling of milk of milk which can lead to high milk losses. This is coupled with the inadequate organization among milk processors and the fluctuations in milk supply due to seasonal forage availability which contribute to instability of the markets and the long-term economic viability of the sector (Makoni et al., 2014[113]; Rademaker et al., 2016[114]; CSIRO, 2023[115])

96. Milk processing at an industrial scale is severely limited in Africa partly because dairy processing machinery is imported mainly from outside the African continent and is expensive. In countries where commercial dairy processing plants have been set up, only a few dairy products are produced, sometimes, due to the lack of appropriate handling and processing technologies and the shortage of knowledgeable experts to manage the industry professionally. When dairy scientists/technologists are available, managerial expertise may lack. The lack of technology may also combine with the lack of market, an unstable market or a market located far away from the site of processing plants, to curtail processing capability (Lokuruka, 2016)[116].

97. In **Kenya,** the total losses in the dairy cattle milk supply chain in Kenya is estimated at 7.3 % (KDB, 2021). In **Rwanda** post-harvest losses during transport and milk handling is estimated to up to 50 or 60 litres of milk per day per Milk Collection Center (MCC) (RDDP, 2016[117]). Milk losses are highest at the farm level especially with evening milk when collection ceases and farmers do not have adequate milk preservation techniques. In **Tanzania**, losses represent 5-10% of total production and under some circumstances can be 40% of production (SRCU, 2020[118]). In **Uganda** post-harvest milk losses represent 21% of total milk production (DDA, 2021[119]).

98. The key overarching challenge across the region is transforming the informal sector to a formal commercialized sector that has traceability safeguards and securing the quality and safety of dairy products. Poor husbandry practices such inadequate use of antimicrobials, milk handling on farm, the shortage of cooling equipment to store it during the transport can contribute to a sub-optimal sanitary and sensorial quality of the product (Ter Steeg, 2019[120]). This is also undermined by the inadequacy of regulations on livestock movement, which can facilitate the spreading of diseases and zoonosis (Muriuki, 2011[121]).

99. Quality-based milk payment systems (QBMPS) offer opportunities to improve the quality, income, and marketing in the sector. The attributes of these systems can include physical, chemical, microbial milk traits and socio-economic parameters such as biodiversity protection and animal welfare (Ndambi et al., 2020[122]). Overall, the QBMPS in East Africa led to improvements in handling practices through establishments of milk collection centres (MCCs), use of metal cans and instant chillers, and testing of milk (Özkan Gülzari et al., 2020[123], Ndambi et al., 2020[124]). Milk collection centers (MCCs) and milk collection points (MCPs) are the conduit for aggregating milk produced by smallholder farmers, they collect and store milk on behalf of smallholders to be sold on. They are typically the key route for raw like to enter the formal processing aspects of the value chain. The ownership and management of these varies across countries, but they can be owned and run by processors or farmer cooperatives.

2.7 ROLE OF WOMEN AND YOUTH

100. In **Kenya** women often cover the role of primary caretakers of livestock daily, performing tasks such as milking and feeding the animals, without owning them. However, their role in leadership and decision-making position is often limited. Men, on the other hand, are usually responsible for weekly or seasonal tasks (e.g., planting forage, organizing animal health service providers). This is especially true for rural households, where roles are often organized according to traditional gender roles, causing work-load disparities. In this context, women are usually unpaid for their productive work within households (Katothya, 2017[125]).

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[112] https://www.dairyreporter.com/article/2004/10/27/post-harvest-loss-costs-east-african-milk-market-90m
[113] Ibid.
[114] Rademaker, C. J., Bebe, B. O., Van Der Lee, J., Kilelu, C., & Tonui, C. 2016. Sustainable Growth of the Kenyan Dairy Sector: A Quick Scan of Robustness, Reliability and Resilience. Wageningen: Wageningen University and Research. Available at https://library.wur.nl/WebQuery/wurpubs/508760

[115] CSIRO. 2023. Dairy production in Tanzania. [Cited 25 July 2023]. Available at https://research.csiro.au/livegaps/findings/livestock-production/dairy-production-in-tanzania/

[116] Lokuruka, Michael. (2016). Overview of dairy processing and marketing in East African dairy value chains: Opportunities and challenges. African Journal of Food Science. 10. 254-262. 10.5897/AJFS2016.1465.

[117] RWANDA DAIRY DEVELOPMENT PROJECT (RDDP) 2016

[118] SRUC 2020 Tanzania Milk Quality. https://www.sruc.ac.uk/research/research-facilities/dairy-research-facility/dairy-projects/tanzania-milk-quality/

[119] Uganda Dairy Development Authority 2021, Performance of Milk collection centres Facilitating evidence-based policy dialogue on performance of the dairy value chain

[120] Ter Steeg. 2019. Investment opportunities in the Rwandan dairy sector (TRAIDE Resilience Rwanda). Report from TRAIDE Rwanda. Available at https://static1.squarespace.com/static/633f7112f252f6538fa8ed01/t/63d75e1d8b87803e05c60ba9/1675058721722/BORDairy_Rwanda2019_ver4.pdf

[121] Muriuki, H. G. 2011. Dairy Development in Kenya. FAO. Rome, Italy. Available at https://www.fao.org/3/al745e/al745e.pdf

[122] Ndambi, A., Kilelu, C. W., Lee, J. van der, Njiru, R., & Koge, J. 2019. Making milk quality assurance work on an unlevel playing field lessons from the Happy Cow pilot. Wageningen Livestock Research report 1165, Wageningen, The Netherlands: Wageningen University & Research WLR. Nairobi. Available at: https://library.wur.nl/WebQuery/wurpubs/fulltext/476559

[123] Özkan, Ş., Teillard, F., Lindsay, B., Montgomery, H., Rota, A., Gerber P., Dhingra M. and Mottet, A. 2022. The role of animal health in national climate commitments. Rome, FAO. Doi: https://doi.org/10.4060/cc0431en

[124] Ndambi, A., Kilelu, C. W., Lee, J. van der, Njiru, R., & Koge, J. 2019. Making milk quality assurance work on an unlevel playing field lessons from the Happy Cow pilot. Wageningen Livestock Research report 1165, Wageningen, The Netherlands: Wageningen University & Research WLR. Nairobi. Available at: https://library.wur.nl/WebQuery/wurpubs/fulltext/476559

[125] Katothya Gerald 2017 Gender assessment of dairy value chains: evidence from Kenya FAO

101. Youth are involved in activities which require low capital investments such as transport and sales of milk and casual labour; both youth women and men are involved, with men tending to own means of transport and women relying on public transport. Some youth, especially men, through trainings and credit, can access more difficult, specialized, and remunerative roles such as running agrovet shops, providing artificial insemination (AI) services and installing biogas. Men are often members of cooperatives while youth and women sometimes organize into youth groups through regional dairy projects that support business and skill development. The high access to mobile phones by youth has ushered in new ways of learning about local and global dairy practices, linking to markets, e.g. heifer sales, and connecting with dairy farmers in social media platforms.

102. In **Rwanda,** 40% of women own dairy cattle as heads (GMO, 2017[126]). However, when it comes to decision-making about herd management, breeding, purchase, and selling of cattle, these are often taken by the male head of the household in any case. In addition, traditional cultural beliefs, domestic responsibilities, issues of mobility and insecurity combined with poverty, can still represent a barrier that limits the participation of women in agricultural programmes and activities. For this reason, The Government of Rwanda is working to promote women's full participation and to reduce these barriers (Ngamije, 2022[127]).

103. Men are much more involved than women in milking cows, transporting the milk to the milk collection centres (MCCs) using bicycles or motorcycles and marketing it. Although women and men have equal land ownership rights and can own cattle without cultural prejudice, women are still constrained with limited capital and limited access to finance and do not occupy critical decision-making positions. Youth are faced with labour underutilization (high time-related unemployment) compared to adults (18.7% versus 12.3%). Land holding and access to natural resources will be a significant consideration of geographical targeting while value chain analysis will inform the activities most attractive to women, youth, and poorer members of the community, targeting beneficiaries according to wealth ranking, as guided by Government the Ubudehe system. The Programme will actively target to increase the number of women-owned livestock farmers and increased involvement in profitable value chain activities. Practical and strategic challenges faced by youth and women will be addressed, for example provision of water closer to the farmers and provision of motorcycles or tricycles for milk collection and transport, reducing both the burden and time spent, and making the enterprise more attractive.

104. Although women play a major role in the dairy sub-sector in **Tanzania**, they still face several barriers in accessing and benefitting from marketing of livestock and livestock related products (Achandi et al., 2021[128]). Tanzania has made strides since 1980, moving from a gender-blind approach, towards an awareness of gender issues also thanks to international programmes (e.g., Heifer International (Heifer International) (Sikira et al., 2018[129]). Women have an active role in the production node of the dairy value chain, and are mostly involved in the herd management, calves care, and milking activities (Sikira et al., 2018[130]). Dairy cattle raised in the cool highland regions of Kilimanjaro and Arusha, Southern Highlands (Mbeya and Iringa), as well as Tanga and Kagera areas are mainly owned by women such as the KIJIMO women group of Arusha, and Kalali and Nronga women groups of Kilimanjaro region. In this area, women keep cattle and process milk into various product, selling them to various consumers (e.g., school children, tourists etc). However, women are not fully involved in decision making processes, even when it has to do with their own livestock (Sikira et al., 2018[131]). Women are also practically excluded from the role of transporting and collecting milk due to a lack of capital to buy means of transport such as bicycles and motorbikes. However, they do play an important role in milk processing in the case of small farms. In contrast, large processing plants are usually operated by men (Sikira et al., 2018[132]). As far as trade is concerned, women are generally involved in the sale of milk traded in the non-formal channel. On the contrary, the decisions, sale of animals, and the sale of milk in the formal market is a role maintained mostly by men (Mkenda-Mugittu, 2003[133]).

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[126] Gender in Agriculture 2017 Ministry of Agriculture Rwanda

[127] Ngamije, F. 2022. The Livestock System in Rwanda–An Overview. Feed the Future Innovation Lab for Livestock Systems (University of Florida).

[128] Chandi, Esther & Mujawamariya, Gaudiose & Agboh-Noameshie, Rita & Abera, Shewaye & Rahalivavololona, Njaka & Rodenburg, Jonne. (2018). Women's access to agricultural technologies in rice production and processing hubs: A comparative analysis of Ethiopia, Madagascar and Tanzania. Journal of Rural Studies. 60. 188-198

[129] Sikira, A.N. & Waithanji, Elizabeth & Galiè, Alessandra & Baltenweck, Isabelle. (2018). Gender aspects in the dairy value chain in Tanzania: A review of literature. Livestock Research for Rural Development. 30.
[130] Ibid
[131] Ibid
[132] Ibid
[133] Mugittu, Vera. (2003). Measuring the invisibles: Gender mainstreaming and monitoring experience from a dairy development project in Tanzania. Development in Practice. 13. 459-473. 10.1080/0961452032000125848.

105. As value chains commercialize and markets become sophisticated, moving further away from the farm gate, women tend to lose control and ownership of the commodities in question. Commercialization thus poses a risk to women's engagement and must be explicitly mitigated. Household level interventions such as GALS as well as joining cooperatives through groups have proven effective. Two-thirds of Tanzania's labour force is younger than 35 years. For the youth, being linked to a market (earning money) and working with modern and digital technologies are important. Around half of the 16 million youth are, however, engaged in farming (off-farm agribusiness: 24 percent). Young men more often than young women find non-agriculture employment, approximately 60 percent versus 40 percent. Collective action for the youth has been explored and has successfully worked in Zanzibar, as a result of the Agricultural Sector Development Programme–Livestock (ASDP-L) project. Communal Cowsheds for dairy are a type of L-FFS that is dependent on social cohesion from which youth learn and farm dairy together.

106. It is estimated that 23% of **Ugandan** dairy households are held by women (FAO & NZAGRC, 2019[134]). In general, women are mostly responsible for dairy activities, such as feeding, watering, and milking of cows as well as cleaning the stalls (Bain et al., 2018[135]), yet largely marginalized in decision making and utilization of the cash income and other benefits from the dairy enterprise (FAO & NZAGRC, 2019[136]). Several programs such as the "Bill & Melinda Gates Foundation East African Dairy Development Program" are contributing to assist dairy production efficiency and to support the increased role of women in production.

107. Men generally own cattle while women engage more in dairy processing and have ownership of the milk. In some MCCs, women have formed groups to produce and market products such as yoghurt by purchasing milk from the MCCs. Although women's participation in the dairy value chain is higher in eastern and northern Uganda, their participation in beef is generally lower. However, women still face constraints such as limited capital and access to finance, which limit their potential to scale up their businesses. There is also a notable lack of women's participation in livestock organisations and cooperatives, coupled with data gaps on gender roles in both value chains. To address these challenges, there is an opportunity for improvement by applying gender-sensitive approaches to ensure that both men and women benefit from dairy and beef development initiatives. Activities such as small-scale processing and feed will be mobilized for women. Uganda has the second youngest population in the world, but youth are constrained in access to productive assets and being linked to markets. Initiatives related to modern and digital tools, as well as employment generation are critical. Many youths are actively seeking pathways into the labour market that still allow them to engage in agriculture, driven by the belief that they may ultimately rely on agriculture after formal employment. To address this, efforts should be directed at attracting youth into profitable agricultural activities, thereby nurturing the next generation of farmers, processors, and traders.

2.8 GHG EMISSIONS BASELINE AND BUSINESS-AS USUAL PATHWAYS

108. Methane (CH_4) is a potent short-lived climate pollutant, with an atmospheric lifetime of around 12 years. In East Africa, livestock – (especially ruminants) are the leading source of methane emissions, which arise from enteric fermentation and manure management (UNEP and CCAC, 2021[137]). Enteric fermentation represents about 70% of total GHG emissions from livestock in this region and is the second highest source from agriculture, forestry, and other land use (14%) (FAO, 2022[138]). The IPCC 2019 Special Report noted that livestock in the tropics is one of the more probable sources of increased methane emissions, which is consistent with inventory data (Wolf et al. 2017[139]; Patra et al. 2016[140]; Schaefer et al. 2016[141]).

109. The launch of the GMP at 26th Conference of the Parties (COP) has further focused attention, with countries, including Rwanda, committing to jointly reduce methane emissions by at least 30% by 2030 from 2020 levels. Methane makes up about 17% of all GHG emissions, and methane emissions from ruminant livestock are about 30% of total methane emissions (Saunois et al., 2016)[142]. Methane emissions contribute to an estimated 0.5°C of global temperature increase. The dairy sector also used COP26 to further the Pathways to Net Zero initiative, launched at the 2022 UN Food Systems Summit, by initiating the process to develop a typology of dairy production farm systems, together with East African countries, as a basis for planning, monitoring, and evaluation of low-emission pathways as well as and mitigation and adaptation interventions[143].

110. The three main measures to reduce enteric fermentation include: (i) improving animal diets (higher quality, more digestible livestock feed); (ii) using supplements and additives (reduce methane by changing the microbiology of the rumen); and (iii) animal management and breeding (improve husbandry practices and genetics). In addition, measures to manage manure include anaerobic digestion for energy use, composting as a nutrient source, reducing storage time, and changing livestock diets, which also have mitigation potential l(IPPC, 2019)[144]. This had been previously noted by FAO who estimated that improved management practices alone could reduce net emissions from livestock systems – methane in particular – by about 30% (FAO 2013)[145]. FAO, through the Livestock Environmental Assessment and Performance (LEAP) Partnership, will publish a comprehensive report on methane emissions from livestock and rice production, which outlines many existing methane mitigation interventions that are applicable to East African dairy systems (FAO,2013)[146].

111. To assess the outcome of different mitigation and adaptation scenarios at local, national, regional or global scale, FAO developed GLEAM (the Global Livestock Environmental Assessment Model) Gerber et al., 2013[147] and its open and online version (GLEAM-*i)* to simulate the bio-physical processes and activities along livestock supply chains, and analyse the multiple environmental dimensions, such as feed use, GHG emissions, land use and land degradation, nutrient and water use and interaction with biodiversity. FAO and the dairy sector have continued to analyze the trends in emissions and emission intensities from milk production with an assessment of the emissions from the dairy cattle sector for 2005, 2010 and 2015[148].

GLEAM is a geo-referenced model framework that simulates the bio-physical processes and activities along livestock supply chains based on the life cycle assessment. The analysis of the direct GHG emissions was conducted using the Global Livestock Environmental Assessment Model (GLEAM), version 4. The model is based on the IPCC Tier 2 methodology but for some processes, GLEAM also uses Tier 3 approaches, developed by FAO. The model has been used previously to estimate global GHG emissions (FAO, 2019; Gerber et al., 2013), nitrogen emissions (Uwizeye et al., 2020) or soil carbon stocks in grasslands (Dondini et al., 2023). For this study, the focus is on the direct emissions

[134] FAO, & NZAGRC. (2019a). Options for low emission development in the Tanzania dairy sector—Reducing enteric methane for food security and livelihoods (p. 34). Food and Agriculture Organization of United Nations. https://www.fao.org/3/ca3215en/CA3215EN.pdf

[135] Bai, Yongfei & Cotrufo, M. Francesca. (2022). Grassland soil carbon sequestration: Current understanding, challenges, and solutions. Science (New York, N.Y.). 377. 603-608. 10.1126/science.abo2380.

[136] FAO, & NZAGRC. (2019a). Options for low emission development in the Tanzania dairy sector—Reducing enteric methane for food security and livelihoods (p. 34). Food and Agriculture Organization of United Nations. https://www.fao.org/3/ca3215en/CA3215EN.pdf

[137] CCAC and UNEP published the Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions (UNEP,CCAC 2021

[138] FAO. 2022. Prioritizing the reduction of methane in livestock climate actions in East Africa – Policy brief. Rome. Available at: https://doi.org/10.4060/cc0714en.

[139] C. Wolf, F. Pomponi, A. Moncaster 2017 Measuring embodied carbon dioxide equivalent of buildings: a review and critique of current industry practice Energy Build., 140 (2017), pp. 68-80 https://doi.org/10.1016/j.enbuild.2017.01.075

[140] Patra P.K., Saeki T., Dlugokencky E.J., Ishijima K., Umezawa T., Ito A., Aoki S. (2016). Regional methane emission estimation based on observed atmospheric concentrations. J. Meteorol. Society Japan. Ser., 94: 91–113.

[141] Schaefer, H., et al. (2016), A 21st century shift from fossil-fuel to biogenic methane emissions indicated by 13CH4, Science, 352, 80–84

[142] Saunois et al., 2016. The global methane budget 2000-2012. Earth Syst. Sci. Data, 8, 697–751

[143] Pathways to Dairy Net Zero https://www.globaldairyplatform.com/pathways-to-dairy-net-zero/

[144] IPCC. 2019. Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems

[145] FAO. 2013. Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Available at: http://www.fao.org/3/a-i3437e.pdf

[146] Ibid.

[147] Gerber, P., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., & Tempio, G. (2013). Tackling climate change through livestock – a global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of United Nations.

[148] FAO and GDP. 2018. Climate change and the global dairy cattle sector – The role of the dairy sector in a low-carbon future. Rome. Available at: https://www.fao.org/3/CA2929EN/ca2929en.pdf.

(CH4 and N2O), which represent about 81 percent of total GHG emissions along cattle supply chains in Kenya based on the recent estimates of GHG emissions from livestock supply chains for 2015 (FAO, 2015).

112. Using the GHG emissions as initially reported in national inventories, baseline estimates derived from the latest national data were updated, primarily centred around the year 2020, which have been meticulously calculated utilizing the geo-referenced GLEAM. These revised estimates were used for the in-depth analysis. Pre-feasibility Study 2 provides details descriptions of the baseline emissions.

1.1.3 National GHG inventories

113. Based on the national GHG inventory in **Kenya**, using the Tier 2 approach, it is estimated that in 1995, CH_4 emissions amounted to 129 Gg CH_4 and increased to 192 Gg CH_4 in 2017, (+49%,Figure 36). This increase is due to both an increase in dairy cattle numbers and changes in cattle management and animal performance.

Textbox 1: the Global Livestock Environmental Assessment Model

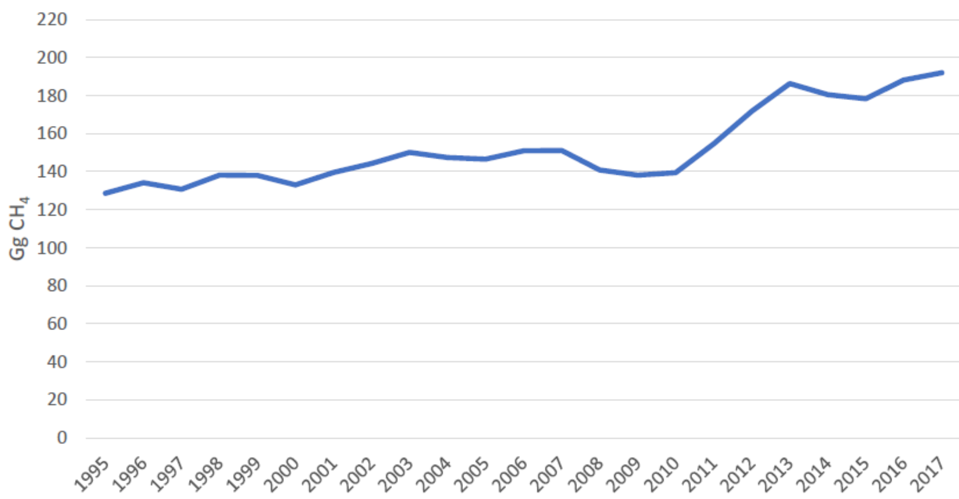


Figure 36: Trend in enteric fermentation emissions from dairy cattle in Kenya, 1995-2017 (Gg CH4). Source: Ministry of Agriculture, Livestock, Fisheries and Cooperatives (MoALFC)

2020 (Inventory of GHG Emissions from Dairy Cattle in Kenya 1995-2017)

114. GHG inventory reported in **Rwanda**'s First Biennial Update Report (BUR) covers the period 2006-2018. Tier 1 and Tier 2 methodologies were applied to estimate emissions of direct GHG for all sectors and country-specific data were considered where available. According to the first biennial updated report, CH_4 emissions from the livestock sector (enteric fermentation and manure management) increased from 2,529 Gg CO_2-eq in 2006 to 3,332 Gg CO_2-eq in 2018 (Republic of Rwanda, 2021[149]). Agriculture represented 46% of the total GHG emissions in Rwanda in 2018, estimated to be 6,756 Gg CO_2-eq., as illustrated in figure 38. The total emissions from AFOLU increased in the last decades by 34 %. Within agriculture, most emissions were CH_4 and originated from enteric fermentation and manure management systems, as shown in Figure 37.

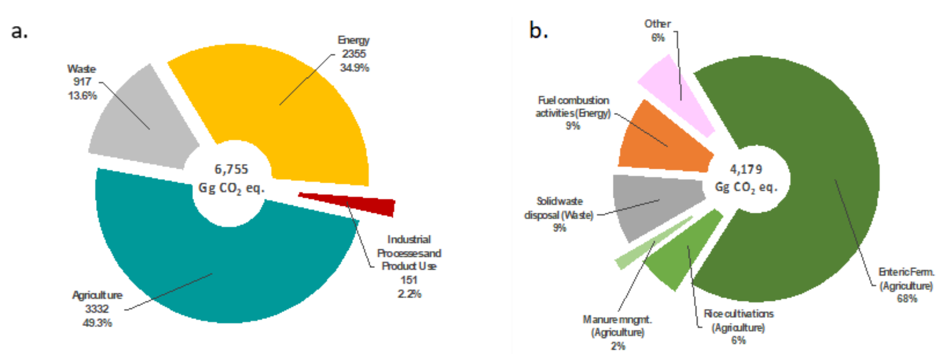


Figure 37: (a) Contribution to the total GHG emission by sectors in 2018 (b) Sources of methane emissions in 2019 Source: The Republic of Rwanda (2021)

[149] Republic of Rwanda. (2021). Rwanda's First Biennial Update under the United Nations Framework Convention on Climate Change. Republic of Rwanda.

115. The total GHG emissions in **Tanzania** in 2014 were estimated to be 286 Mt CO_2-eq (CAIT, 2022). The dominant source of emissions was land use change and forestry which contributed 208 Mt CO_2-eq (72%). The agriculture sector contributed 49.7 Mt CO_2-eq, representing 17% of the country's total emissions.

116. **Uganda's** total aggregate emissions reached 94 650 Gg CO_2-eq in 2017 (MWE, Uganda National Communication 3, 2022). The AFOLU sector remained the main source of emissions accounting for 83.7 percent in 2017. In 2017 the AFOLU sector was the major source of CO_2, CH_4 and N_2O. CO_2 emissions from AFOLU were estimated at 56 430 Gg or 92 percent of total CO_2 emissions. This was mainly from deforestation and forest degradation. Milk production from the dairy cattle sector in Uganda emits about 19.1 million tons CO_2eq.

2.8.1 Greenhouse gas emissions from dairy cattle

117. In **Kenya**, the dairy sector emitted about 6.4 million tons of CO_2eq on farms in 2019. More than three-quarters of the total emissions are concentrated in regions with the highest share of the national dairy herd. Most direct emissions are in the form of CH_4 at 92.4 percent and N_2O at 6.6 percent. Approximately 82% of the emissions arise from enteric fermentation in the rumen whereas 11% of emissions are in the form of CH_4 from manure management systems.

118. In **Rwanda,** Based on GLEAM model, the production of dairy cattle in Rwanda emits about 3,593 Gg CO_2eq in 2020. The sources of emissions are mainly enteric fermentation (74%) and manure management systems (CH_4: 15 % and N_2O: 11 %). Regarding annual CH_4 emissions per animal, it varies from 55 kg CH_4 for other cattle to 81 kg CH_4 for dairy cows, which is slightly lower to the estimate of 96 kg CH_4 obtained from the Rwanda's First Biennial Update report (Republic of Rwanda, 2021[150]).

119. Based on GLEAM analysis, total direct GHG emissions from dairy cattle systems in **Tanzania** are estimated at 59 Mt CO_2-eq per year based on the global warming potential (GWP_{100}) from IPCC Assessment Report 6 (IPCC, 2023[151]). Most of the emissions are in the form of CH_4 from enteric fermentation (about 92%) and manure management systems (2 %). Emissions of N_2O from manure are estimated at 6 %.

120. The total direct GHG emissions from the dairy cattle sector in **Uganda** are estimated at 24.3 Mt of CO_2-eq in 2020. These emissions are mainly in the form of enteric fermentation (81%), CH_4 from manure management systems (17 %) and a minor quantity of N_2O (2 %). Figure 38 indicates the sources of total emissions in each country.

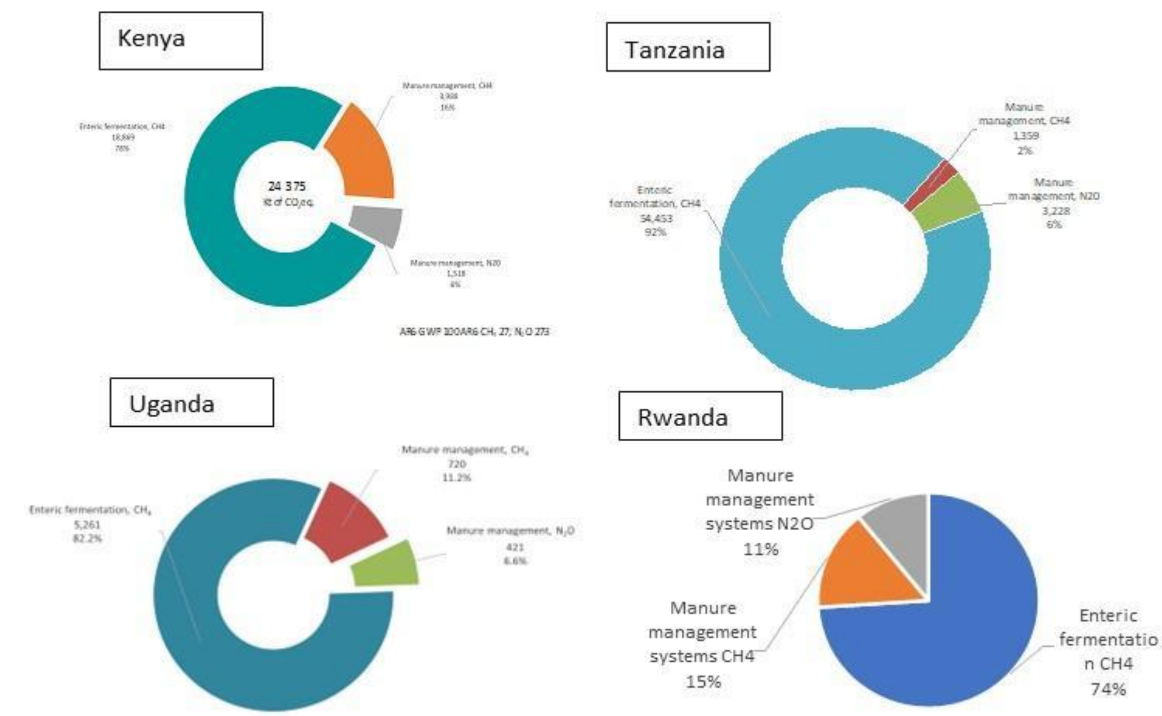


Figure 38: Sources of greenhouse gas emissions in Kilotonnes of CO2eq. and as a percentage of the total

[150] Republic of Rwanda. (2021). Rwanda's First Biennial Update under the United Nations Framework Convention on Climate Change. Republic of Rwanda

[151] IPCC. (2023). Summary for Policymakers. In: Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. (p. 36). Intergovernment Panel for Climate Change. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

121. The distribution of GHG emissions originating from dairy farming is predominantly influenced by the agro-ecological zoning depicted in Figure 39. This allocation aligns closely with the geographical distribution of dairy cattle populations.

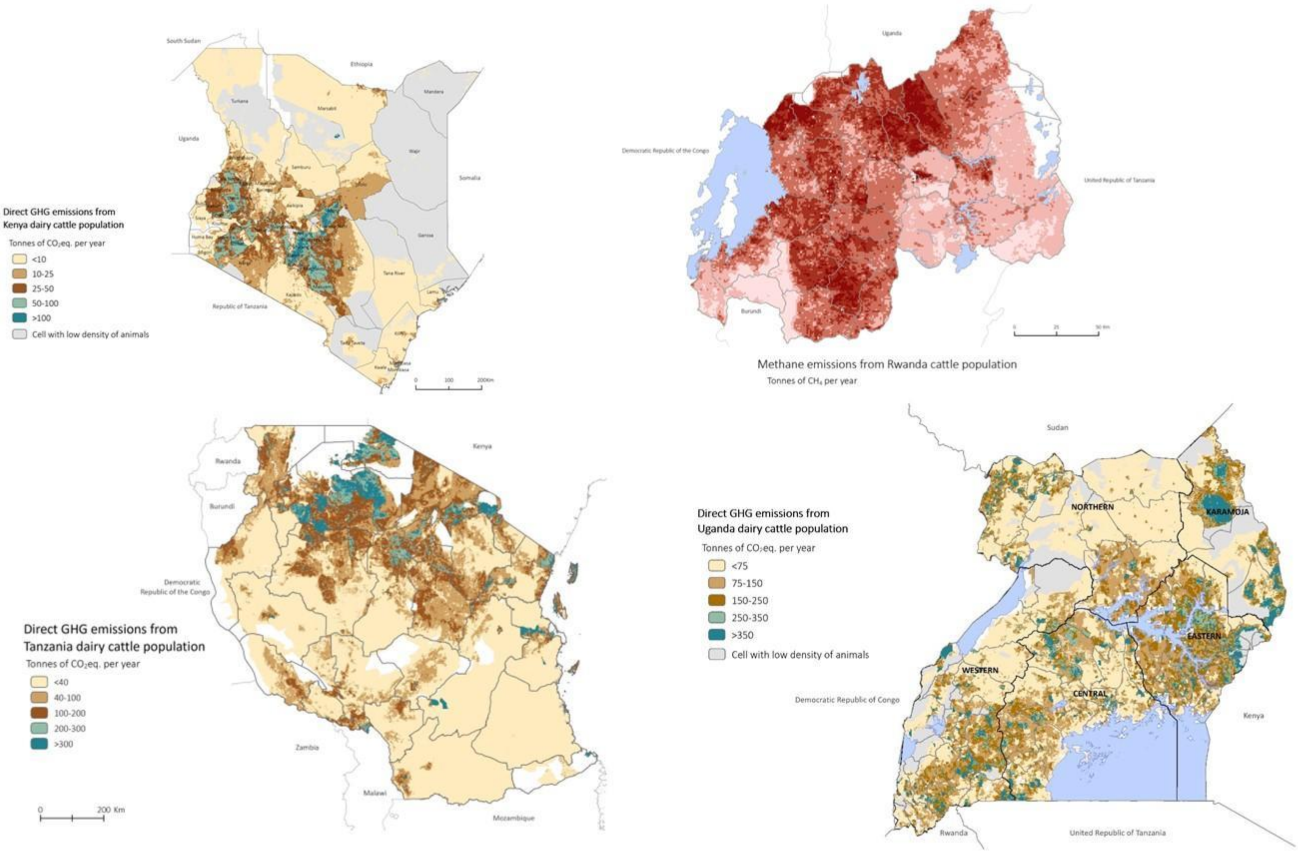


Figure 39: Regional distribution of total GHG emissions from cattle milk production

2.8.2 Methane emissions

122. In **Kenya**, across all production systems, methane (CH_4) emissions from enteric fermentation comprise the bulk of emissions (82 % of the total emissions). The contribution of each production system ranges from 8 to 23 % of total CH_4 emissions (Figure 40). The bulk of CH_4 emissions is highly related to the animal number and diet digestibility as well as feed resources used. Methane emissions from manure management systems are relatively low but are concentrated in intensive indigenous, exotic intensive and semi-intensive systems.

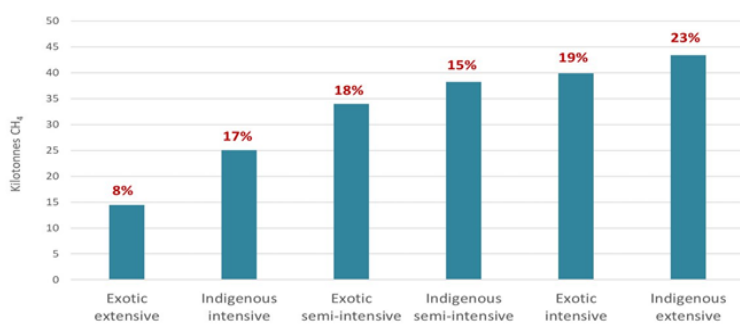


Figure 40: Methane emissions by production systems

123. The average absolute CH_4 production for indigenous dairy cows ranges from 110 to 170 g of CH_4 per day per head, whereas it ranges from 170 to 230 g of CH_4 per day for exotic dairy cows due to the difference in feed rations and gross energy intake (Figure 41). For other cattle categories (non-lactating), the average CH_4 production is less variable ranging from 110 to 150 g of CH_4 per day (Figure 41). Estimated CH_4 yield, defined as CH_4 emissions per kg of dry matter intake (DMI), ranged from 21 to 23 g of CH_4 per kg DMI for all dairy cattle categories across all production systems.

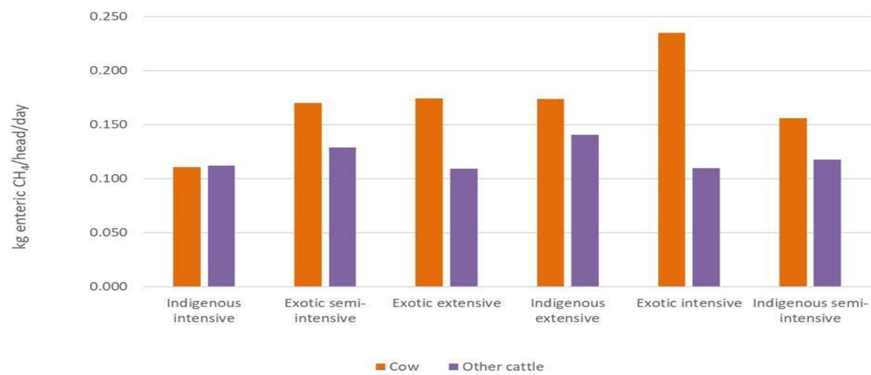


Figure 41: Enteric methane production for cow and other dairy cattle category (kg CH4/head/d)

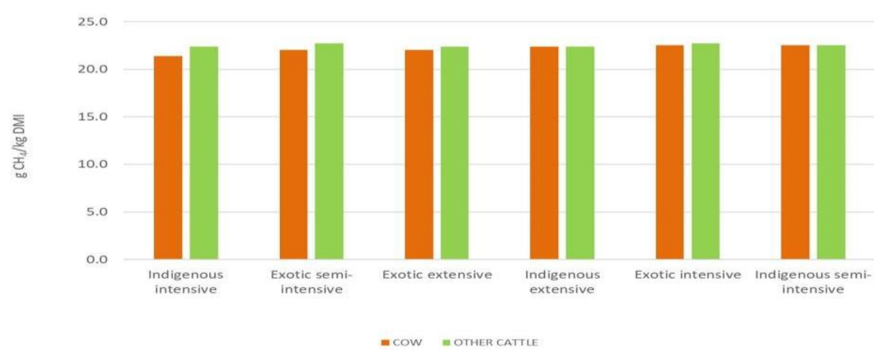


Figure 42: Enteric methane yield per cow and other dairy cattle category (gCH4/kg DMI)

124. In **Rwanda,** the on-farm CH_4 emissions represent 92% of total GHG emissions from dairy cattle systems in Rwanda. In detail, CH_4 emissions from enteric fermentation are evenly distributed across all the production systems. Crossbreed in zero-grazing system contributes about 59% to the absolute CH_4 emissions while the exotic dairy cattle in open grazing system have the lowest value of emissions of 0.3 % (Figure 43 panel a). Most of these emissions, accounting for 92%, are attributed to zero grazing practices. In contrast, open grazing contributes about 5%, whereas semi-grazing systems emit a minor share of 2% (Figure 43 panel a).

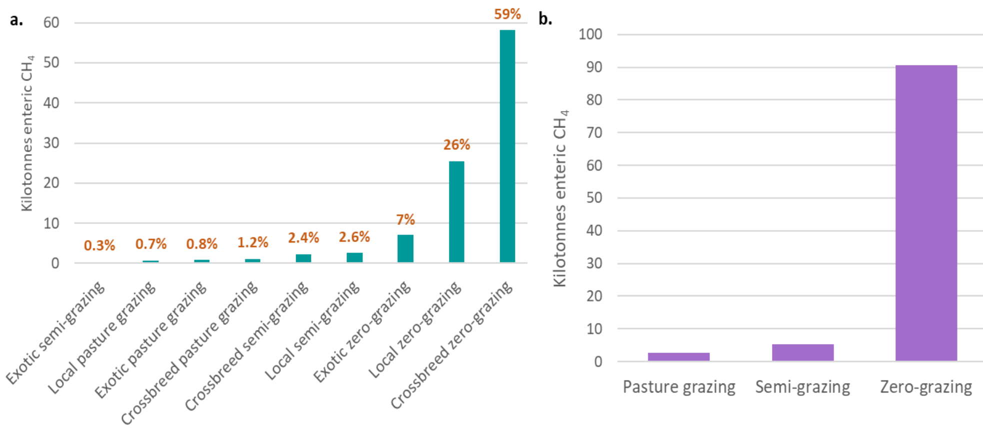


Figure 43: (a) Methane emissions from enteric fermentation by detailed production systems and (b) aggregated enteric methane emissions by broad systems

125. The contribution of different breeds to Rwanda's enteric CH_4 emissions from dairy cattle, with crossbreeds accounting for the largest share at 63% followed by local breeds contributing 29%, and exotic breeds contributing 8% (Figure 44, Figure 45, Figure 46, Figure 47) average enteric CH_4 production was estimated at 133 g CH_4/head/d for local cattle, 156 g CH_4/head/d for crossbreeds and 189 g CH_4/head/d for exotic cattle. Within the production systems, average enteric CH_4 productions were estimated at 147 g CH_4/head/d for zero-grazing, 207 g CH_4/head/d for semi-grazing and 202 g CH_4/head/d for pasture grazing system, respectively. Enteric methane production is within the range of values summarized in the study by Niu et al., (2018[152]). CH_4 yield estimated in this study ranges from 22.3 to 22.6 g CH_4/DMI for exotic cattle, 22.5 to 22.6 g CH_4/DMI for local cattle and from 22.5 to 22.7 for crossbreed cattle. CH_4 yield estimated in this analysis is in line with the meta-analysis conducted by Niu et al., (2018[153]).

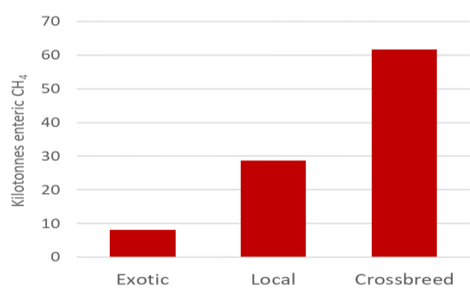


Figure 44: Emissions from enteric fermentation by breeds

[152] Niu, M., Kebreab, E., Hristov, A. N., Oh, J., Arndt, C., Bannink, A., Bayat, A. R., Brito, A. F., Boland, T., & Casper, D. (2018). Prediction of enteric methane production, yield, and intensity in dairy cattle using an intercontinental database. *Global Change Biology*, *24*(8), 3368–3389.
[153] Ibid.

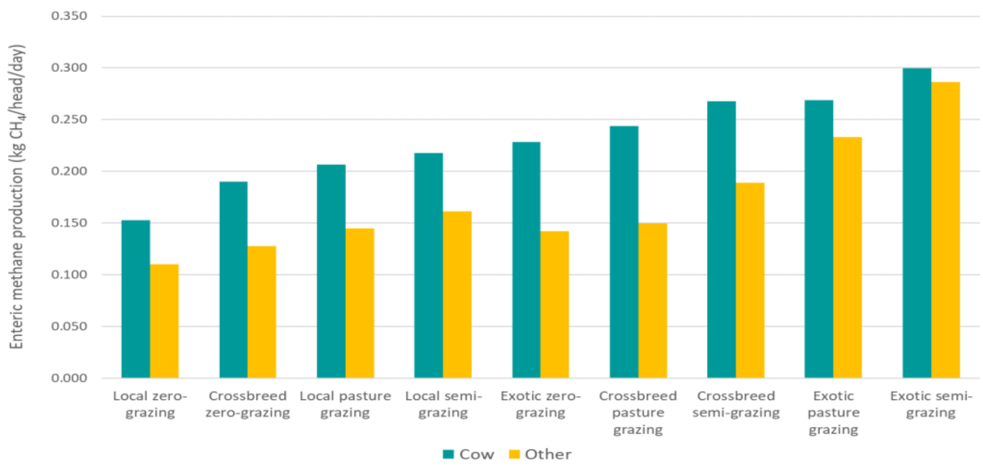


Figure 45: Average methane production for dairy cow and other cattle per day and production system

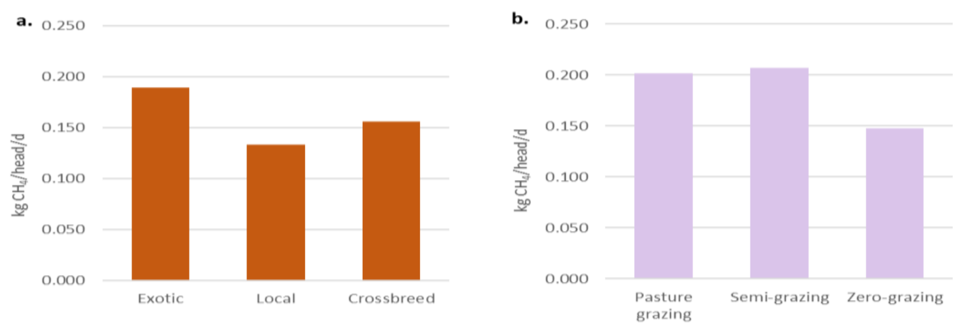


Figure 46: Average enteric methane production per (a) cattle breed and (b) dairy production system in Rwanda

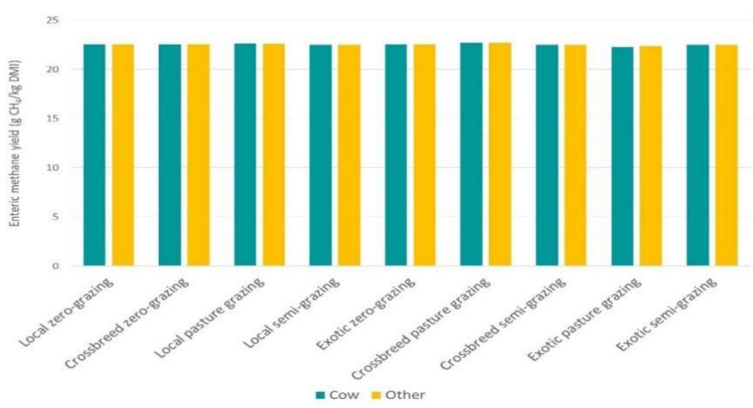


Figure 47: Average methane yield for dairy cows and other cattle by system

126. In **Tanzania**, the main source of CH_4 emissions is enteric fermentation which represents about 92% of total GHG emissions. Enteric CH_4 emissions, however, are associated with traditional dairy cattle systems (about 97%), whereas improved dairy systems contribute to about 3%. CH_4 emissions daily fluctuate between 180 and 280 grams, with the improved system emitting higher levels in contrast to the traditional system (Figure 48, Figure 49, Figure 50).

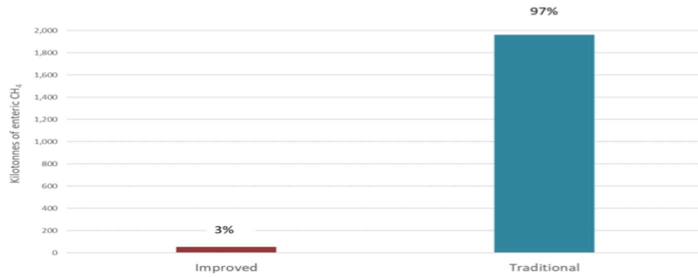


Figure 48: Enteric methane fermentations by dairy systems in Tanzania

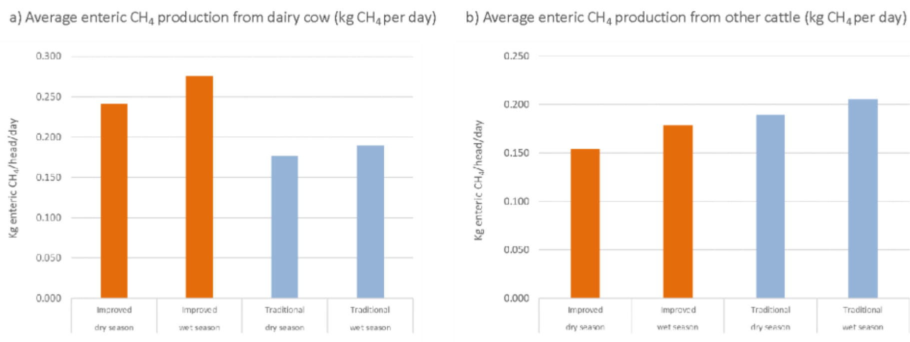


Figure 49: Average daily enteric methane production from dairy cow (a) and other cattle (b) by production systems and seasons

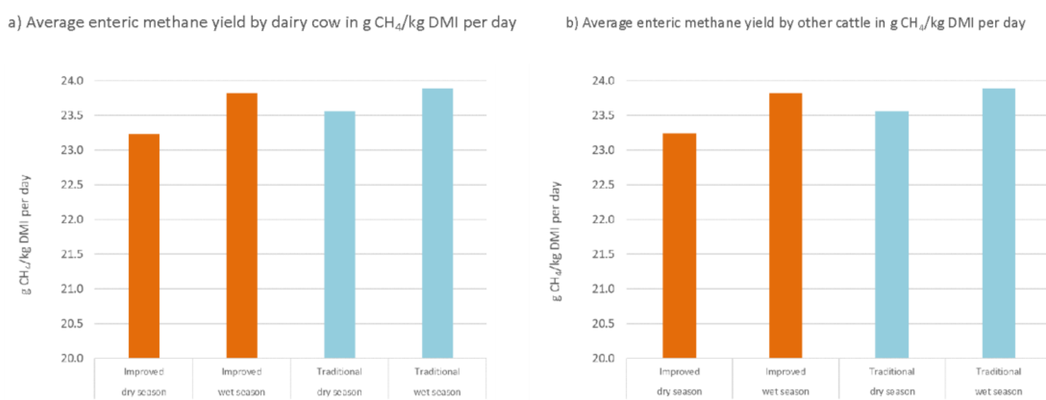


Figure 50: Average daily enteric methane yield from dairy cow (a) and other cattle (b) by production systems and seasons

127. In **Uganda,** most CH_4 emissions take place in agropastoral systems, followed by pastoral and medium-scale extensive systems. CH_4 production for dairy cows varies from 139 g in pastoral system to 473 g of CH_4 per day in large scale intensive systems (Figure 51, Figure 52, Figure 53). These findings are in line with CH_4 production reported in literature although measured on high-productive dairy cow (Niu et al., 2018[154]). Regarding other cattle, CH_4 production ranges from 96 g in pastoral systems to 136 g of CH_4 per day in large-scale intensive systems. CH_4 yield expressed in CH_4 emissions per unit of DMI ranges from 21-22.4 g CH_4 per kg DMI. Overall, CH_4 yield is similar across all production systems.

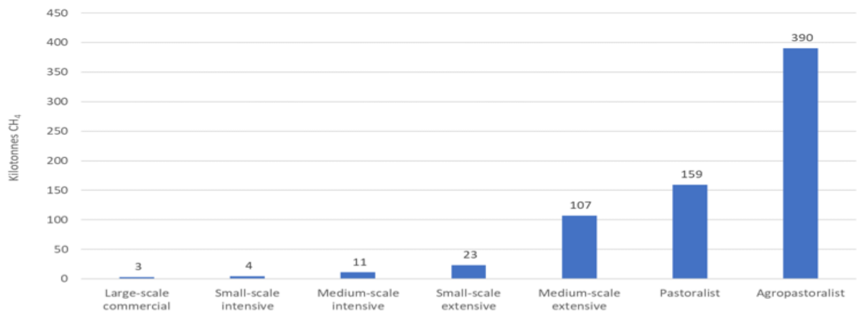


Figure 51: Absolute enteric methane emissions by dairy production systems in Uganda

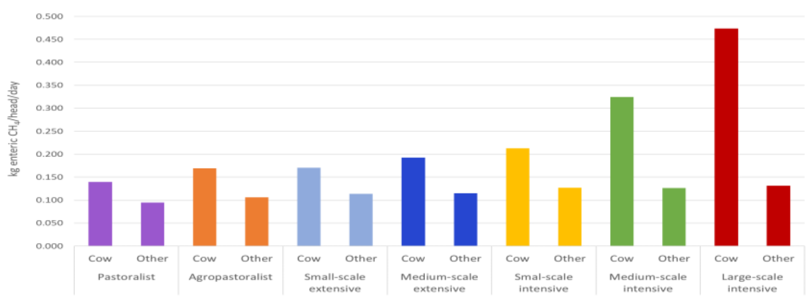


Figure 52: Average methane production per dairy cow and other cattle category by production systems in Uganda

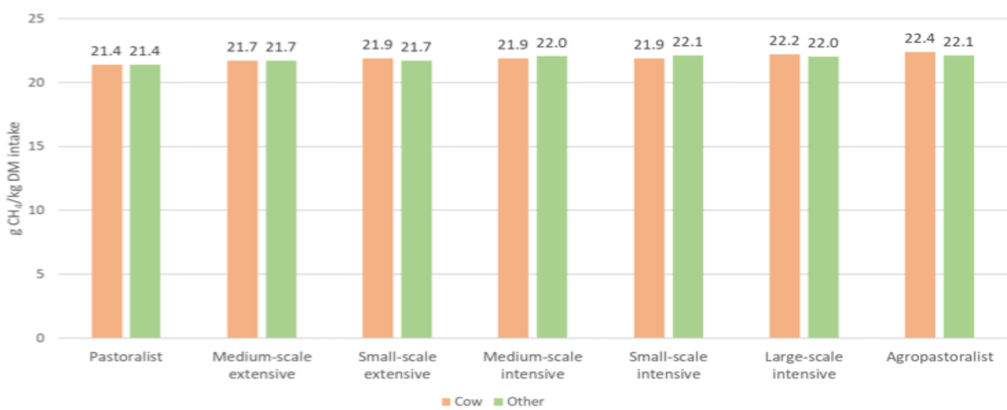


Figure 53: Average methane yield for dairy cow and other cattle category by production system

[154] Ibid.

2.8.3 *Enteric methane emission intensity*

128. In **Kenya**, At the national level, the enteric CH_4 emission intensity of milk produced in Kenya is on average 2 kg CO_2eq./kg milk; the highest values were estimated for extensive indigenous systems at 5 kg CO_2eq./kg milk and the lowest in the intensive exotic system at 1.4 kg CO_2eq./kg milk. Emissions intensities were on average higher for the indigenous systems (average 3.5 kg CO_2eq./kg milk) as compared to exotic systems (average: 1.5 kg CO_2eq./kg milk) because exotic breeds produce more milk per cow (Figure 54).

129. Overall, there is a wide variation in on-farm enteric CH_4 emission intensity by production system which is closely related to the diversity of the production and management practices within the dairy production systems.

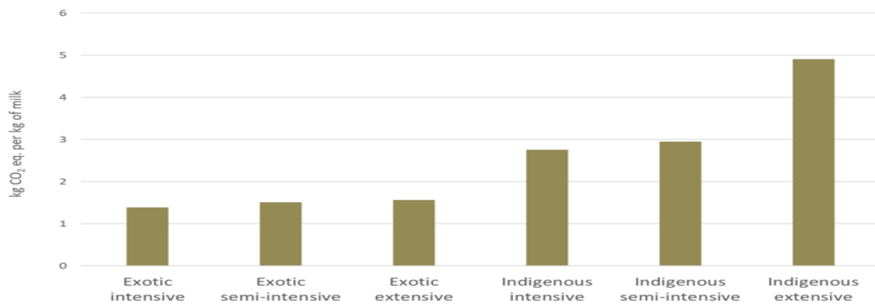


Figure 54: Enteric emission intensities per production system in Kenya

130. In **Rwanda**, considering that dairy cattle systems in Rwanda provide both meat and milk products for both local and international markets, the enteric CH_4 emission intensity, expressed per kilo of animal product, showed a variability of the environmental performance by systems and breeds with relatively low emissions for exotic and crossbreeds in zero grazing and pasture grazing systems as illustrated in Figure 55.

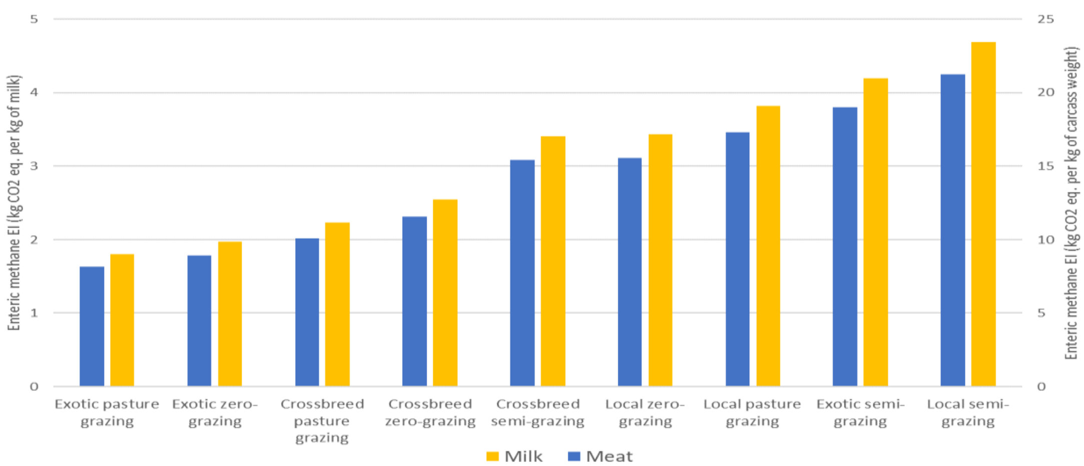


Figure 55: Enteric methane emission intensities for both milk and meat from dairy systems in Rwanda

131. In **Tanzania**, the intensity of enteric CH_4 emissions varies between 19 and 1.9 kilograms of CO_2eq. per kilogram of milk (Figure 56). Unlike CH_4 production, CH_4 intensity is notably elevated in the traditional system when compared to the improved system.

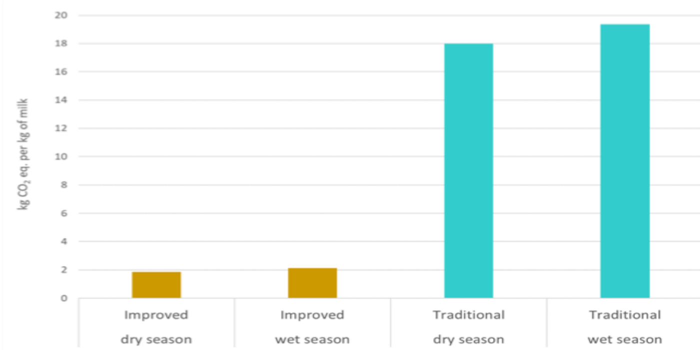
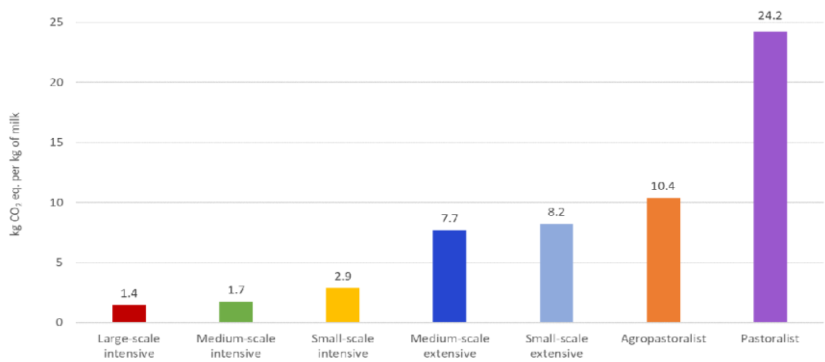


Figure 56: Enteric methane emission intensity by systems and by seasons (kg CO2eq. per kg of milk) in Tanzania

132. In **Uganda,** the emission intensity of milk produced at national level is on average 8 kg CO_2eq./kg milk; the highest values were estimated for the traditional systems (6 to 28 kg CO_2eq./kg) and the lowest for commercial systems (0.8 to 1.5 kg CO_2eq./kg milk) (Figure 57). At production system level there is a wide variation in emission intensity which is closely related to the level of productivity and feeding, and management practices adopted by each system. The highest value in emission intensity is observed for pastoral systems at 28 kg CO_2eq./kg milk. The existence of a wide variability is strong indication of the potential for reductions in GHG intensity of milk through the adoption of practices associated improvements in efficiency.



AR6 GWP 100 AR6 CH_4 27

Figure 57: Average enteric methane emission intensity per kg milk by production system in Uganda

2.9 BASELINE OF SOIL ORGANIC CARBON STOCKS

133. Soil carbon sequestration is one way to remove CO_2 from the atmosphere and bind it into stable soil fractions. It is estimated that soil C sequestration between 150 up to 700 Mt CO_2-eq year^{-1} could be achieved through changes in grazing management, with more than 80% of this soil C sequestration potential attributable to grazing areas in developing countries (Bai & Cotrufo, 2022[155]; Costa et al., 2022[156]).

134. Assessing the current state of grassland systems and their capacity to sequester carbon in the soil is, therefore, essential to understanding the trade-offs between grassland services on food security, biodiversity conservation, and climate mitigation, as well as how grassland management could be improved to meet climate targets (Dondini et al., 2023[157]). The analysis is done based on datasets provided by the Global Assessment of Soil Carbon in Grasslands including empirical and soil model approaches as defined by the FAO LEAP guidelines, and following the GSOC-MRV Protocol for measurement, monitoring, reporting, and verification of SOC in agricultural landscapes (Dondini et al., 2023[158]; FAO, 2020[159]). The FAO LEAP guidelines provide methodology to model SOC stocks and changes in livestock production systems (FAO, 2019[160]).

135. Soils of rangelands and pastures stored an estimated 18.58 Mt, 16.88 Mt, 2.65 Mt, and 0.22 Mt of organic carbon at 30 cm depth in the year 2010, respectively, in Kenya, Tanzania, Uganda, and Rwanda. Rwanda presented the greatest average amount of SOC stock on surface unit basis, estimated at 75.99 tC/ha, followed by Tanzania (65.19 tC/ha), Uganda (50.80 tC/ha), and Kenya (41.93 tC/ha). In Rwanda, average SOC stocks in mixed crop-livestock production systems, rainfed, located in humid and sub-humid climate (76 tC/ha) and temperate and tropical highlands climate (80.68 tC/ha) presented the highest average values compared to the other LPS. These high values correspond to high activity clay (HAC) soil type (Umbrisol, Cambisols, Regosols, Leptosol, Vertisols) and volcanic soils (Andosols). In Tanzania, mixed crop-livestock production systems, located in irrigated land, and in ASAL areas presented the highest SOC stocks (78.10 tC/ha) followed by the mixed crop-livestock production systems located in rainfed land, and in temperate and tropical highlands (70 tC/ha). These high values correspond to HAC soil type (Luvisols, Leptosols, Cambisols) and volcanic soils (Andosols). The lowest SOC stocks were observed in Kenyan rangeland associated with mixed (39 tC/ha) and grassland-based (43 tC/ha) LPSs, located in ASAL areas (Figure 58).

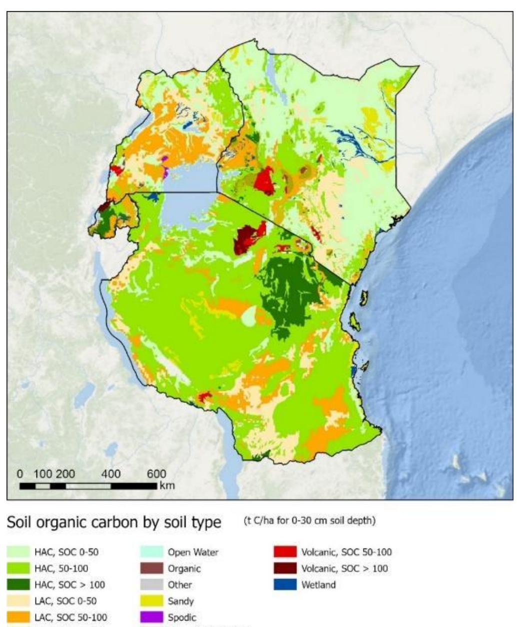


Figure 58: Soil organic carbon stock baseline according to the main soil types encountered in the countries

155 Bai, Yongfei & Cotrufo, M. Francesca. (2022). Grassland soil carbon sequestration: Current understanding, challenges, and solutions. Science (New York, N.Y.). 377. 603-608. 10.1126/science.abo2380.

2.10 IMPACTS OF CLIMATE CHANGE ON THE DAIRY SECTOR

2.10.1 Heat stress and impacts on milk production

136. The most anticipated direct impact of climate change on dairy production along the targeted countries is heat stress. This is because dairy production in these countries is mainly small-holder low input system where animals are directly exposed to climate variables. Heat stress on animals is considered when the body temperature of dairy cattle rises above their normal range due to their exposure to excessive heat and humidity. It occurs when the animal's ability to dissipate heat is compromised, leading to various physiological and behavioural changes. This normal range is known as the thermoneutral zone (TNZ). Within this temperature range, dairy cows require no additional energy above maintenance to cool or heat their body. The TNZ depends on the age, breed, feed intake, diet composition, previous state of temperature acclimatization, production, and housing and stall conditions, tissue insulation (fat and skin), external insulation (coat), and animal's behaviour. Dairy breeds display differences in the ability to maintain a relatively constant internal body temperature regardless of the external environmental conditions due to several temperature-regulating mechanisms.

137. The degree to which heat stress causes hyperthermia and other changes in physiological function is determined to some extent by the animal genetics and the conditions of the cow. During heat stress, several physiological and behavioural responses happen through the integration of many organs and systems, namely behavioural, endocrine, cardio-respiratory, and immune system. These responses vary in intensity and duration depending on the animal's genetic make-up and environmental factors. The physiological responses include sweating, high respiration rate, vasodilation with increased blood flow to skin surface, elevated rectal temperature, reduced metabolic rate, decreased dry matter intake, efficiency of feed utilization and altered water metabolism (Ganaie, 2013[161]). These responses will affect the production and productivity of dairy animals.

138. Annual-averaged THI results shows that moderate stress (79 < THI < 89) is observed across Uganda, Kenya, and the eastern and western regions of Tanzania from 1981 to 2016 (Figure 59). In these areas, elevated THI is likely to have affected milk production and reproductive parameters. Climate projections indicate a significant increase in moderate THI stress, particularly under RCP 8.5. High-producing dairy cattle have increased sensitivity to heat stress, compared with lower-producing cows (Kadzere et al. 2002[162]). Cows with greater milk production potential have greater feed intake, and thus higher metabolic heat production through processes such as body tissue synthesis and milk secretion and lower yielding breeds. Response to heat stress by decreasing their feed intake gradually results in lower milk yield (Figure 60). Even among the exotic breeds the impact of heat stress on milk production is varied. Smith et al. (2013[163]) found that *Holstein* milk yield and fat percentage declined during moderate and severe heat stress climatic conditions in comparison to *Jersey* cows.

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[156] Costa, Joana & Silva, Joaquim & Deus, Ernesto & Pinho, Simão & Pinto, Joaquim & Borralho, Nuno. (2022). Costa et al. 2022 The Genetics and Ecology of Post-Fire Eucalyptus globulus recruitment in an isolated stand in Central Portugal. Forests. 13. 680. 10.3390/f13050680.
[157] Dondini, M., Martin, M., De Camillis, C., Uwizeye, A., Soussana, J.-F., Robinson, T. & Steinfeld, H. (2023). Global assessment of soil carbon in grasslands – From current stock estimates to sequestration potential. FAO Animal Production and Health Paper No. 187. Rome, FAO. https://doi.org/10.4060/cc3981en
[158] Ibid.
[159] FAO (2020). A protocol for measurement, monitoring, reporting and verification of soil organic carbon in agricultural landscapes – GSOC-MRV Protocol. Rome, FAO. https://doi.org/10.4060/cb0509en
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[161] Ganaie, A.H.et al.(2013). Biochemical and physiological changes during thermal stress in bovines: A Review. Iranian Journal of Applied Animal Science, 3, 423-430.
[162] Kadzere, C. et al. (2002). Heat stress in lactating dairy cows: a review. Livestock Production Science, 77(1), 59–91.
[163] Smith, D. L.et al2013).Short communication: Comparison of the effects of heat stress on milk and component yields and somatic cell score in Holstein and Jersey cows. J. Dairy Sci. 96, 3028–3033

139. Multiparous cows are more resistant to heat stress than primiparous cows (Collier et al. 2008[164]; Gantner, 2017[165]; Gantner et al. 2017[166]). Heat stress in dairy cows' results in greater nutritional requirements, lower fertility, reduced milk production and milk quality, and increased frequency of health-related issues such as mastitis. Pre-feasibility Study 3 provides detailed information on the impacts of heat stress on dairy cattle in the target countries.

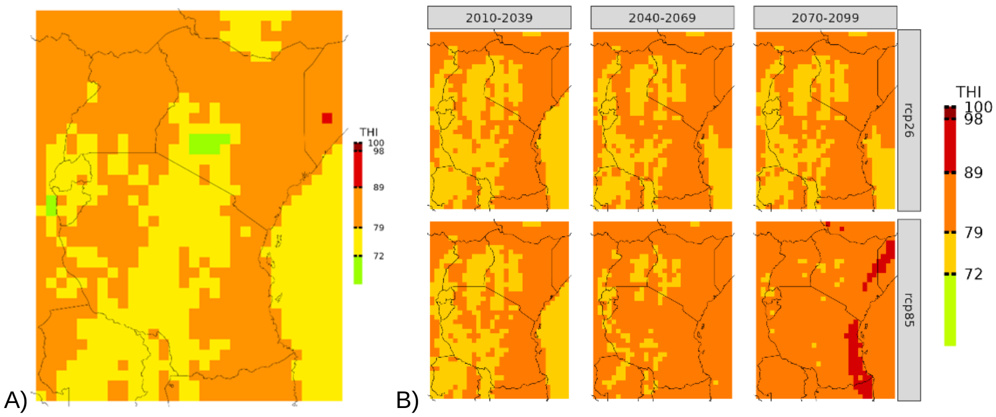

Figure 59: THI classes (no stress: THI <72; slight/mild stress: THI >72 and <79; moderate stress: THI >80 and <89; severe stress: THI >90 and <98; extreme stress: >98) over (a) 1981-2016 and (b) over the 21st century from historical period (1976-2005)

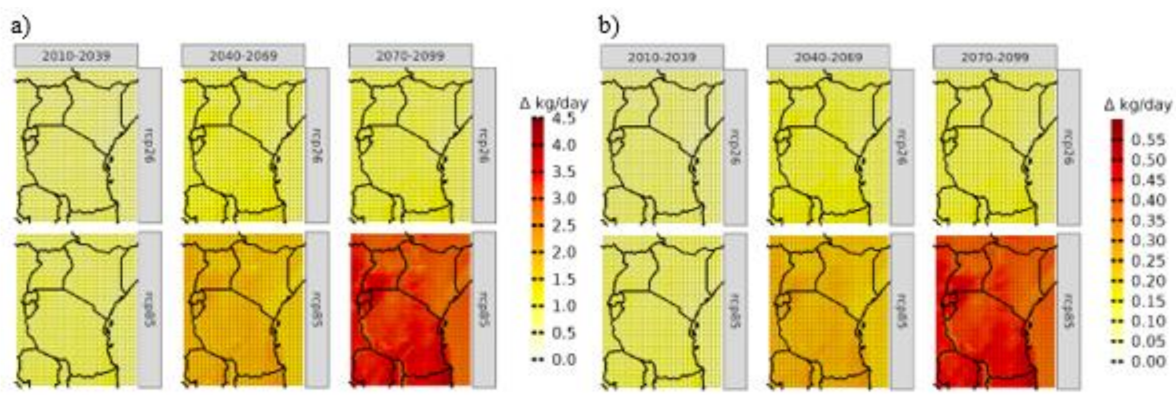

Figure 60: Changes in milk production (kg/day) on annual average for the (a) Holstein Friesian and (b) Boran breeds (under pastoral conditions) over the 21st century from historical period (1976-2005)

For future simulations, a multi-model ensemble mean of 3 GCMs downscaled with REMO2015.

[164] Collier, R.et al. (2008). Effects of climate change on dairy cattle production. Annals of Arid Zone, 47(3–4).
[165] Gantner, V. (2017a). The differences in heat stress resistance due to dairy cattle breed. Mljekarstvo.
[166] Gantner, V.et al. (2017b). Differences in response to heat stress due to production level and breed of dairy cows. International Journal of Biometeorology, 61(9).

140. Although the greatest detrimental consequence of heat stress is thought to be decreased milk production in cows, and this effect is generally noticeable in terms of economic impacts within a few days, breeders may have to worry more about reproductive disorders. Fertility is influenced by heat stress; however, problems with fertility only become apparent over time, negatively affecting fertility by limiting the reproductive capacity of animals through decreasing insemination effectiveness. Heat stress makes it difficult to identify oestrus in cows. It also increases calving difficulties, postpartum paralysis, more stillbirths, and uterine mucous membrane irritation (St-Pierre et al. 2003). Heat stressed cows may not display the usual signs of heat, leading to missed mating or insemination. Missing an oestrus period is costly for producers because of consequent income losses due to unexploited potential milk production and or calf production. These losses are caused by prolonged calving intervals, and expenditure on replacement heifers and on infertile inseminations. Postpartum heat stress builds a negative energy balance that can also encourage the development of ovarian cysts, interfere with the growth of germinal vesicles, affect steroid concentration, potentially resulting in embryonic death, besides lowering sperm production in stud bulls (Wathes & Diskin, 2021).

141. Lastly, high temperatures will further create a conducive environment for rapid multiplication and growth of bacteria and moulds (Guzmán-Luna et al. 2021[167]). This is particularly important in warm environments and where unsuitable containers such as plastics (which cannot be properly sterilized) and uninsulated containers are used during transportation and storage stages. Food safety risks and losses are expected to be higher during the wet season due to the proliferation of mould and fungi. Extreme rainfall events and flooding may damage road infrastructure and reduce access to milk storage, processing, and marketing facilities, leading to milk spoilage, thus reducing sales and dairy farmers' income (Mwongera et al. 2019[168]). Drought may lead to inadequate supply of water to be used for sanitation along the value chain.

2.10.2 Impacts of climate change on feed, fodder and grazing resources

142. Feed shortage especially during the dry season is a major constraint in dairy production in East Africa, leading to high milk production fluctuations due to farmers' dependence on rainfall for feed production. The most obvious impact of climate change on ruminant feed supplies is in the changes in the primary productivity of cereals used in the dairy sector, forages, and rangelands. Indirectly, climate change may impact the quantity and quality of livestock feeds due to CO_2 enrichment. Positive effects on legumes under unstressed conditions are expected, whereas a small effect on C4 crops is envisaged due to improved water use efficiency and changes in temperature. These positive impacts are, however, small and easily offset by the negative impacts of high temperatures and or water scarcity due to droughts and prolonged dry spells.

143. The major impacts on feed crops and grazing systems include: (i) changes in temperature and atmospheric CO_2 concentrations that impact herbage growth, (ii) modifications in the composition of pastures, such as shifts in the proportion of grasses to legumes, (iii) changes in the quality of the herbage, such as variations in the concentrations of nitrogen and water-soluble carbohydrates at certain dry matter levels, (iv) more frequent droughts, which might cancel out any gains in dry matter output, and (v) more intense rainfall, which might cause nitrogen leaching in some systems to raise. Table 6 describes the impacts of climate change on some crops used as dairy feed in the region.

Table 6: Climate change impacts on some crops often used as dairy feed in the region

	Main climatic drivers				**Projected impacts**
	High temperatures	**Water stresses (drought and flooding)**	**Pests and diseases**	**CO2effect**	

[167] Guzmán-Luna, P. & Mauricio-Iglesias, Miguel & Flysjö, Anna & Hospido, Almudena. (2021). Analysing the interaction between the dairy sector and climate change from a life cycle perspective: A review. Trends in Food Science & Technology. 126. 10.1016/j.tifs.2021.09.001.

[168] Caroline, Mwongera & Nowak, Andreea & Notenbaert, An & Grey, Sebastian & Osiemo, Jamleck & Kinyua, Ivy & Lizarazo, Miguel & Girvetz, Evan. (2019). Climate-Smart Agricultural Value Chains: Risks and Perspectives: Investigating the Business of a Productive, Resilient and Low Emission Future. 10.1007/978-3-319-92798-5_20.

Maize	Warmer temperatures accelerate maize's development rate resulting in shorter vegetative and reproductive phases. Heat stress is a main threat to current and future global maize production. Heat stress (Tmax ≥36ºC) may cause a reduction in yields via pollen viability that in turn determines the kernel number.	Water deficit stresses at flowering and grain-filling stage leads to significant yield penalty, especially among non-drought tolerant lines.	Maize streak virus (virus transmitted by leafhoppers, mainly *Cicadulina mbila)*, *Aspergillus flavus, A. fungus* (aflatoxin producer), *Fusarium verticillioides* (fumonisin producer) may increase under rising temperatures	As a C4 crop, leaf photosynthesis can decline in a CO2 enriched environment and, thus, result in yield decline.	Crop models show that Africa is likely to suffer up to 10% yield losses in maize by 2055 due to climate change. Pests such as Fall Army Worm may become more prevalent.
Sorghum	Simulation studies have shown that temperature is a dominant driver of the global climate change influencing future sorghum productivity. Heat stress conditions (Tmax ≥32ºC) during flowering may result in a yield decline	Water stresses during the vegetative stage can reduce sorghum yields	Rising temperatures may accelerate life cycle of pests and diseases (e.g., *Sporisorium holci-sorghi* also known as sorghum head smut) affecting sorghum.	Increase in water demand for sorghum production is likely in a CO2 enriched environment.	Sorghum is a more climate resilient crop than other crops grown in the region. A slight/moderate yield decrease is expected under climate change.
Lucerne	Increased temperatures may reduce photosynthetic capacity and increased leaf dark respiration.	Drought may limit water availability for irrigation and negatively impact biomass production, morphology, and nutritional quality of herbage.	Impact is variety specific. The impacts could either reduce or enhance resistance to aphids, due to quantitative and qualitative changes in foliar amino acids.	For aphids, there is a variety of specific changes in response to elevated CO2.	Drought may be the major driver of nutritional and morphological changes under climate change.

References maize: Cooper & Law (1977[169]); Jones & Thornton (2003[170]); Paudel Timilsena et al. (2022[171]); Sah et al. (2020[172]); Stuch et al. (2020[173]); Vanaja et al. (2017[174]);

[169] Cooper, P. J. M., & Law, R. (1977). Soil temperature and its association with maize yield variations in the Highlands of Kenya. The Journal of Agricultural Science, 89(2).
[170] Jones, P. G., & Thornton, P. K. (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. In Global Environmental Change (Vol. 13, Issue 1, pp. 51–59). Elsevier Ltd.
[171] Paudel Timilsena, B.et al. (2022). Potential distribution of fall armyworm in Africa and beyond, considering climate change and irrigation patterns. Scientific Reports, 12(1).
[172] Sah, R. et al. (2020). Impact of water deficit stress in maize: Phenology and yield components. Scientific Reports, 10(1).
[173] Stuch, B.et al.(2020). Projected climate change impacts on mean and year-to-year variability of yield of key smallholder crops in Sub-Saharan Africa. Climate and Development.
[174] Vanaja, M., et al.(2017). Elevated temperature and moisture deficit stress impact on phenology, physiology and yield responses of hybrid maize. Journal of Agrometeorology, 19(4), 295–300.

References sorghum: Adhikari et al. (2015[175]); Bosire et al. (2018[176]); Getachew et al. (2021[177]) ; lucerne: Johnson et al. (2014[178]); Jacob et al. (2020[179]); Catunda et al. (2022[180]);Peixoto et al. (2022[181])

144. The impacts on fodder crops (maize and Napier grass) are based on simulated agroclimatic potential yields (kg/ha) emerging from the Python Package for Agro-ecological zoning (PyAEZ) tool developed by FAO. Pre-feasibility Study 3 provides detailed description of the methodology.

145. Maize is a versatile multi-purpose crop, primarily used as a feed globally, but also as an important food crop, especially in Sub-Saharan Africa, being Kenya and Tanzania the 6th and 9th highest maize consumers per capita in Africa (Ranum et al. 2014[182]). The key energy sources in maize are digestible fiber and starch. Maize starch supplies a combination of rumen fermentable energy, which fuel the microbial population and rumen bypass starch, which is converted into glucose that is then absorbed and utilized by the animal. In the dairy industry, maize is used as a basal feed and source of fiber, carbohydrates, and protein. Heat stress is a main threat to current and future global maize production. Warmer temperatures accelerate the development rate, resulting in shorter vegetative and reproductive phases. Maize grain yield is reduced mainly via pollen viability that in turn determines kernel number (Lizaso et al. 2018)[183]. Water deficit stresses at flowering and grain filling stage leads to significant yield penalty, especially among non-drought tolerant lines than in drought tolerant lines (Sah et al., 2020[184]; Vanaja et al. 2017[185]). Jones & Thornton (2003)[186] demonstrated that Africa is likely to suffer up to 10% yield losses in maize by 2055 due to climate change.

[175] Adhikari, U.et al. (2015). Climate change and eastern Africa: A review of impact on major crops. In Food and Energy Security (Vol. 4, Issue 2).
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[178] Johnson, S. N. et al. (2014). Global climate change and crop resistance to aphids: Contrasting responses of lucerne genotypes to elevated atmospheric carbon dioxide. Annals of Applied Biology, 165(1).
[179] Jacob, V. et al. (2020). Warming reduces net carbon gain and productivity in medicago sativa l. And festuca arundinacea. Agronomy, 10(10 October).
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[181] Peixoto, L. et al. (2022). Deep-rooted perennial crops differ in capacity to stabilize C inputs in deep soil layers. Scientific Reports, 12(1).
[182] Ranum, P. et al. (2014). Global maize production, utilization, and consumption. Annals of the New York Academy of Sciences, 1312(1).
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[184] Sah, R. et al. (2020). Impact of water deficit stress in maize: Phenology and yield components. Scientific Reports, 10(1).
[185] Vanaja, M., et al. (2017). Elevated temperature and moisture deficit stress impact on phenology, physiology and yield responses of hybrid maize. Journal of Agrometeorology, 19(4), 295–300.
[186] Jones, P. G., & Thornton, P. K. (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. In Global Environmental Change (Vol. 13, Issue 1, pp. 51–59). Elsevier Ltd.

146. Figure 61 shows the areas in East Africa with highest potential to sustain maize yields under rainfed conditions both in the present (1981-2016) and in the future periods (2031-2060 and 2061-2090) for RCPs 2.6 and 8.5. Figure 61a shows that the west of Tanzania (e.g., Kigoma, Kagera, Geita, Shinyanga, Tabora, Katavi, Rukwa, Songwe and Mbeya), the West and the Central regions of Uganda, and the north of Kenya (e.g., counties of Turkana, West Pokot, Baringo and Lakipia) have the highest yield potential (denoted in green colors) in the baseline period (1981-2016). On the contrary, both the east and south of Tanzania (e.g., Ruvuma, Mtwara, Lindi, Pwani, and Morogoro, among others) and Kenya (e.g., Garissa, Kilifi, and Kwale) have the least yield potential in the baseline period (1981-2016). In addition, the yield change for different RCPs and time-horizons is displayed in Figure 61b. The north of Kenya and Uganda are likely to experience the greatest yield change in the mid-term (2031-2060) and far-future (2061-2090) in both RCPs. In these areas (e.g., Northern region of Uganda and Turkana, Marsabit, Samburu, Isiolo, Wajir, and Mandera counties in Kenya) maize yields are likely to experience a decline of -5 to -15% under RCP 2.6, and of -20 to -25% under RCP 8.5 in the far-future (2061-2090). On the other hand, in the Central, Western and Eastern regions of Uganda, the entire Rwanda, as well as most of Tanzania (except the north) may experience an increase in yields both in the mid-term (2031-2060) and far-future (2061-2090) for both RCPs.

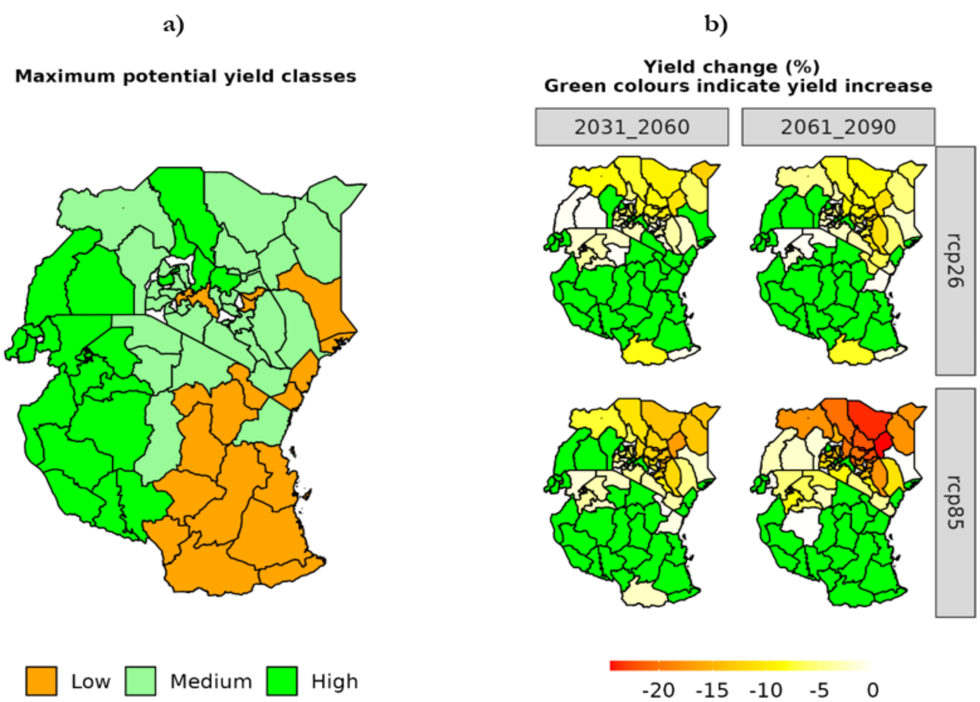

Figure 61: (a) Maximum potential yield classes for maize in the baseline period (1981-2016) and (b) projected yield changes (%) under rainfed conditions over the 21st century

147. Napier grass (Pennisetum purpureum) is a fast-growing perennial grass native to Sub-Saharan Africa. It is a multipurpose forage crop, primarily used for feeding cattle in cut and carry feeding systems (Negawo et al. 2017)[187]. Because most smallholder livestock producers predominantly own small and fragmented pieces of land, grasses such as Napier grass offer a best-fit alternative to other feed options, as these are high yielding forages which require a minimum number of inputs and acreage. Napier grass, with its perennial nature and fast-growing characteristics, has been reported to produce a dry matter yield of up to 78 tons/ha on annual average (Oliveira et al. 2014). However, according to the existing literature, the potential to use Napier grass as a climate-smart forage crop has not been fully investigated.

[187] Negawo, A. et al. (2017). Opportunities for Napier grass (Pennisetum purpureum) improvement using molecular genetics. Agronomy, 7(2), 28.

148. Figure 62 shows the areas in East Africa with highest potential to sustain Napier grass yields under rainfed conditions both in the present (1981-2016) and in the future periods (2031-2060 and 2061-2090) for RCPs 2.6 and 8.5. Most of Uganda and Kenya are classified as medium potential yield classes in the baseline period (1981-2016), whereas some parts of Rwanda and the southwest of Tanzania as high. Conversely, the east and north of Tanzania (e.g., Ruvuma, Mtwara, Lindi, Pwani, Mara, Manyara, among others) are classified as low. Under RCP 8.5, Napier grass yield losses are extended to all studied sites, though with some spatial differences that deserve attention. For example, Napier grass yields are likely to decline mostly in Uganda (e.g., North region by more than -30%), the north of Kenya (e.g., Turkana, Marsabit, and Isiolo counties by -30%), and the southeast of Tanzania (e.g. Mtwara, Ruvuma, and Pwani by -20 to -30%). Under RCP 8.5, the Napiergrass yield losses are lower (0 to -10%) in the southwest of Tanzania both in the mid-term (2031-2060) and into the future (2061-2090).

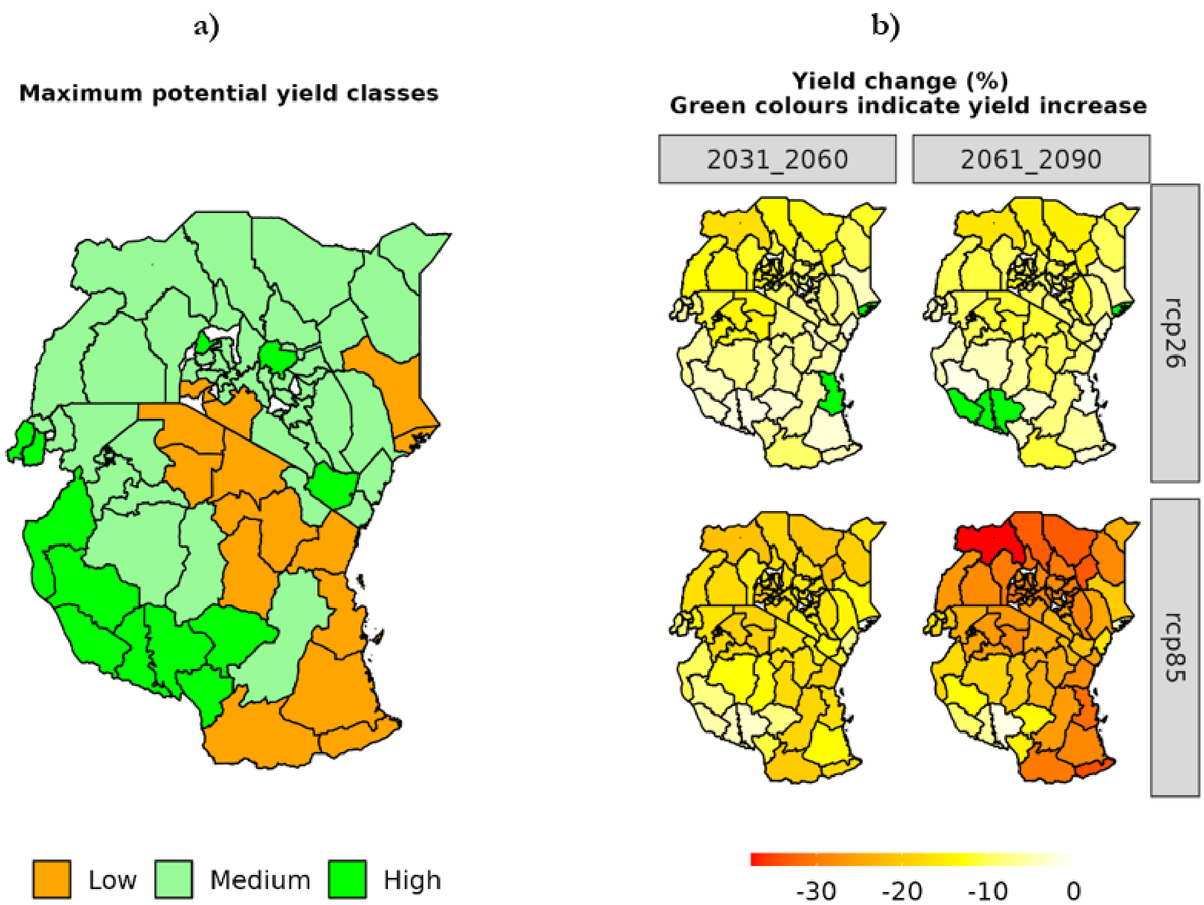

Figure 62: (a) Maximum potential yield classes for Napier grass in the baseline period (1981-2016) and (b) projected yield changes (%) under rainfed conditions over the 21st century

2.10.3 Impacts of climate change on animal diseases

149. Climate change influences the emergence and proliferation of disease hosts, vectors, and pathogens and their breeding, development, and disease transmission. Consequently, it affects distributions, host-parasite relationships, and its assemblages to new areas. Climate change is likely to affect the health of animals greatly, both directly and indirectly (Abdela and Jilo, 2016[188]). The direct effects of climate on animal disease are likely to be more pronounced for vector- borne diseases, soil associated, water or flood associated, rodent associated, or air temperature/humidity associated and sensitive to climate (Grace et al 2015[189]). Indirect impacts follow more complex pathway, especially those deriving from the attempt of animals to adapt to thermal environment or from the influence of climate on microbial populations, distribution of vector-borne diseases and host resistance to the distribution of vector-borne diseases and food-borne diseases (Yatoo et al 2012[190]).

150. *Effects on Pathogens.* Increased temperature will have effect on some pathogens and parasites in that it causes, increased development on their life cycle outside their hosts. This will reduce their generation time and hence have more generations per year resulting into higher number of pathogens/parasites which predicts more infections (Kimaro and Chibinga 2013[191]). However, there are some pathogens/parasites that are sensitive to higher temperature and will affect their survival. Another effect to consider is moist and dry conditions. Pathogens and parasites that are sensitive to moist or dry conditions will be affected by changes to precipitation, soil moisture and the frequency of floods. Changes to winds could affect the spread of certain pathogens as well (Kimaro and Chibinga 2013[192]).

151. *Effects on effects on the vectors.* Changes to temperature and moisture will also lead to increases or decreases in the abundance of many disease vectors. For example, biting midges and mosquito-borne diseases outbreaks have been linked to the occurrence of ENSO (Anyamba et al 2002[193], Gagnon et al [194]). Increase in temperature will alter the balance between lifespan and the Extrinsic Incubation Period (EIP), increasing or decreasing the proportion of infected vectors that live long enough to transmit the infection forward. This effect will be most important for short-lived vectors such as biting midges and mosquitoes (Lines J 1995[195]).

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[188] Abdela N, Jilo K. Impact of Climate Change on Livestock Health: A Review', Global Veterinaria.2016.
[189] Grace D, Bett B, Lindahl J, Robinson T. Climate and livestock disease: assessing the vulnerability of agricultural systems to livestock pests under climate change scenarios. CCAFS Working Paper. 2015
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[194] A S, Smoyer-Tomic K E and Bush A B G 2002 The El Nino Southern Oscillation and malaria epidemics in South America. International Journal of Biometeorology 46, 81-89
[195] Lines J 1995 The effects of climatic and land-use changes on insect vectors of human disease. In: Harrington, R., Stork, N.E. (Eds.) Insects in a Changing Environment. Academic Press: London, 157-175

152. *Effects on hosts.* According to Aucamp 2003[196] and de Gruijl et al 2003[197] mammalian cell immunity level may be suppressed following a sharp exposure of ultraviolet B (UV-B) as a result of expected ozone layer depletion. Biologically, there is depletion in specific Lymphocyte cells and for that reason animals become susceptible to some pathogens such as viruses; rickettsia (such as *Cowdria* and *Anaplasma*, and some bacteria, such as *Brucella (*Kimaro and Chibinga, 2013[198]). Another host related effect is "endemic stability" of animals. This means the infection is common and there is lifelong immunity after infection, also occurs when the disease is less severe in younger than older individuals. Tick borne diseases such as anaplasmosis, babesiosis and cowdriosis, show endemic stability (Eisler et al [199]). If climate change drives such diseases to new areas, non-immune individuals of all ages in these regions will be newly exposed, and outbreaks of severe disease could follow.

153. *Effect on epidemiology.* Climate change will alter transmission rates between hosts by affecting the survival of the pathogen/parasite or the intermediate vector, but also by other, indirect, forces that may be hard to predict with accuracy for example, a series of droughts in East Africa between 1993 and 1997 resulted in pastoral communities moving their cattle to graze in areas normally reserved for wildlife. This resulted in cattle infected with a mild lineage of rinderpest transmitting disease both to other cattle and to susceptible wildlife such as buffalo and impala, causing severe disease, and devastating certain populations (Kock et al. 1999[200]). Climate change will affect the abundance or distribution of hosts or the competitors, predators, and parasites of vectors and influence patterns of disease in ways that cannot be predicted from the direct effects of climate change alone. Climate change-related disturbances of ecological relationships, driven perhaps by agricultural changes, overgrazing, deforestation, construction of dams and loss of biodiversity, could give rise to new mixtures of different species/strains, thereby exposing hosts to novel pathogens and vectors and causing the emergence of new diseases (WHO, 1996[201]).

154. *Non vector borne diseases.* The effect of climate change on the distribution and prevalence of non-vector borne diseases varies greatly (Van den Bossche and Coetzer, 2008[202]). Changes in the environmental condition resulted directly or indirectly by the climatic change can increase or reduce the survival of the pathogen agent in the environment or predispose the susceptible animal to the infection. These environmental changes could also increase or reduce contact between infected and susceptible animals. Pathogens which spend a period outside the host are sensitive to changes in temperature and humidity. These pathogens include the infective spores of anthrax and blackleg, and foot and mouth disease (FMD), contained in wind-borne aerosol droplets (Van den Bossche and Coetzer, 2008 [203]). Drought, overgrazing and environmental stress expose anthrax spores similarly scarce water may get contaminated with anthrax spores. The prevalence of Fasciola infections may increase in areas where rainfall increases and create water bodies for snail's survival as intermediate host of *Fasciola hepatica (*Van den Bossche and Coetzer, 2008[204]). Climate variables can affect the prevalence, intensity, and geographical distribution of helminths. Various reports indicate that the impact of climate change on helminths is more patent in temperate and colder areas as well as in high altitude. The influence of climate change is manifested directly to free-living larval stages and indirectly mainly on invertebrate, but also vertebrate hosts (Mas-Coma et al 2008[205]).

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[199] Eisler M C, Torr S J, Coleman P G, Machila N and Morton J F 2003 Integrated control of vector-borne diseases of livestock - pyrethroids: panacea or poison? Trends in Parasitology 19, 341-345
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[201] WHO 1996 Climate Change and Human Health. World Health Organisation: http://www.who.int/globalchange/publications/climchange.pdf
[202] Van den Bossche P and Coetzer J A W 2008 Climate change and animal health in Africa Review Science Technology Off. int. Epiz, 2008, 27 (2), 551-562
[203] Ibid.
[204] Ibid.
[205] Mas-Coma S, Valero M A and Bargues M D 2008 Effects of climate change on animal and zoonotic helminthiases Review Science Technology Off. int. Epiz., 2008, 27 (2), 443-45

155. *Effects on vector borne diseases.* Tsetse transmitted trypanosomiasis is one of the greatest diseases of economic importance in the region. The vectors are sensitive to warming because temperature can alter vector development rates, shifts their geographical distribution, and alter transmission dynamics (Alsan, 2015[206]). Ticks transmit many important livestock diseases in Africa such as ECF, Babesiosis, Cowdriosis and heart water and, like tsetse; ticks inflict significant constraints on productivity. This has suggested that some species may expand their ranges in the future and others may contract (Bett et al 2019[207], Martin et al 2008[208])

Table 7: Likely impact of climate change on important diseases affecting dairy in East Africa

Pathogen	**Climatic link**
Trypanosomiasis transmitted by *tsetse* fly	Temperature, humidity, and vegetation patterns. Changes in temperature and rainfall can affect the geographical range and seasonal activity of tsetse fly populations. Land use change and climate change will lead to changes in habitat, water availability, and vegetation cover, altering the movement and density of wildlife populations, potentially influencing the reservoir capacity and transmission dynamics of trypanosomes.
Rift valley fever transmitted by *Aedes* mosquitoes	High rainfall events and flooding will lead to increase in vectors and, thus, increase transmission and incidences. Epidemics in Eastern Africa follow El Niño ocean-atmospheric phenomena. A rise in temperature increases the rate of transmission by increasing vectors' feeding interval, development rate, and reduces the virus's intrinsic incubation period. Vector thrives in warm and humid environments, and increased temperatures and rainfall can enhance their breeding habitats, leading to higher mosquito populations and potentially increased RVF transmission shifts in the distribution may also occur.
East coast fever transmitted by a tick *Rhipicephalus appendiculatus*)	Change in tick size and suitability for tick infestation.
Foot rot	Excessive moisture, such as increased rainfall or prolonged periods of high humidity, can create favorable conditions for the growth and survival of the bacteria responsible for foot rot. Wet and muddy conditions soften the hooves and make them more susceptible to infection.
Foot and Mouth Disease (FMD)	Changes in temperature, rainfall patterns, and availability of water and forage can affect livestock migration patterns, market dynamics, and trade routes. Movement of infected animals or introduction of susceptible animals to FMD-endemic areas can facilitate the spread of the disease.
Mastitis	Climate change is expected to increase mastitis occurrence in lactating cows, meaning an increment of these biological hazards in raw milk.

[206] Alsan, Marcella. 2015. "The Effect of the TseTse Fly on African Development." American Economic Review, 105 (1): 382-410.
[207] Bernard Bett, Johanna Lindahl, and Grace Delia 2019. Climate Change and Infectious Livestock Diseases: The Case of Rift Valley Fever and Tick-Borne Diseases. T. S. Rosenstock et al. (eds.), The Climate-Smart Agriculture Papers, https://doi.org/10.1007/978-3-319-92798-5_3
[208] V. Martin , V. Chevalier, P. Ceccato), A. Anyamba), L. De Simone),J. Lubroth , S. de La Rocque (& J. Domenech 2008 The impact of climate change on the epidemiology and control of Rift Valley fever. Rev. sci. tech. Off. int. Epiz., 2008, 27 (2), 413-426

References: Anyamba et al. (2001[209]); Moore & Messina (2010[210]); Messina et al.(2012[211]);Hiko & Malicha (2016[212]); Taylor et al. (2016[213]); Bett et al.(2017[214]); Mweya et al.(2017[215])

1. RELEVANT POLICIES AND INSTITUTIONAL FRAMEWORK FOR LOW-CARBON, CLIMATE-RESILIENT DAIRY SECTOR

156. The below tables outline the relevant policy frameworks at regional and country level.

Table 8: Regional policy frameworks for low-carbon, climate-resilient dairy sector

Plans, policies, & strategies / Year	**Priority areas of action**
East African Community Climate Change Master plan (EAC-CCMP 2011-2031 **(2011)**	Focuses on priority areas related to livestock, including promoting climate-smart livestock production, sustainable rangeland management, and livestock health. It emphasizes the development of climate-resilient livestock breeds, value chain development, and capacity building. Highlights the importance of research, innovation, and collaboration in addressing climate change challenges in the livestock sector within the East African Community region.
The East Africa climate change policy **(2011)**	Prioritizes climate-smart livestock production systems, sustainable rangeland management, livestock health, genetics, and breeding. It emphasizes value chain development, livestock insurance, and risk management. Advocates for the promotion of climate information services, capacity building, research, and collaboration to enhance resilience, productivity, and sustainability of the livestock sector in the face of climate change.
The IGAD Regional Climate Change Strategy (IRCCS) (2023-2030) **(2022)**	It aims to strengthen the adaptive capacity, foster research, and innovation, and promote regional collaboration to address climate change impacts on the livestock sector along the IGAD region. This is done by (i) enhancing the production and productivity of the livestock and fisheries sectors, (ii) improving market access to livestock products, including control of illicit cross-border trafficking and illegal fishing, (iii) promoting inter-state and regional trade in agricultural, livestock and fisheries commodities, (iv) designing programs and plans of actions aimed at reducing the GHG emissions from agriculture and livestock production focusing on the balance between quality and quantity of herds/products, (v) adopting agro-pastoral systems and rangelands management techniques to improve feed quality and mitigation actions with high co-benefits for food security, poverty reduction and enhanced resilience of livestock production systems.
The African Union Climate Change and Resilient	Prioritizes novel, integrated livestock management approaches, such as the Herding 4 Health model, which is scalable and traditionally acceptable, enables

[209] Anyamba, A.et al. (2001). Climate-disease connections: Rift Valley Fever in Kenya. Cadernos de Saúde Pública / Ministério Da Saúde, Fundação Oswaldo Cruz, Escola Nacional de Saúde Pública, 17 Suppl.
[210] Moore, N., & Messina, J. (2010). A landscape and climate data logistic model of tsetse distribution in Kenya. PLoS ONE, 5(7).
[211] Messina, J.et al. (2012). Climate Change and Risk Projection: Dynamic Spatial Models of Tsetse and African Trypanosomiasis in Kenya. Annals of the Association of American Geographers, 102(5).
[212] Hiko, A., & Malicha, G. (2016). Climate change and animal health risk. In Advances in Sustainability and Environmental Justice (Vol. 19).
[213] Taylor, D. et al. (2016). Environmental change and rift valley fever in eastern Africa: Projecting beyond healthy futures. Geospatial Health, 11(1S).
[214] Bett, B.et al. (2017). Effects of climate change on the occurrence and distribution of livestock diseases. Preventive Veterinary Medicine, 137.
[215] Mweya, C. et al. (2017). Climate influence on emerging risk areas for rift valley fever epidemics in Tanzania. American Journal of Tropical Medicine and Hygiene, 97(1).

Development Strategy and Action Plan (2022-2032) **(2022)**	wildlife-livestock coexistence, climate-change adaptation, carbon sequestration and water regulation. Develops policies to allow livestock development strategies that support rural development and contribute to a restoration economy, including the development of national policies and mechanisms to allow for carbon credit trading and benefit sharing for communities that implement rangeland restorative practices
East African Community Livestock Policy (2016) and EAC livestock bill 2020 **(2016)**	Aims to enhance the resilience and sustainability of the livestock sector in the IGAD region by improving livestock health services, enhancing livestock market systems, and promoting climate-smart livestock production systems. It also emphasizes community-based rangeland management, securing pastoral mobility, livestock breed improvement, and capacity building increase through ASAL Livestock Production and Productivity
The IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI) (2019-2024) **(2019)**	Aims to enhance the resilience and sustainability of the livestock sector in the IGAD region by improving livestock health services, enhancing livestock market systems, and promoting climate-smart livestock production systems. It also emphasizes community-based rangeland management, securing pastoral mobility, livestock breed improvement, and capacity building increase through ASAL Livestock Production and Productivity.
The IGAD Strategy for Sustainable and Resilient Livestock Development in View of Climate Change (2022 -2037) **(2022)**	Improves preparedness and the temporal allocation of resources and income in response to climate shocks by making financial and technical mechanisms available to pastoralists. Enhances and increases access to natural resources and builds the necessary capacity to absorb climate shocks. Enhances the research capacity and knowledge sharing in and between IGAD member states and accelerates knowledge development and innovation for resilience among livestock production systems and value chains. Streamlines and improves the alignment of policy action for improved livestock sector resilience across the IGAD intraregional boundaries

Table 9: Relevant policies and regulatory frameworks for low-carbon, climate-resilient dairy sector in Kenya

Plans, policies, & strategies	**Priority areas of action**
National Determined contributions **(2022)**	Kenya seeks to abate its GHG emissions by 30% by 2030 relative to the BAU scenario of 143 MtCO2eq; and in line with its sustainable development agenda. It seeks to enhance the resilience of the agriculture, livestock, and fisheries value chains by promoting climate smart agriculture and livestock development. Sustainable Land Management: The livestock sector in Kenya is closely tied to land use and land management. Sustainable land management practices, including rotational grazing and afforestation, are required to sequester carbon, reduce deforestation, and enhance resilience in the livestock sector. Enhance climate information services: Increase the resilience of current and future energy systems, including promotion of renewable energy in livestock farming to reduce emissions from the energy-intensive aspects of livestock farming.
Agriculture Sector Development Strategy (2019-2029) **(2019)**	Guides the development of the agriculture sector over a ten -year period. The strategy addresses various aspects of agriculture, including livestock.
The National Climate Change Action Plan (NCCAP) **(2018)**	This plan outlines specific actions to be taken to implement the National Climate Change Response Strategy (NCCRS), including measures to reduce GHG emissions, enhance carbon sinks, and strengthen climate resilience. It includes specific sectoral strategies for agriculture, water, energy, and forests.

Plans, policies, & strategies	Priority areas of action
	The plan includes measures to increase the resilience of livestock production systems to climate change, promote sustainable livestock management practices, and reduce GHG emissions from the livestock sector.
Kenya Climate Smart Agriculture Implementation Framework (2018–2027) **(2018)**	Provides a roadmap for promoting climate -resilient and sustainable agriculture in Kenya. By integrating climate change considerations into agricultural practices, the framework aims to enhance food security, reduce vulnerability to climate change, and contribute to the overall development goals of the country.
Kenya National Strategy on Climate Change and Low Carbon Development **(2018)**	Outlines the country 's vision for a low-carbon, climate-resilient future. The strategy focuses on promoting sustainable development, reducing GHG emissions, and building climate resilience.
Kenya Climate Smart Agriculture Strategy (2017–2026) **(2017)**	This framework promotes climate-smart agriculture practices in Kenya, including the livestock sector. The strategy includes measures to promote sustainable livestock management practices, such as improved animal feeding and watering, pasture management, and manure management.
The Climate Change Act **(2016)**	This legislation establishes a legal framework for addressing climate change in Kenya and supports the establishment of a National Climate Change Council to coordinate climate change-related activities.
The National Adaptation Plan **(2016)**	This plan aims to enhance Kenya 's capacity to adapt to the impacts of climate change, including the livestock sector. The plan includes measures to enhance the resilience of livestock production systems to climate change, such as promoting drought-tolerant livestock breeds, improving water management, and enhancing veterinary services.
National Policy on Climate Finance **(2016)**	The purpose of this national policy is to improve the ability to mobilize and effectively manage and track adequate and predictable climate change finance. Establishes a national climate finance mechanism (Climate Change Fund) within the legal framework established in the Climate Change Act to support the funding of activities. Identifies examples of climate friendly actions in agriculture and livestock requiring increased investment.
National Livestock Policy **(2015)**	Aims to promote the sustainable development of the livestock sector in Kenya. The policy includes measures to improve livestock productivity, promote sustainable livestock management practices, and enhance the value chain. The policy establishes a livestock insurance scheme operated under a public-private-partnership.
Kenya Livestock Master Plan (KLMP) **(2013)** (Under review)	The KLMP is a roadmap for the development of the livestock sector in Kenya. The plan includes strategies to improve livestock productivity, enhance the value chain, and promote climate-resilient livestock management practices.
Agriculture, Livestock and Food Authority Bill **(2012)**	Provides a legal framework for the regulation and promotion of the livestock sector in Kenya, ensuring the well-being of animals, the safety and quality of livestock products, and the facilitation of trade and market access for Kenyan livestock farmers and businesses.
The National Climate Change Response Strategy (NCCRS) **(2010)**	This is Kenya's overarching policy framework for addressing climate change. It sets out the country's vision, goals, and strategies for climate change mitigation, adaptation, and disaster risk reduction. It includes actions to reduce the vulnerability of communities and ecosystems to climate change, as well as the strategies necessary to build the resilience to climate change impacts.

Plans, policies, & strategies	Priority areas of action
Kenya Vision 2030 **(2008)**	Acknowledges the importance of sustainable rangeland management to mitigate climate change impacts in pastoral areas, emphasizes efficient resource use in livestock production, recognizes the importance of value addition and market access for livestock products, and underscores the significance of research and innovation in addressing climate change challenges in the livestock

Table 10: Relevant policies and regulatory frameworks for low-carbon, climate-resilient dairy sector In Rwanda

Plans, policies, & strategies	Priority areas of action
Rwanda's Nationally Determined Contributions (NDC) **(2015)** (updated in 2020)	The NDCs outline the country's goals for reducing greenhouse gas emissions and adapting Rwanda to the impacts of climate change; Develop climate resilient crops and promote climate resilient livestock; Expand crop and livestock insurance; Reduce enteric fermentation emissions from livestock, including the introduction of new species to replace local herds and improved husbandry, and the use of windrow composting; Reduction in GHG emissions from manure management through adoption of more efficient manure management systems, including promotion of collective farms and training, under the Rwanda Livestock Master Plan.
National Climate Change and Environment Policy **(2019)**	Comprehensive framework for addressing climate change in Rwanda. The ▪ policy aims to mainstream climate change considerations across all sectors of the economy and the society. It also outlines the country's priorities for adaptation and mitigation measures.
National Climate Change and Environment Policy **(2019)**	The policy promotes the sustainable management of livestock as a means of mitigating and adapting to climate change. It includes measures to promote sustainable livestock production systems such as improved animal health management, feed management, and manure management.
Rwanda Livestock Master Plan **(2017)**	Provides a roadmap for the development of the livestock sector in Rwanda. The plan includes strategies for improving livestock productivity, enhancing the value chain, and promoting climate-resilient livestock management practices.
National Adaptation Plan for the Agricultural Sector **(2017)**	Provides a framework for adapting the agriculture sector to the impacts of climate change. The plan includes measures to improve the resilience of livestock production systems such as promoting drought-tolerant livestock breeds, improving water management, and enhancing veterinary services.
National Livestock Policy **(2015)**	Provides a framework for the sustainable development of the livestock sector in Rwanda. The policy aims to improve livestock productivity and promote sustainable livestock management practices that are climate resilient.
National Dairy Strategy and Strategic Plan **(2013)**	Guides the development of the dairy sector. The plan includes interventions such as capacity building, infrastructure development, research and extension services, and policy support.
National Agriculture Policy **(2013)**	Aims to promote sustainable agriculture in Rwanda. The policy includes measures to promote climate-smart agriculture practices, such as conservation agriculture, agroforestry, and improved livestock management.
Rwanda Green Fund (FONERWA) **(2012)**	Provides finance for climate change mitigation and adaptation projects in Rwanda. The fund supports projects in sectors such as renewable energy, sustainable agriculture, and ecosystem management.

Table 11: Relevant policies and regulatory frameworks for low-carbon, climate-resilient dairy sector in Tanzania

Plans, policies, &strategies	Priority areas of action
National determined Contributions **(2021)**	Promoting local and modern climate resilience knowledge for (i) sustainable pasture and rangeland management systems and practices, (ii) enhancing climate resilience livestock infrastructures and services, (iii) promoting livelihood diversification of livestock keepers, (iv) promoting accessible mechanisms for livestock keepers against climate related shocks, including livestock insurance, (v) enhancing livestock productivity through climate-smart interventions, and (vi) strengthening livestock research and development.
Tanzania Livestock Modernization Initiative (TLMI) **(2020)**	Program aimed at transforming the livestock sector in Tanzania through the adoption of modern and innovative technologies and practices. The initiative includes measures to promote climate-resilient livestock management practices, such as the use of climate-smart feeds, breeding of heat-tolerant livestock, and improved disease management.
Tanzania Climate Smart Agriculture Program (TCSAP) **(2017)**	Framework for promoting climate -smart agriculture practices in Tanzania, including the livestock sector. The program includes measures to promote sustainable livestock management practices, such as improved animal feeding and watering, pasture management, and manure management.
The National Livestock Policy **(2006)** (updated in 2017)	Aims to promote the sustainable development of the livestock sector in Tanzania. The policy includes measures to improve livestock productivity, promote sustainable livestock management practices, and enhance the value chain.
National Adaptation Plan (NAP) **(2015)**	Provides a framework for adapting Tanzania to the impacts of climate change, including the livestock sector. The plan includes measures to enhance the resilience of livestock production systems to climate change, such as promoting drought-tolerant livestock breeds, improving water management, and enhancing veterinary services.
Livestock Development Master Plan (LDMP) **(2013)**	This is a roadmap for the development of the livestock sector in Tanzania. The plan includes strategies to improve livestock productivity, enhance the value chain, and promote climate-resilient livestock management practices.
National Climate Change Strategy **(2012)**	Outlines Tanzania's strategy to address climate change across all sectors, including the livestock sector. The strategy includes measures to increase the resilience of livestock production systems to climate change, promote sustainable livestock management practices, and reduce GHG emissions from the sector.

Table 12: Relevant policies and regulatory frameworks for low-carbon, climate-resilient dairy sector in Uganda

Plans, policies, &strategies	Priority areas of action
The National Organic Agriculture Policy **(2019)**	Develops the capacity for organic agriculture, conducts regulatory reforms, participatory planning, and research with reference to stakeholder needs in crops, livestock, wild animals, beneficial insects, and fisheries. Critically absent from the current organic agenda is the framework and guidelines for an organic livestock, poultry, and fisheries sector and associated sub-sectors such as feed, fodder, and veterinary medicine, especially considering the significant number of domestic livestock and an emerging dairy sector.

Plans, policies, &strategies	Priority areas of action
National determined Contribution **(2022)**	Promotes highly adaptive and productive livestock breeds; agricultural(livestock) diversification; livestock management in the cattle corridor. Promotes improved cattle breeds and feeds, improved water availability for livestock through constructing water dams and valley tanks, and the establishment of fodder agroforestry plantations for zero grazing and stall-feeding. The measure will reduce emissions by approximately 2.9 MtCO2e by 2030. TheNAMA seeks to(i) sustainably increase agricultural milk productivity and incomes, (ii)adapt and build resilience to climate change along the milk production value chain, (iii)and reduce greenhouse gas emissions through improved feed quality, supplement, and manure management.
National Adaptation Plan (NAP) **(2016)**	A framework for adapting to the impacts of climate change, including the livestock sector. The plan includes measures to enhance the resilience of livestock production systems to climate change through the promotion of drought-tolerant livestock breeds, improving water management, and enhancing veterinary services.
Livestock Development Strategy and Investment Plan (LDSIP) **(2015)**	Provides a framework for the development of the livestock sector in Uganda. The plan includes strategies to improve livestock productivity, enhance the value chain, and promote climate-resilient livestock management practices.
Climate Change Policy **(2015)**	Aims to promote the integration of climate change considerations into all sectors of Uganda's economy, including the livestock sector. The policy includes measures to increase the resilience to climate change, reduce GHG emissions, and promote sustainable development.
National Livestock Policy **(2006)** (Updated in 2015)	Aims to promote the development of the livestock sector in Uganda. The policy includes measures to improve livestock productivity, enhance the value chain, and promote sustainable livestock management practices.
National Agricultural Research Policy (NARP) **(2013)**	Aims to promote the development of Uganda's agricultural sector, including the livestock sector. The policy includes measures to promote climate-resilient livestock management practices, such as improved animal feeding and watering, pasture management, and manure management.
National Agriculture Policy (NAP) **(2013)**	Aims to increase the income of farming households from livestock, by encouraging and promoting dry season livestock feeding through pasture preservation and other feeding practices. Proposes the development of a well-developed and maintained agricultural marketing infrastructure. The infrastructure includes, but is not limited to, physical crop and livestock markets, fish handling facilities, abattoirs, warehouses, silos, and cold chain storage.
National Delivery of Veterinary Services Policy **(2003)**	Prioritizes a sustainable increase in the production of live animals and livestock products, including milk, meat as well as by-products.

157. In addition, countries have specifics policies and legal frameworks to enhance disease surveillance and control. These are complemented by regional legal frameworks. The table below provides a list of these frameworks. These policies and legal frameworks are described in detail in Pre-feasibility Study 2 and the table below provides a summary.

Table 13: Regional and national Animal health Policies in East Africa

Regional level	Kenya	Tanzania	Rwanda	Uganda
East African Community EAC Strategy on Transboundary Disease Control and Zoonosis	The Dairy Industry (Registration, Licensing, Cess and Levy) Regulations, 2021 Veterinary Surgeons and Veterinary Para-professionals Act (2011) Animal Diseases Act (2012) Veterinary Policy2020	Animal Diseases Act (2003) Veterinary Services Act (2003) National Veterinary Laboratory Services Strategy (2013-2023)	Animal Health Law (2018) National Animal Health Policy (2016-2020) Veterinary Services Policy (2017-2022) National Veterinary Laboratory Services Strategy (2017-2022)	National Delivery of Veterinary Services Policy 2003 Animal diseases Act (2003) National animal health policy (2006)

2.11 ADAPTATION AND MITIGATION BARRIERS

158. The East African dairy sector is critical for rural development, poverty reduction, and food and nutrition security in East Africa. However, its full potential remains unexploited due to a variety of production, marketing, and trade obstacles, as well as technological, organizational and policy constraints (Bingi & Tondel, 2015[216]). This section assesses the main barriers and adaptation needs as well as the maladaptation risks that can exacerbate vulnerabilities instead of diminishing them.

159. The key adaptation barriers in the dairy sector in East Africa are:

- *Misalignment of multiple sector policies.* Although intensification of the dairy sector can lead to increase production and productivity in the dairy sector, caution must be taken to align the different sectoral policies so as to minimize the carbon leakage due to the conversion of forest lands in favour of livestock feed production (Brandt et al. 2020[217]; Hawkins et al. 2021[218]).
- *Government commitment to investments in the livestock sector.* East African governments commitments to the livestock sector have generally been low. This is largely due to the undervaluation of the sector's contribution to the GDP. According to the IGAD Center for Pastoral Areas and Livestock Development (ICPALD), this figure is undervalued by 150% and 87% in Kenya and Uganda, respectively.
- *Technical / Knowledge: technical capacity to adapt to the changing climate is limited among farmers and extension workers.* Limited outreach and coverage of extension services has also been observed. Detailed information, including weather forecasting, exists as local knowledge. However, it has not been fully integrated into interventions or supplemented by "western science" for maximum efficacy in adaptation.
- *Poor processing facilities.* Milk is highly perishable and, therefore, without good accessible milk collection, coolers and processing plants it may perish. The current dairy is sparse and, sometimes, nonfunctional leading to sales at prices that are too low. This is a disincentive for the pastoralists to invest in the livestock sector. Furthermore, in good seasons, the facilities are not able to process the excess of milk, leading to waste and losses.
- *Weak promotion of dairy products market.* Lack of clear milk marketing system and lack of market information further exacerbate this situation. Inadequate organization of milk marketing systems prevents smallholder farmers from producing and investing more. Disparities in regulations among countries create unnecessary barriers to trade.

216 Bingi, S., & Tondel, F. (2015). Recent developments in the dairy sector in Eastern Africa: Towards a regional policy framework for value chain development. ECDPM Briefing Note, 78.
217 Brandt, P.et al. (2020). Intensification of dairy production can increase the GHG mitigation potential of the land use sector in East Africa. Global Change Biology, 26(2).
218 Hawkins, J.et al.(2021). Feeding efficiency gains can increase the greenhouse gas mitigation potential of the Tanzanian dairy sector. Scientific Reports, 11(1).

- *Insufficient improved breeds and their adaptability issues.* Indigenous cattle breeds are generally low milk producers. Exotic breeds are intolerant to local diseases and environment.
- *High transactional costs.* As a highly perishable and bulky product, milk requires efficient and costly transportation systems from farm to the consumers. This very nature of the product, plus the highly seasonal nature of the production, exposes the product to intermediaries. Farmers dispose their milk at low prices or risk losses due to spoilage. As a result, pastoralists become discouraged to invest in the production.
- *Dependence on rainfed production.* In East Africa, it is estimated that 70-90% of agriculture production is rain fed, particularly in rural areas where small-scale farmers rely heavily on seasonal rainfall for their crops, both for food and fodder production. These exposes dairy production to significant temporal and spatial variations, making it very difficult to make strategic planning for the sector.
- *Limited women participation in decision making, access to extension and control of resources*. Men are the default target group for information, services and innovations; information relevant to women is scarce in societies where tasks are often assigned by gender. Women's access to credit and natural resources is also limited. These constraints are borne and compounded by unequal distribution of decision making power within the household and society.

2.12 MAIN ADAPTATION AND MITIGATION NEEDS

160. Adaptation needs are the specific requirements and or actions that are necessary to cope with the impacts of climate change and, consequently, ensure the resilience of livestock systems. Identifying adaptation needs helps prioritize actions and allocate resources to address the most critical challenges. Based on the emerging findings of this study, the adaptation needs in the dairy sector in East Africa are:

- *Access to climate-smart technologies.* Farmers need access to climate-smart technologies such as improved livestock breeds, drought-tolerant forage varieties, and energy-efficient milk cooling and processing equipment. These technologies can enhance productivity, conserve resources, and mitigate climate change impacts. Improving the dairy industry's production efficiency is an effective way towards reducing emissions per unit of milk (Place & Mitloehner, 2010[219]).
- *Capacity building and knowledge transfer.* Providing training programs, Farmer Field Schools (FFS), and extension services can enhance farmers' technical knowledge and skills in dairy management. This includes training on sustainable feeding practices, breeding strategies, disease control measures, and effective use of water resources.
- *Financial and market support.* Ensuring access to affordable finance and micro-credit services enables farmers to invest in productive assets, infrastructure development, and value addition. Additionally, supporting farmers in accessing fair and transparent markets and promoting value chain linkages can enhance their incomes and improve market resilience. Connecting resource-poor smallholder farmers to large enterprises can improve input and output markets as well as other productivity-enhancing services (Omondi et al. 2017[220]). Cooperative selling institutions can help mitigate transaction costs, stimulate entry into the market, and promote growth in rural communities (Holloway et al. 2000[221]).
- *Strengthening infrastructure.* Investing in rural infrastructure, such as improved road networks, electricity supply, and milk collection and processing facilities, can reduce transportation costs, post-harvest losses, and improve overall market access for dairy farmers.
- *Climate information and early warning systems.* Developing and disseminating climate information, early warning systems, and advisory services can assist livestock producers in making informed decisions related to feed management, breeding, and disease control. This helps pastoralists anticipate and adapt to climate-related risks. Market information systems form a key component of these early warning systems.

[219] Place, S. E., & Mitloehner, F. M. (2010). Invited review: Contemporary environmental issues: A review of the dairy industry's role in climate change and air quality and the potential of mitigation through improved production efficiency. In Journal of Dairy Science (Vol. 93, Issue 8)
[220] Omondi, I. et al. (2017). Processor Linkages and Farm Household Productivity: Evidence from Dairy Hubs in East Africa. Agribusiness, 33(4)
[221] Holloway, G. et al. (2000). Agroindustrialization through institutional innovation transaction costs, cooperatives and milk-market development in the east-African highlands. Agricultural Economics, 23(3).

- *Policy support and institutional strengthening.* Developing supportive policies and regulations that address the specific needs of the dairy sector, as well as strengthening the institutions involved in research, extension, and market development, are crucial for enabling a conducive environment for dairy farmers to thrive. Collaboration between governments, research institutions, dairy cooperatives, financial institutions, and development partners is required to address the identified key barriers and adaptation needs.

3 THEORY OF CHANGE AND LINKAGES WITH OTHER IFAD PROJECTS

3.1 THEORY OF CHANGE

161. The Theory of Change (ToC) presented below outlines the intervention logic of the Programme. This section describes the expected shift in the development trajectory as a result of the Programme's intervention. The impact statement of the Programme is as follows: *"IF practices and technological solutions for increasing resilience to climate change and other shocks and for reducing GHG emissions are adopted by dairy producers and processors and IF financial services that efficiently sustain production and marketing are utilized and an enabling environment with supporting policies and regulations is developed, THEN a decrease in producers' and other stakeholders' vulnerability and GHG emissions will take place in the dairy sectors of Kenya, Rwanda, Tanzania and Uganda. This is BECAUSE low-emissions and climate-resilient dairy production will be perceived as financially beneficial to producers and processors".*

162. As described in Section 2, the dairy sector faces significant challenges related to climate change in East Africa, including in Kenya, Rwanda, Tanzania, and Uganda. Dairy farming contributes substantially to GHG emissions in national inventories, with the impacts of CC threatening its sustainability. Inefficiencies at the dairy farm level result in excessive GHG emission intensities per kg of milk. In addition, many dairy farmers face barriers to accessing markets, procuring local feed and fodder, obtaining extension and financial services, and managing risks. Low genetic potential of livestock, herd management challenges, animal diseases, inadequate extension services, limited knowledge of climate-resilient and low carbon practices and technologies, rangeland degradation and gender inequalities further harm the dairy sector in these countries.

163. With the barriers and climate adaptation & mitigation needs in mind, the Programme will address the following challenges: (i) strengthening climate resilience, (ii) reducing emissions across the dairy value chain; (iii) the reduction of GHG emissions per kg of milk; and (iv) improving the livelihoods of dairy farmers in East Africa. This requires a holistic approach to improving all aspects of the dairy sector, from improving policy, institutional and service delivery environments to building the capacity of smallholder farmers, including women, youth and the marginalized. It also includes measures to facilitate access to finance and innovative technologies with mitigation and adaptation benefits, as well as socio-economic co-benefits (CB). As a result, dairy farmers and processors will be motivated to adopt more efficient, climate-resilient practices that will increase incomes and reduce production costs. Central to this transformative approach is the symbiosis of private sector support and financial access within the dairy sector. This integration aims to foster market growth while promoting climate resilience and reducing GHG emissions.

164. The paradigm shift envisioned by the Programme is a more efficient, climate-resilient dairy industry that contributes to national and regional economic growth, improved smallholder farmers' livelihoods, and reduced GHG emissions. To achieve the above vision, the Programme aims to achieve the following three Outcomes:

Outcome 1: Systemic and institutional capacities in the dairy sector are strengthened to enable smallholder dairy farmers and local value chain actors to reduce methane and other GHG emissions.

165. Outcome 1 aims to foster an enabling environment for the transformation of the East Africa's dairy sector towards increased productivity, climate resilience and lower emission intensity. To achieve this, several outputs must be achieved.

166. The Programme will establish a climate-responsive policy and regulatory environment for the dairy sector (Output 1.1) by reviewing regulatory frameworks, supporting value chain governance initiatives, and work on food safety and dairy consumption. Through improved public services (Output 1.2.) as a result of the expansion of proximity veterinary services and innovative extension services, both male and female farmers will be supported to address animal health, feed quality, manure, and herd management issues. This will help scaling up climate-smart practices and addressing the lack of knowledge and perception regarding adaptation. Enhanced measurement, reporting and verification (MRV) capacities (Output 1.3.) will generate detailed Tier 2 emissions data to improve national inventories, and inform evidence-based policies, planning and investment. Robust MRV and modelling will address data gaps and strengthen climate scenarios and assessments. Certification for low-carbon production and facilitating access to the carbon markets will create financial incentives for mitigation efforts. This will accelerate the transition to low-carbon practices by providing a potential source of revenue for dairy farmers and businesses that achieve low-carbon certification. Regional cooperation and knowledge sharing (Output 1.4.) will ensure coordinated strategies, amplify each country's efforts, and promote joint learning. This collaboration will be essential to overcome national institutional and knowledge barriers.

Outcome 2: Smallholder dairy farmers and private sector value chain operators adopt low-emission, climate-resilient, and sustainable practices for increased production and access market knowledge and tools.

167. Outcome 2 aims to improve the incomes and productivity of smallholder dairy farmers, dairy cooperatives and SMEs by promoting sustainable and climate-resilient low-emission pathways for future growth. The three Outputs leading to this Outcome will also have a positive effect on gender equality, increased food security and nutrition for rural/urban consumers (CB1) and women empowerment and inclusion of marginalized groups (CB2).

168. Output 2.1 supports dairy cooperatives to ensure that smallholder dairy farmers have a stable market for their produce, reduce losses, and are interested in adopting the pathway innovations. Renewable energy solutions at cooperative level will also be supported. The promotion of integrated pathway-specific solutions (Output 2.2.) will include the introduction of better dairy cattle breeds, improved herd composition and animal health, increased availability of high-quality feed and fodder, better manure management for biogas production and nutrient recycling. This will increase productivity, improve circularity and reduce GHG emission intensity at animal, herd and farm levels. This Output helps to remove technological and natural barriers by improving on-farm infrastructure and overcoming limitations related to animal nutrition, disease, mortality, and genetic potential. Improved pasture management (Output 2.3), through participatory learning and the promotion of sustainable grazing practices and land management practices will rehabilitate degraded rangelands, increase access to fodder and address ecosystems degradation. Together, the three Outputs contribute to broader replication through increased productivity and income for smallholder dairy farmers, increased carbon sequestration in soils, resulting in reduced greenhouse gas emissions. This aligns with the desired paradigm shift towards a more productive, climate-resilient, and low-emission dairy sector, supported by sustainable practices and gender-transformative growth.

Outcome 3: Financial institutions make available the appropriate resources to make the necessary transition to low-carbon, climate-resilient, and sustainable dairy production and strengthen value chain linkages and improved productivity.

169. By improving access to finance for climate-smart technologies and practices, Component 3 aims to facilitate access to finance for larger formal stakeholders in the value chain (dairy cooperatives, private enterprises, processors, input suppliers). Thereby facilitating a .

larger-scale transition to sustainable, low-carbon, climate-resilient dairy value chains. To achieve this outcome, dairy value chain actors (including agri-input and technology providers, groups of dairy farmers, aggregators and processors) will be supported in overcoming technological and financial barriers to increase their productivity and green their operations.

170. To contribute to the envisaged paradigm shift, Component 3 will target and benefit 767 direct enterprise beneficiaries to support the greening of their operations and increased productivity. By investing directly into enterprises, the GDFF will enhance its reach across the value chain, ultimately (indirectly) benefiting approximately 276,,803 dairy farmers and their enterprises. The result is transformative change in East Africa's dairy sector, leading to increased productivity, climate resilience and reduced emissions.

171. **Two main co-benefits (CB)** will be generated through the implementation of the Programme activities:

(1) **CB1 - Increased food security and nutrition for rural/urban consumers.** Dairy is an essential component of a healthy diet. The programme will increase the amount, and choice, of safe dairy products that will reach the consumer, predominantly through increased milk availability and more efficient marketing chains, enhanced processing, and distribution. Being a nutrition sensitive project, DaIMA will look at the interconnectedness of the production - income - nutrition pathways. Increasing purchasing power of farmers, the investment strives to increase availability of nutrient-dense animal sourced foods such as dairy and meat for consumption at home and for sale and purchase in markets.

(2) **CB2 - Women empowerment and inclusion of marginalized groups.** Project will engage marginalized groups, which will significantly reduce the risk of creating new climate vulnerability[222]. The project will create equal opportunities for women and men and aim to: (i) Increase women economic empowerment through access to technical knowledge, finance and skills; (ii) Increase women participation, voice and decision making in farmer organizations and cooperatives, (iii) Reduce and balance workloads with increased resilient production and greater efficiency of dairy production and post-harvest technologies; (iv) Policy engagement to address gender barriers related in the sector. Furthermore, gender empowerment is tackled at the root by adopting household methodology/ GALS approach to ensure women's capacity development, and examination of decision-making power sharing at household level. The project's GALS interventions will: (i) instill mindset change by enhancing the social acceptance of gender and youth empowerment, (ii) influence positive gender norms and to prevent Gender based violence (GBV) as well as Sexual Exploitation, Abuse and Harassment (SEAH), (ii) promote equitable and inclusive sharing of decision-making power at household and community levels, (iii) develop the capacity of women and youth for their meaningful participation in domestic and public life, and (iv) economically empower the vulnerable particularly women and youth.

[222] Eriksen, S. *et al.,* 2021. "Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance?" *World Development.* Vol. 141, 105383.

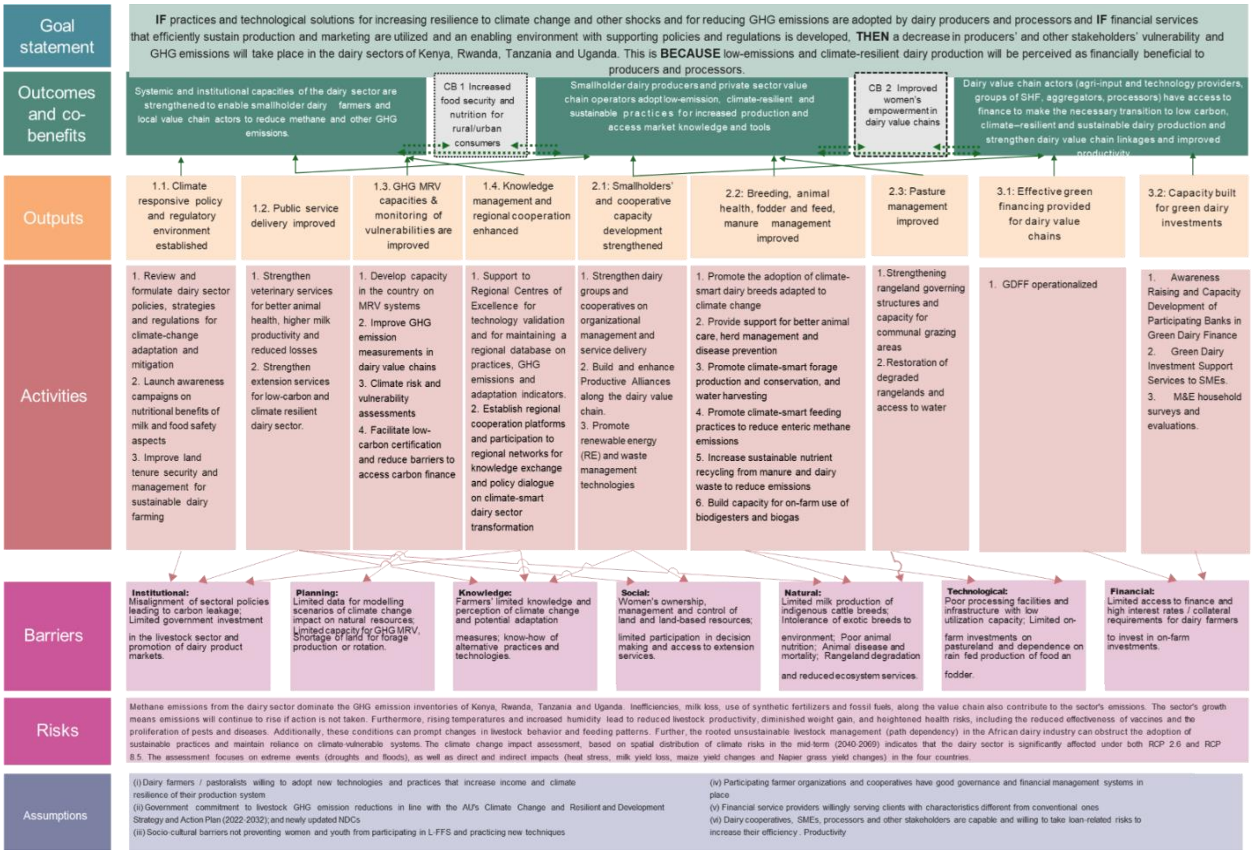

Figure 63: Theory of change

3.2 COMPLEMENTARITY AND LESSONS LEARNT FROM OTHER PROJECTS

172. The Programme will build on various lessons learned from past and on-going Projects in the sector, in particular those financed and operated by IFAD (see table 14 and table 15 below).

173. In **Kenya**, the IFAD-funded INReMP has dairy as one of the main value chains and seeks to build complementarities and synergies in production and productivity, integrated natural resource management (INRM), landscape & rangelands rehabilitation, payment for ecosystem services (PES), market access and linkages as well as promotion of climate adaptation and mitigation measures such as fodder conservation, pasture management, agroforestry water harvesting and renewable energy. The Programme will build on the legacy of the IFAD-funded Kenya Livestock Commercialization Project (KeLCoP)[223] which focuses on small stock value chains, fodder and forage establishment, forage conservation and storage, extension provision and disease surveillance and animal health, water harvesting, feed management, market access and linkages and capacity enhancement. The intervention will also build on a draft concept note called "the Dairy NAMA", that Kenya had prepared in 2020[224] for GCF consideration. Linkages with the Rural Kenya Financial Inclusion Facility (RK-FINFA) project, which has a green financing facility, will be explored under DaIMA's component 3. The Programme closely coordinate with the "Transforming Livelihoods through Climate Resilient, Low Carbon, Sustainable Agricultural Value Chains in the Lake Region Economic Bloc" proposed by FAO to the GCF in 2025, on the dairy value-chain aspects. It will also build on the lessons learnt of the GCF-funded "Towards Ending Drought Emergencies: Ecosystem Based Adaptation in Kenya's Arid and Semi-Arid Rangelands" (FP113, IUCN as AE), which has invested in increasing the adaptive capacities of communities and local institutions to develop evidence-based landscape planning.

174. In **Rwanda**, the Climate-Resilient Post-Harvest and Agribusiness Support Project (PASP)[225] included the promotion of dairy value chains. Matching grants were provided to milk processing plants that fostered new partnerships with dairy producers. The Programme will also integrate with the on-going RDDP-2[226], which will address low milk productivity, limited support services, limited organisation of farmers, and inadequate development and management of milk collection, processing, and marketing. Knowledge from the Transforming Eastern Province through Adaptation (GCF FP167, IUCN as AE), which has restored ecosystems and transformed the fragile landscapes of Rwanda's Eastern Province.

175. In **Tanzania**, where fodder quality and availability are a key concern in the dairy sector, the recently approved Agriculture and Fisheries Development Programme would strengthen formal crop seed systems through the breeding and supply of early-generation and climate-risk resilient (fodder) varieties. The Programme will integrate with the Climate Smart Smallholder Dairy Transformation Project (C-SDTP), whose objective is to transform the dairy industry toward higher productivity, value addition and commercialization level, and increase smallholder income for improved livelihood, food security and nutrition. It will also leverage lessons learnt from the "Building climate resilience in the landscapes of Kigoma region" (GCF FP218, UNEP as AE), which has created land use plans and rehabilitated degraded ecosystems to mainstreaming climate change adaptation measures into the region's developmental plans and policies.

176. In **Uganda**, the Programme will integrate with the planned Resilient Livestock Value Chains Project (ReLIV) which will include a dairy value chain development focus. The project will be fully integrated with DaIMA.

177. **Regionally,** the GCF-funded ARCAFIM project (FP220, IFAD being the AE) is expected to assist the Programme with access to adaptation finance and financial services by dairy sector smallholders from local commercial banks or microfinance institutions (MFIs). Lessons learnt from the Regional Pastoral Livelihoods Resilience Project (World Bank funded, 2013-2019), more particularly on rangeland management in cross-border districts and counties in Kenya and Uganda will be sought. The Programme will also draw lessons from IFAD's reports of the Independent Office of Evaluation and Impact Assessments that have been carried out by its Research and Impact Assessment Division.

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[223] https://www.ifad.org/documents/38711624/40089492/Kenya+2000002339+KeLCoP+Project+Design+Report+December+2020.pdf/ba678718-358f-c3a0-bb8d-45c0e21ddd88?t=1610121756000

[224] Kenya Dairy NAMA Project: Low-emission and climate resilient dairy development in Kenya" (as referred to the "Dairy NAMA"). Over the 2017-2020 period, Kenya had prepared a CN to submit to the GCF – through IFAD. The Project had not reached the Funding Proposal (FP) stage, and the design has stopped. The Dairy NAMA Project

Table 14: Main development objectives and components of other IFAD-funded project relevant for DaIMA

Country and Project	Goal, project development objective and components
Rwanda Dairy Development Project, phase 2 (RDDP-2)	The goal of the project is to reduce poverty level of targeted rural households and mitigate the impact of the dairy sector on climate change. The Project Development Objective is to enhance income, nutrition and resilience of rural households through a more inclusive, sustainable, digitalized and competitive dairy sector. The project will comprise three components: (i) increasing productivity and resilience of dairy smallholder production systems; (ii) increasing dairy value chain efficiency, through scaled-up investments, improved market access, and consumption of dairy products; and (iii) policy support and project management, monitoring & evaluation and knowledge management.
Climate Smart Smallholder Dairy Transformation Project (C-SDTP)	The goal is “to contribute to the transformation of the dairy value chain to improve livelihoods, increase food safety, and to mitigate the impact of the dairy sector on climate change”. The project development objective is “to improve income, climate resilience and nutrition of smallholder dairy producers and their participation in a competitive and safe value chain”. The project will include three components: (i) Climate smart productivity and resilience of dairy smallholder production systems; (ii) Inclusive and climate-smart value chains, private investment, milk consumption and policy; and (iii) Project management, monitoring & evaluation and knowledge management.
Resilient Livestock Value chain Project (RELIV)	The goal of the project is to contribute to the improved livelihoods of smallholder livestock farmers in Uganda. The Project Development Objective is to enhance income, nutrition and resilience of smallholder dairy and beef producers. The project outcomes are: (i) increased productivity, resilience and reduced climate impact of smallholder beef and dairy production systems; (ii) enhanced access to markets for smallholder producers and access to finance; and, (iii) strengthened policy and regulatory environment. RELIV will cover 41 districts across the cattle corridor and will be nutrition and youth (age 18-35) sensitive and will include climate finance.
Integrated Natural Resources Management Programme (INReMP)	INReMP interventions will seek to address the identified natural resources management challenges in the ten target counties by providing alternative livelihood opportunities to the target groups. The following are the expected outcomes: a) Outcome 1: Enhanced environmental sustainability and integrated natural resources management (INRM), ecosystem services and climate action; b) Outcome 2: Improved nutrition and inclusive and sustainable rural livelihoods; and c) Outcome 3: Strengthened policies and institutions for sustainable and inclusive natural resources management and rural livelihoods. INReMP Components – The Programme comprise the following components: Component 1: Community-led Enhanced Environment and INRM, Ecosystem Services, and Climate Action; Component 2: Improved, Inclusive and Sustainable Rural Livelihoods; Component 3: Strengthened Policies and Institutions for INRM and Rural Coordination
Kenya Livestock Commercialisation Project (KeLCoP)	The KeLCoP’s overall goal is to contribute to the Government's agriculture transformation Agenda of increasing rural small-scale farmers' incomes, food and nutrition security. The project’s development objective is to improve the opportunities for the rural poor, especially youth, women and smallholders to enable them to increase their output and value added, access markets and increase their resilience to economic and climate risks. The project will have two technical and intrinsically linked components, namely: Component 1 (Climate-smart production enhancement for the livestock sector), and Component 2: (Support to Livestock Market Development). Component 3: will comprise project management and coordination as well as policy and institutional support.

Table 15: Lessons learnt from IFAD operations relevant for DaIMA

Lesson Learnt	**Lesson application to DaIMA (see FS Section 8 for details on each activity)**	**Note and source**
Sustainability and climate. Recognising the interdisciplinary and cross-cutting nature of climate change adaptation and mitigation in the livestock/ dairy sector, interventions can be approached from different entry points along the value chains, such as the animal perspective, inputs, land management or processing facilities. It is important to understand the holistic nature of these interventions and to integrate and mainstream them into all project activities, rather than looking at them in isolation, to ensure their overall success. Finally, the link between improving sector productivity and achieving positive outcomes in terms of climate change adaptation and mitigation should be emphasized, so that the target beneficiaries have an incentive to continue on this sustainable development path even after the project has ended.	DaIMA's investment strategy and Theory of Change (ToC) are built on this principle of addressing the dairy sector holistically to reduce methane (and other GHG) emissions and enhance vulnerability to climate change	Lessons learnt in Uganda. From IFAD's ReLIV, see ReLIV Project Development Report
Farmers Field Schools (FFS) and Livestock Farmer Field Schools. Globally, and in East Africa in particular, FFS has proven to be highly effective in empowering farmers, sharing knowledge and promoting uptake of new technologies to increase production and climate resilience. An L-FFS impact assessment – from IFAD operations in Tanzania - showed that animal productivity has increased significantly (+33%) for L-FFS members, and 86% of L-FFS beneficiaries now cultivate improved fodder. FFS can be leveraged for climate change adaptation and mitigation. FFS put the farmers at the centre of climate-adaptation action. FFS is a farmer-led adaptation approach which allows interventions to be locally-led, and effectively adapted to specific challenges faced in each region.	Component 1: Activity 1.2.2 Component 2: Activity 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.2.5 and 2.3.2	Lessons learned in Tanzania, from IFAD's C-SDTP, see Project Development Report See FAO publication about FFS and Climate Change See more details on FFS lessons learnt in FS Section 8.
Gender. Community engagement and participatory approaches, such as GALS methodology (which integrates gender and social justice) implemented in other IFAD Projects (e.g. Upper Tana Natural Resources Management Project – UTaNRMP, Kenya Cereal Enhancement Programme Climate Resillient Agricultural Livelihoods Window – KCEP-CRAL) led to better decision making in the use of household, community and natural resources. GALS create opportunities for sincere dialogues, involving women and men, at the household level to challenge gender norms and facilitate behaviour change, the basis for transformation at higher levels. This was because it created a shift in gender roles in the households, brought family members together and reduced gender-based violence (GBV). L-FFS approach combined with GALS has played a pivotal role in terms of capacity development of farmers, organization of groups, natural resources management (NRM), introduction of climate-resilient technologies for livestock, gender transformation and even market access. Furthermore, according to the evaluation of	Component 1: Activity 1.2.2 Component 2: Activity 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.2.5 and 2.3.2 Sub-activity 2.1.1.4	Lesson learned in Rwanda, from IFAD's RDDP, phase 1, see Project Development Report Lesson learned in Kenya, from IFAD's InREMP, see Project Development Report

Lesson Learnt	Lesson application to DaIMA (see FS Section 8 for details on each activity)	Note and source
the IFAD-funded Rwanda Dairy Development Project (RDDP), the L-FFS approach helped in reaching 42 percent female membership in self-support groups.		
Animal health and access to animal health services. Animal health and access to animal health services are critical for productivity and climate-resilient dairy management. Farmers who manage animal health and practice new dairy management technologies can achieve health, productivity, as well as climate mitigation and adaptation goals.	Component 1, Activity 1.2.1 Component 2, Activity 2.2.2	Lessons learned in Tanzania, from IFAD's C-SDTP, see Project Development Report
Feed and fodder. Underfeeding, inadequate feed quality and water supplies hinder livestock productivity. Brachiaria species combined with a legume such as Desmodium can boost milk production per cow by 15 to 40 percent (and hence reduce GHG emission intensities). Forages are context-specific and differ in their qualities and farmers have to select the best fit for their climate, soil type and feeding needs. Other livestock development projects (e.g. in Uganda) have proved that feed and fodder improvement is the main trigger to improve productivity and climate resilience of smallholder systems but must be accompanied with parallel efforts on genetics, and animal health, to achieve impact. This also contributes to reducing enteric methane (CH4) emissions.	Component 2, Activities 2.2.3 and 2.2.4 As mentioned above, DaIMA's investment strategy and ToC are built on this principle of addressing the dairy sector holistically to reduce methane (and other GHG) emissions and enhance vulnerability to climate change.	Lessons learnt in Uganda. From IFAD's ReLIV, see ReLIV Project Development Report
Circularity, nutrient management and biogas production. IFAD has well documented the main lesson learnt (social, economic, technical, health, environmental, policy) from biogas units, and highlights the benefits for e.g. of portable biogas systems in Kenya and Rwanda. Biogas adoption has been limited in Rwanda, due to high capital and maintenance costs, limited financial mechanisms, lack of quality control measures, limited institutional coordination and collaboration. Lessons learned from the Tanzania Domestic Biogas Programme show that choosing the right implementing partners, tracking performance of biodigestors and farmers' perceptions through applied research and dissemination of the technologies are key to ensure the sustainability of the system.	Component 2, Activity 2.2.6	Lesson learned in Rwanda, from IFAD's RDDP-1, see Project Development Report Lessons learned in Tanzania, from IFAD's C-SDTP, see Project Development Report See IFAD How to do Note: Mainstreaming portable biogas systems into IFAD-supported projects. Lessons learnt are found in annex 1

Lesson Learnt	Lesson application to DaIMA (see FS Section 8 for details on each activity)	Note and source
Rangelands management and restoration, and community participation. **The effect of rangeland** and pasture management practices on soil carbon sequestration, greenhouse gas (GHG) emissions, soil health and community economics is highly dependent upon geographic location, e.g. soil and plant properties, climate. General mapping will therefore need to be supplemented with local surveying/sampling. IFAD, FAO and the International Livestock Research Institute (ILRI) draw upon many lessons from, for instance, Tanzania, Ethiopia, Somalia, Kyrgyzstan, Mongolia and Lesotho regarding rangeland restoration and pasture management. Activities need a community based participatory approach, including establishment of land use rights, agreed grazing plans and monitoring	Component 1, Activity 1.1.3 Component 2, Activity 2.3.1	Lessons learnt in Uganda. From IFAD's ReLIV, see ReLIV Project Development Report Lessons learnt in Kenya, from the IFAD-funded Upper Tana Natural Resources Management Project (UTaNRMP). See InREMP Project Development Report See also lessons learnt from ILRI in Textbox 2: Interventions for rangeland management, lessons from Research projects implemented by ILRI, presented in Section 8.2.2 below.
Dairy value-chain development and multistakeholder platforms. The previous and ongoing IFAD livestock projects in the region in Kenya, Rwanda (e.g. RDDP, PRISM) and Tanzania have proven that the multistakeholder platforms are powerful tools to initiate and promote value chain partnerships (such as productive alliances), as well as policy participation of value chain actors. This will be upscaled at national and decentralised levels.	Component 1, Sub-activity 1.1.1.3 Component 2, Activity 2.1.2	Lessons learnt in Uganda. From IFAD's ReLIV, see ReLIV Project Development Report
Access to finance. Only a small subset of the dairy value chain enterprises in East Africa are generating sufficient revenues and margin to sustainably and responsibly borrow to invest in greening technologies and practices.	All component 3. The GDFF will be structured to overcome these challenges by providing access to finance for the target groups and support the implementation of climate-smart technologies and practices, thereby facilitating the transition to climate resilient, sustainable, and low-carbon dairy value chains.	Lessons learnt from access to finance. See Section 6, sub-section 6.7 on Access to finance.

4 PROGRAMME AREA SELECTION

4.1 METHODOLOGY FOR AREAS SELECTION

178. In each of the four countries, Programme areas were pre-identified based on the integration of several factors, which include: (i) climate risk; (ii) direct absolute GHG emissions from the dairy sector; (iii) soil carbon sequestration potential in natural ecosystems (pastures and grasslands); (iv) milk production by district/county; and (v) complementarity with other international financing institutions (IFI)-funded interventions, more particularly IFAD-financed Projects.

179. Climate risk analysis (climate "hot-spot mapping") was conducted in Kenya, Rwanda, Tanzania, and Uganda. A climate risk mapping (see figure 65) overlayed climatic hazards, exposure, vulnerability, and adaptive capacity. For this, geospatial tools (ArcGIS) were used to identify "hot spot" areas of climate risks affecting the livestock and dairy sectors across targeted countries. By pulling together the best available climate, biophysical and socioeconomic information into a climate "hot spot" map, a single representation of a complex, intermingle, and multi-faceted problem is represented. Hotspot on climate risks allows to discern the geographic areas with high risk, both from a geospatial, climatic and a temporal perspective.

180. Geospatial datasets used in each risk category (impacts, hazards, exposure, vulnerability, adaptive capacity) and pre-defined thresholds to reclassify the layers are presented in Table 16. Geospatial layers are obtained from pre-feasibility study 3 and described in Section 1 of this study. Additional layers from other pre-feasibility studies were used; for example, that on livestock distribution (from pre-feasibility Study 2), feed balance/carrying capacity and rangeland degradation (from pre-feasibility Study 6). A set of complementary and fundamental layers, particularly those related to socioeconomic indicators (such as population density, human development index, households with access to electricity, and distance to roads and markets) were retrieved from different other UN databases as well as from FAO's Hand-in-Hand platform227.

181. A total of 15 raster layers have been overlayed (see Table 16 below). In the hot-spot map, the sum of less than 2 overlayed layers is considered as low risk (in light yellow), the sum of 2 to less than 5 overlayed layers as moderate risk (in orange), the sum of 5 to less than 9 overlayed layers as high risk (in red), and more than 9 overlayed layers as high risk (in purple).

Table 16: Geospatial datasets used in each risk category and pre-defined thresholds to reclassify the layers

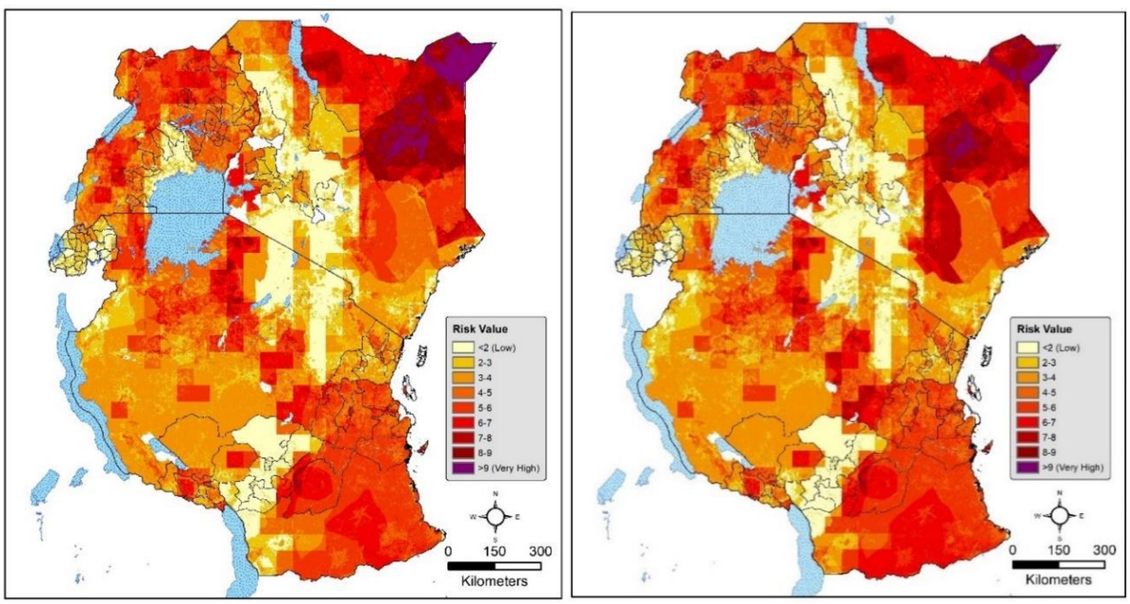
[227] See Hand in Hand website: https://data.apps.fao.org/?lang=en

Risk category	Geospatial layer	Units	Threshold used for pixel reclassification	Reclassified value
Impacts	Temperature-Humidity Index	-	<89 >89	0 1
	Boran breed: milk production loss	kg/day	<0.2 >0.2	0 1
	Holstein breed: milk production loss	kg/day	<2 >2	0 1
	Napier grass yield loss	%	>10 <10	1 0
	Maize yield loss	%	>10 <10	1 0
Hazards	Count on maximum number of days on annual average with rainfall ≤1mm/day	days/year	<100 >100	0 1
	Count on number of days on annual average with rainfall ≥50mm/day	days/year	<2 >2	0 1
Exposure	Livestock distribution	heads/km²	<50 >50	0 1
	Rangeland degradation	-	Positive or stable Negative or declining	0 1
	Population density	people/km²	<100 >100	0 1
	Carrying capacity	ton/ha	>100 <100	0 1
Vulnerability	Integrated Phase Classification	-	<4 >4	0 1
	Human Development Index	-	>0.55 <0.55	0 1
	Households with access to electricity	%	>25 <25	0 1
Adaptive capacity	Distance to roads and markets	hours	>1 <1	0 -1

Note: maximum potential value when overlaying all the layers = 14
Note: impact and hazard layers available for RCPs 2.6 and 8.5, mid-term (2040-2069) and far-future (2070-2099)

182. Results of the climate hotspot mapping show that most of the region has a high risk to climate hazards under both RCP 2.6 and RCP 8.5 in the mid-term (2040-2069) and far future (2070-2099).

a) b)



c) d)

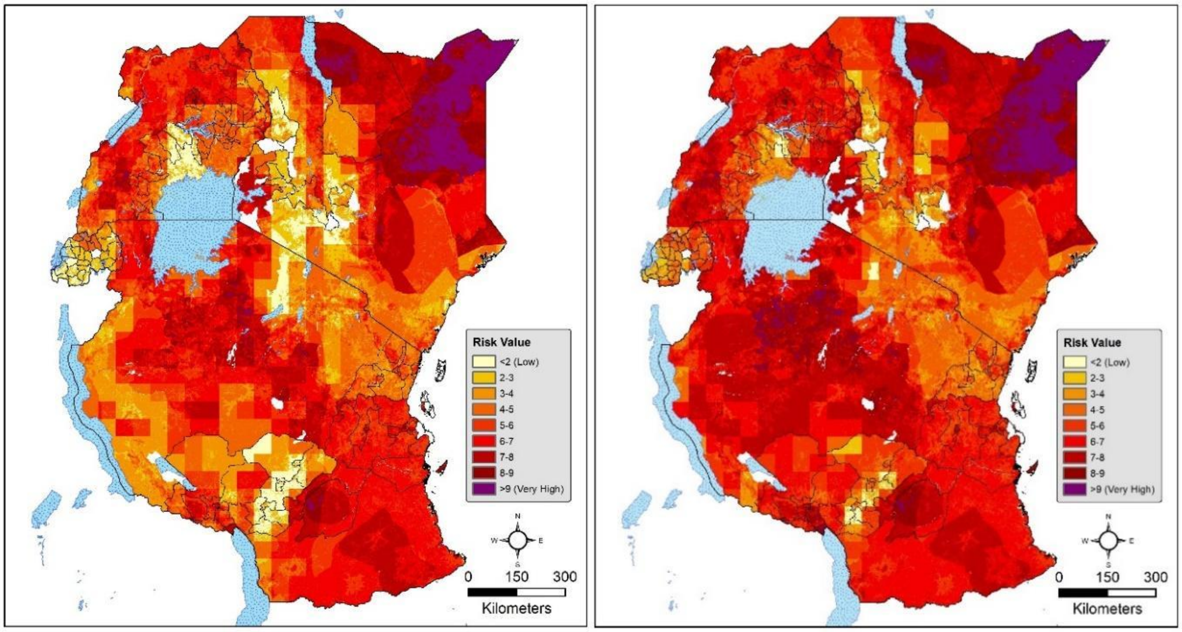


Figure 64 Spatial distribution of climate risks in the mid-term (2040-2069) for RCPs 2.6 (a) and 8.5 (b), and far-future (2070-2099) for RCPs 2.6 (c) and 8.5 (d)

4.2 PROPOSED PROGRAMME AREAS

183. As illustrated in Figure 65, maps of climate risks (“hotspot” maps), direct GHG emissions from the dairy sector, soil carbon sequestration potential, local milk production and other IFAD-funded projects were used to construct and populate a selection matrix, to screen and prioritize project areas (counties in Kenya; districts in Kenya/Uganda/Tanzania). The dairy systems targeted by the various interventions include (i) mixed cropped livestock systems, particularly intensive and semi-intensive dairy production systems; (ii) grazing and pastoralist systems; and (iii) dairy value chain processes, including renewable energy.

184. To perform the screening, a colour code was applied to each of the variables:

- For climate risks: red for high climate risk; orange for medium climate risk; and green for low climate risks. Data used is by mid-term (2040-2069) and far future (2070-2099), under RCP 8.5. More details on climate risk analysis can be found in pre-feasibility Study 3.
- GHG emissions baseline: red for high absolute emissions; orange for medium emissions; green for low emissions. Different thresholds were set, depending on each country's specificity regarding GHG emissions. Data source is detailed in Section 1 of this Study. More detail on emissions is found in pre-feasibility Studies 2 and 4.
- Soil carbon sequestration potential: red for high potential; orange for medium potential; green for low potential. Different thresholds were set, depending on each country's specificity regarding the soil carbon sequestration potential. Data source is detailed in Section 1 above, with more detail in pre-feasibility Study 6.
- Local milk production: High milk production (relative to the total country milk production) in red; orange for medium milk production; green for low milk production). Different thresholds were set, depending on each country's specificity regarding milk production. Data source is version 4 of the Global Livestock Environmental Assessment model, version 4 (GLEAM 4).

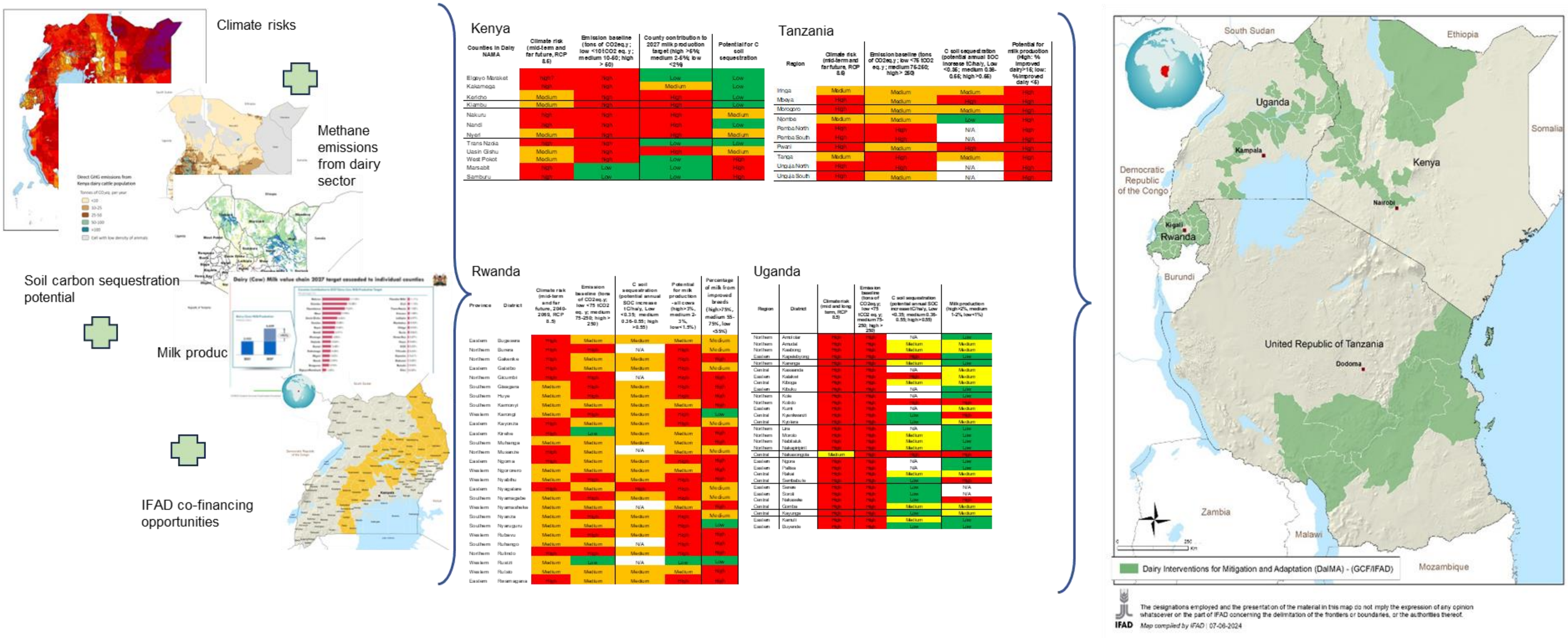


Figure 65: Illustration of the methodology to select areas (districts, counties)

185. In Kenya, the screening started with the initial list of 29 districts identified during the formulation of the Dairy NAMA Project. For the emission baseline (tons of CO2eq.yr), the following thresholds were set: low (<10 tCO2eq.yr); medium (10-50); and high (> 50). Local milk production was proxied by the milk county contribution to 2027 milk production target (high >5%; medium 2-5%; low <2%). In addition, complementarity with the IFAD co-funded projects KeLCoP and INReMP was considered, as appropriate (see map Figure 67). Twelve (12) counties were selected, namely: **Elgeyo Marakwet, Kakamega, Kericho, Kiambu, Nakuru, Nandi, Nyeri, Trans Nzoia, Uasin Gishu, West Pokot, Marsabit and Samburu.** Illustration of the methodology to select areas (districts, counties). Table 17 provides an assessment of the counties.

Table 17: Assessment of counties selected in Kenya

Counties in Dairy NAMA	Climate risk (mid-term and far future, RCP 8.5)	Emission baseline (tons of CO2eq.y; low <10 tCO2 eq. y; medium 10-50; high > 50)	County contribution to 2027 milk production target (high >5%; medium 2-5%; low <2%)	Potential for C soil sequestration
Elgeyo Maraket	high?	high	Low	Low
Kakamega	high	high	Medium	Low
Kericho	Medium	high	High	Low
Kiambu	Medium	high	High	Low
Nakuru	high	high	High	Medium
Nandi	high	high	High	Low
Nyeri	Medium	high	High	Medium
Trans Nzoia	high	high	Low	Low
Uasin Gishu	Medium	high	High	Medium
West Pokot	Medium	high	Low	High
Marsabit	high	Low	Low	High
Samburu	High	Low	Low	High

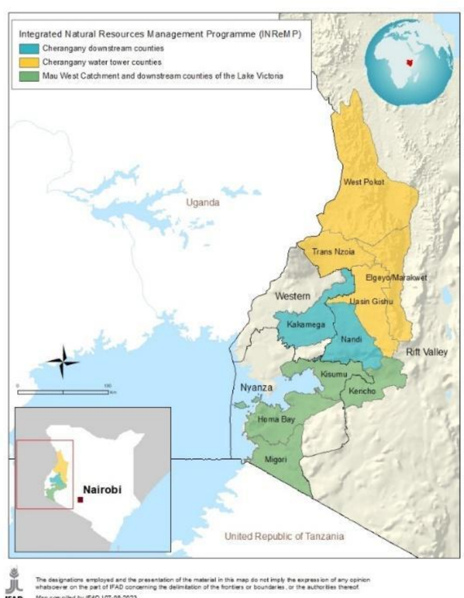


Figure 66: Map of INReMP target areas in Kenya from IFAD Project Design Report

186. In **Rwanda** the programme will target 27 out of 30 districts nationwide, which are essentially the same intervention area as the IFAD-funded RRDDP-2, see map Figure 68).

Figure 67: map of Rwanda indicating RDDP-2 target areas, from IFAD Project Design Report

187. The districts include:

- In the Eastern Province, Nyagatare, Gatsibo, Kayonza, Ngoma, Kirehe, Rwamagana, Bugesera;
- In the Northern Province, Gicumbi, Rulindo, Gakenke, Burera, Musanze;
- In the Western Province, Nyabihu, Rubavu, Ngororero, Rutsiro, Karongi, Nyamasheke, Rusizi;
- In the Southern Province, Kamonyi, Muhanga, Ruhango, Nyanza, Huye, Gisagara, Nyamagabe and Nyaruguru.

188. Bolded Districts were also targeted under RDDP, the predecessor Programme. New districts were selected based on poverty incidence; food insecurity, malnutrition; (ii) high impact of climate change; (iii) high potential for women and youth to get involved in the dairy value chain; (iv) concentration of schools and density of school children; and v) potential for dairy value chain development, including markets for dairy products. The percentage of milk from improved breeds was considered as an additional criterion. An assessment of the Districts in accordance with the criteria can be seen in Table 18.

Table 18: Assessment of Districts selected in Rwanda

Province	District	Climate risk (mid-term and far future, 2040-2069, RCP 8.5)	Emission baseline (tons of CO2eq.y; low <75 tCO2 eq. y; medium 75-250; high > 250)	C soil sequestration (potential annual SOC increase tC/ha/y, Low <0.35; medium 0.36-0.55; high >0.55)	Potential for milk production - all cows (high>3%, medium 2-3%, low<1.5%)	Percentage of milk from improved breeds (high>75%, medium 55-75%, low <55%)
Eastern	Bugesera	High	Medium	Medium	Medium	Medium
Northern	Burera	High	High	N/A	High	Medium
Northern	Gakenke	High	Medium	Medium	High	High
Eastern	Gatsibo	High	Medium	Medium	High	Medium
Northern	Gicumbi	High	High	N/A	High	High
Southern	Gisagara	Medium	High	Medium	High	High
Southern	Huye	Medium	High	Medium	High	High
Southern	Kamonyi	Medium	Medium	Medium	Medium	High
Western	Karongi	Medium	High	Medium	High	Low
Eastern	Kayonza	High	Medium	Medium	High	Medium
Eastern	Kirehe	High	Low	Medium	Medium	High
Southern	Muhanga	Medium	Medium	Medium	Medium	High
Northern	Musanze	High	Medium	N/A	Medium	Medium
Eastern	Ngoma	High	Medium	Medium	High	High
Western	Ngororero	Medium	Medium	Medium	Medium	High
Western	Nyabihu	Medium	High	Medium	High	High
Eastern	Nyagatare	High	Medium	High	High	Medium
Southern	Nyamagabe	Medium	High	Medium	High	Medium
Western	Nyamasheke	Medium	Medium	N/A	Medium	High
Southern	Nyanza	Medium	High	Medium	High	Medium
Southern	Nyaruguru	Medium	Medium	Medium	High	Low
Western	Rubavu	Medium	High	Medium	High	High
Southern	Ruhango	Medium	Medium	N/A	High	High
Northern	Rulindo	High	High	Medium	High	High
Western	Rusizi	Medium	Low	N/A	Low	Low
Western	Rutsio	Medium	Medium	Medium	Medium	High
Eastern	Rwamagana	High	Medium	Medium	High	High

189. In **Tanzania**, the Programme will be implemented in geographic alignment with the IFAD-funded Climate smart Smallholder Dairy Transformation Project (C-SDTP) in Southern Highlands, Eastern Zone and Zanzibar (see Figure 69). In the C-SDTP, districts were chosen based on the following criteria: (i) importance of dairy production in the area; (ii) prevalence of smallholder systems; (iii) existence of off-takers, or potential for local market; (iv) other development partners' interventions; (v) vulnerability to climate change.

Figure 68: map of C-SDTP target areas in Tanzania, from the IFAD Project Design Report

190. Specifically, the Programme will be implemented in:

-Southern Highland: Mbeya (Rungwe, Mbeya, Chunya and Mbarali districts), Iringa (Mufundi, Kilolo, Iringa districts) and Njombe (Njombe, Makete and Wanging'ombe districts);

-Eastern Zone: Tanga (Lushoto, Muheza, Korogwe, Pangani, Tanga districts), Morogoro (Mvomero, Kilosa and Morogoro districts) and Pwani (Kibaha and Bagamoyo).

-Zanzibar: Unguja (West, Central and South districts) and,

-Pemba (South and North districts).

191. These regions represent 44 percent of the milk produced by improved dairy cows (crossbreeds and exotic cows)[228] in the country, implying that the dairy sector that is more market oriented than Central and Western Tanzania region. This market orientation is essential for farmers willing to invest in innovations and technologies, proposed by the Programme. An assessment of the Districts is presented in Table 19.

[228] With an expansion to Arusha and Kilimanjaro regions, this percentage would increase to 66 percent. Dar es Salaam and Mjini Magharibi that have predominantly intensive zero-grazing dairy sector

Table 19: Assessment of Districts selected in Tanzania

Region	Climate risk (mid-term and far future, RCP 8.5)	Emission baseline (tons of CO2eq.y; low <75 tCO2 eq. y; medium 75-250; high > 250)	C soil sequestration (potential annual SOC increase tC/ha/y, Low <0.35; medium 0.36-0.55; high >0.55)	Potential for milk production (High: % improved dairy>15; low: % improved dairy <5)
Iringa	Medium	Medium	Medium	High
Mbeya	High	Medium	High	High
Morogoro	High	Medium	Medium	High
Njombe	Medium	Medium	Low	High
Pemba North	High	High	N/A	High
Pemba South	High	High	N/A	High
Pwani	High	Medium	High	High
Tanga	Medium	High	Medium	High
Unguja North	High	High	N/A	High
Unguja South	High	Medium	N/A	High

192. In **Uganda**, the screening started with the list of districts within the Uganda cattle corridor and identified for the Resilient Livestock Value-chains Project (Re-LIV). This selection was based on (i) high incidence and density of poverty, food insecurity, malnutrition; (ii) herd size by the households and potential for dairy and meat (beef) value chain development, including markets for animal sourced products; (iii) high potential for women and youth to get involved in the dairy and beef value chain; and (iv) climate vulnerability. In addition, the selection was based on subnational priorities and potential complementarities with ongoing development initiatives in dairy and cattle industry. For the emission baseline (tons of CO2eq.y), the following thresholds were set: low (<75 tCO2 eq. y), medium (75-250) and high (> 250). For the potential annual SOC increase (in tC/ha/y), these were set as low (if <0.35); medium (if between 0.36-0.55), and high (if >0.55).

193. Based on these criteria, 30 districts were selected. These include, for each Region:

-Central region: Kasaanda, Kayunga, Kiboga, Kyankwanzi, Kyotera, Nakasongola, Nakaseke, Gomba, Rakai, Sembabule;

-Eastern Region: Buyende, Kamuli, Kapelebyong, Katakwi, Kibuku, Kumi, Ngora, Pallisa, Serere and Soroti;

-Northern Region (this region includes what is sometimes referred to as Karamoja, with a distinct pastoralist livelihoods system): Amolotar, Amudat, Kaabong, Karenga, Kole, Kotido, Lira, Moroto, Nabitaluk and Nakapiripirit;

194. An assessment of the Districts is presented in Table 20 below.

Table 20: Assessment of selected Districts in Uganda

Region	District	Climate risk (mid and long term, RCP 8.5)	Emission baseline (tons of CO2eq.y; low <75 tCO2 eq. y; medium 75-250; high > 250)	C soil sequestration (potential annual SOC increase tC/ha/y, Low <0.35; medium 0.36-0.55; high >0.55)	Milk production (high>2%, medium 1-2%, low<1%)
Northern	Amolotar	High	High	N/A	Low
Northern	Amudat	High	High	Medium	Medium
Northern	Kaabong	High	High	Medium	Medium
Eastern	Kapelebyong	High	High	High	Low
Northern	Karenga	High	High	Medium	Low
Central	Kasaanda	High	High	N/A	Medium
Eastern	Katakwi	High	High	High	Medium
Central	Kiboga	High	High	Medium	Medium
Eastern	Kibuku	High	High	N/A	Low
Northern	Kole	High	High	N/A	Low
Northern	Kotido	High	High	High	High
Eastern	Kumi	High	High	N/A	Medium
Central	Kyankwanzi	High	High	Low	High
Central	Kyotera	High	High	Low	Medium
Northern	Lira	High	High	N/A	Low
Northern	Moroto	High	High	Medium	Low
Northern	Nabitaluk	High	High	Medium	Low
Northern	Nakapiripirit	High	High	Medium	Low
Central	Nakasongola	Medium	High	High	High
Eastern	Ngora	High	High	N/A	Low
Eastern	Pallisa	High	High	N/A	Low
Central	Rakai	High	High	Medium	Medium
Central	Sembabule	High	High	Low	High
Eastern	Serere	High	High	Low	N/A
Eastern	Soroti	High	High	Low	N/A
Central	Nakaseke	High	High	Low	High
Central	Gomba	High	High	Medium	Medium
Central	Kayunga	High	High	Low	Medium
Eastern	Kamuli	High	High	Medium	Low
Eastern	Buyende	High	High	Low	Low

5 BENEFICIARIES DESCRIPTION AND SELECTION

5.1 OVERVIEW OF PROGRAMME BENEFICIARIES

195. Beneficiaries of the Programme will be government and regional institutions regulating, supporting and monitoring the dairy sector (Component 1). Within the project areas, stakeholders along the “dairy food system”, i.e. actors at production (across all production systems) and aggregation (milk collection centres, MCCs, and milk collection points, MCPs) will be targeted (Component 2). Priority will also be given to supporting private enterprises (agri-input suppliers, processors, climate-smart technology or equipment and digital providers) to scale across the four Countries (Component 3) (see Market Study in FS Appendix 1). More details for each component are provided below.

Who are the beneficiaries?

196. Component 1 supports directly the public sector institutions that are mandated to intervene in the dairy value chains, for animal health, gender-inclusive advisory extension services for feed quality, manure, and herd management issues. Interventions will also benefit public services responsible for policy-making and sectoral organisations (dairy boards) in charge of regulating the dairy value-chain. Institutions in charge of dairy sector monitoring (more particularly on GHG monitoring, reporting and verification - MRV systems) are also targeted, as well as regional institutions for enhanced knowledge management in East Africa. Therefore, the recipients (dairy food system stakeholders) enjoying the benefits of this component will be mainly indirect, since they will likely receive a measurable adaptation benefit from improved animal production and health services.

197. Under Component 2, direct beneficiaries are smallholder dairy farmers who have – on average - 1 to 5 dairy cows (6 to 10 kg of milk per cow per day) kept in zero-grazing/ intensive or semi-zero grazing/semi-intensive systems. These farmers currently sell milk in formal and informal channels. According to the Market Study (Appendix 1 of the FS), these smallholder dairy farmers are the critical segment to scale, to grow the formal dairy sector and drive sustainable intensification, while addressing climate change adaptation and mitigation.

198. The support to the dairy value chain will also benefit medium and larger-scale commercial farmers (6 or more dairy cows, 5-9 litre/cow/day for semi-intensive systems; 12 or more litre/cow/day for intensive systems). Under outputs 2.1 and 2.2, these dairy farmers will directly benefit from participation in L-FFS, from improved veterinary and breeding/artificial insemination (AI) services and through their membership in dairy cooperatives, and as suppliers to MCPs/MCCs. Under Output 2.3, the Programme will also benefit pastoralists and agro-pastoralists, and medium and large-scale extensive farmers (10-100 cows).

199. Component 3 will target small and medium-sized enterprises (SMEs) operating in the dairy value chains. Medium-sized “farmer-allied” dairy value-chain actors, including milk aggregators and milk processors, agro-input providers (e.g. feed and fodder producers), equipment providers (e.g. milking machines, mobile milk chillers, water harvesting systems), technology providers (e.g. renewable energy such as PV/ solar solutions, e-bikes for milk transportation, milk pasteurizers, UHT treatment equipment, AI service producers, dairy meal producers, biodigesters providers, biochar producers), agri-fintech providers, and mature dairy farmers’ cooperatives will benefit. The ultimate beneficiaries of the better performing, technically improved, and greener investment operations are the smallholder partners of these dairy SMEs/ businesses. Component 3 will also benefit financial institutions (participating banks) through the TA facility under output 3.2.

How are beneficiaries selected?

200. Within selected project areas (as described above in Section 4), livestock farmers benefitting from previous phases of IFAD-funded projects will be eligible for support, along with others. Eligibility criteria include (i) dairy or dual-purpose cattle[229] ownership as per the given production systems[230]; (ii) access to forage/ feed (own, purchased or through communal rangelands); (iii) market-oriented dairy farmers, i.e. selling milk on the market, formally (through MCCs/MCPs, or directly to processors) or informally (direct selling to consumers or opportunistically via traders), (iv) active dairy farmers, e.g. in the area of use of manure for nutrient cycling and feed production, (v) “innovative” farmers, who are interested in the use of digital technologies, for instance for e-extension or herd management, and renewable energy solutions. In pastoral systems, membership of pastoral organizations (e.g. grazing committees, traditional committees, village land committees, depending on the country) will be a criteria. In all instances, village and other leaders will be engaged in the identification of beneficiaries, but not responsible for their selection. There will be self-selection into the Programme, and verification of eligibility by staff or service providers, based on willingness and open and transparent processes. Direct targeting may be used, especially in relation to women and youth inclusion.

201. Group membership (organisations such as breeders’ organizations, livestock farming field schools – L-FFS, dairy cooperatives) will be added advantage for selection, but not an eligibility criteria, as new groups may be formed and previously unconsidered farmers (including youth, women) may join. Eligibility for existing groups include: (i) good governance principles are being followed and there is no elite capture; (ii) social inclusion criteria are being met; (iii) majority of members are engaged in milk sales, through MCCs and MCPs, and these members are willing to adopt renewable energy solutions to graduate their current milk cooling and processing operations. Baseline studies capturing socio-economic characteristics will be undertaken to identify the number of villages, population, socio-economic conditions of the target groups, existing groups. Eligibility criteria for establishing new groups of farmers are those described in the above paragraph.

202. For engagement with cooperatives and MCCs, eligibility criteria will include the willingness to invest own funds, and for private sector, the willingness to engage in productive alliances or other direct engagements with farmers. Selection will be based on an open and transparent process, based on call for expression of interest, submission of applications and assessment of the entity and proposal. Direct targeting (headhunting) may be used.

203. As detailed in Component 3 description (see table 52, Section 8.3), to qualify for the GDFF loans and technical support, SMEs’ proposed investments have to be in line with the agreed green dairy taxonomy of GDFF. In the component description below, detailed characteristics of the eligible companies, which will benefit from GDFF dairy loans, are listed, separately for larger (annual turnover exceeding US$ 800,000) and smaller (annual turnover less than US$ 800,000).

How are beneficiaries estimated?

204. In **Kenya**, the number of dairy farmers households is estimated by (i) quantifying the total number of cattle animals in the counties targeted by the Program, and distributing these animals across the main livestock production systems prevailing in the country (extensive, semi-intensive, intensive), (ii) quantifying the number of dairy cattle from the contribution of each production system to national milk production (i.e. intensive, 42%; semi-intensive, 44%; extensive, 14%) and, (iii) deriving direct beneficiaries from the cattle ownership per household, in each typical production system (intensive, 6 cows; semi-intensive, 8.2 cows; extensive, 12 cows). In the targeted counties, 75 percent of the dairy farmers are considered as beneficiaries of the Programme. As a result, a total of 467,546 direct beneficiaries from dairy farming households will be reached. Data sources included the GLEAM database as well as national statistics from the Kenya National Bureau of Statistics (KNBS).

205. In **Rwanda**, in the project areas, the majority of the dairy cattle are kept under the zero-grazing system (94%), the rest of the herd being under semi-grazing (4%) and grazing (2%). Average cattle ownership per production system (125 for grazing systems, 10 for semi-grazing, 3 for zero-grazing) was used to calculate the number of dairy farming households in each of the production systems. A total of 615,394 people – about 30 percent of dairy farmers, mainly in intensive and semi-intensive systems - will be reached. GLEAM database and national statistics (5th Rwanda Population and Housing Census 2022) were used to calculate the number of dairy farmers and dairy animals.

[229] Dual-purpose cattle are breeds that are raised for both milk and meat production.
[230] In zero-grazing/ intensive or semi-zero grazing/semi-intensive systems, 1-5 dairy cows.

206. In **Tanzania**, the number of dairy farmers households was derived from (i) the cattle population in the targeted areas by production system (small-scale commercial and traditional), (ii) cattle ownership by household in each production system (i.e. small-scale commercial, 5 cows; traditional system local breed, 5 cows; traditional system cross breed, 5 cows). Seventy five (75) percent of the dairy farmers was considered as potential beneficiary of the Programme. As a result, a total of 758,408 direct beneficiaries will be reached. GLEAM database and national statistics (national livestock keeping households in the National sample census of agriculture in Tanzania, reference year 2019/2020) were used to calculate the number of dairy farmers and dairy animals.

207. In **Uganda**, cattle population in the targeted areas was used and disaggregated to production systems identified in the country (small-scale, medium-scale intensive and large-scale intensive, small-scale and medium-scale extensive, pastoralist, agro-pastoralist). The direct beneficiaries were determined using (i) the cattle and dairy cattle population in each region and, (ii) the cattle ownership per production systems (small-scale intensive, 2 cows; medium-scale intensive, 15 cows; large-scale intensive, 110 cows; small-scale extensive, 3 cows; medium-scale extensive, 8.5 cows; pastoralist, 50 cows; agro-pastoralist, 35 cows). In the targeted districts, 75 percent of the dairy farmers was considered as potential beneficiary of the Programme. As a result, a total of 663,421 beneficiaries from dairy farming households will be reached. Like other countries, GLEAM database and national statistics (e.g. from the Uganda National Survey Report 2019/2020) were used to calculate the number of dairy farmers and dairy animals.

208. Overall, throughout the 6 years, the Programme will **directly benefit** a total of about 2.5 million individuals (see table 21), of which at least 40 percent women, 30 percent youth and 5 percent marginalized groups. Direct beneficiaries (table 21a) include (i) dairy farmers as detailed above, and (ii) other stakeholders in the dairy value-chain, i.e. staff/ partners of MCCs and MCPs, SMEs benefiting from productive alliances (about 105 alliances) and from the financing instruments supported under component 3 (about 767 dairy loans). Adaptation benefits will include: (i) increased dairy farmers' understanding of technical responses to adapt to changing climatic conditions, and enhanced farmers' capacity to integrate (adopt) improved practices in their production systems (animal health and vaccination against diseases exacerbated by climate change, locally-adapted and productive cross-breeds, climate resilient fodder and feed varieties, manure management) (component 2, output 2.2, ARA1), (ii) enhanced access to consistent and stable market outlets, including aggregation centres and private off-takers, allowing better milk price and reducing milk losses, (iii) well-managed and restored pastures and rangelands increasing climate resilience through improved feed quality and water access, biodiversity conservation, healthier ecosystems and reduced land degradation (component 1, output 2.3, ARA4). **Co-benefits** will include: (i) enhanced gender equality and women empowerment (through the "enhanced" GALS+ interventions under component 2, output 2.1), which would otherwise be exacerbated by climate change[231], and (ii) increased health, well-being, food and water security (through One Health and nutrition interventions under component 1, outputs 1.2 and 1.4).

209. **Indirect beneficiaries** were calculated based on (i) the total population in the targeted areas (counties in Kenya, districts in Rwanda and Uganda, regions in Tanzania) where animal production and health services will be enhanced, (ii) the share of rural population and total rural population, and (iii) the share of rural population raising livestock in their farming systems. Assumptions are based on national census[232], FAO studies[233], reviewed journals[234] and conservative assumptions. An estimated total of 15.7 million individuals (and not counting direct beneficiaries, see table 21b) are expected to indirectly benefit, of which 50 percent will be women. Adaptation benefits include: (i) strengthened veterinary services (support to private and public veterinarians and veterinary paraprofessionals, enhanced diagnostic capacity of veterinary laboratories) able to better support dairy farmers in the context of emerging and re-emerging diseases and infestations exacerbated by climate change (component 1, output 1.2), (ii) enhanced extension services (including e-extension tools) focusing on climate-resilient dairy sector through for e.g. the use of drought-resistant fodder, application of crop residues, reproductive management (component 1, output 1.2), (iii) better access to breeding services (including through enhanced capacity of artificial insemination centres) for a improved access to highly productive, locally-adapted and climate resilient cross-breeds (component 2, output 2.2) and, (iv) enhanced climate information (component 1, output 2.3). Improved dairy sector policies, strategies, and regulations (Component 1, output 1.1), built on accurate GHG emission data and inventories (component 2, output 2.3), will also positively benefit the sector's stakeholders.

210. Figure 70 below presents the number of beneficiaries, dairy cattle owned by these beneficiaries, as well as hectares of rangeland to restore, for enhanced feed access.

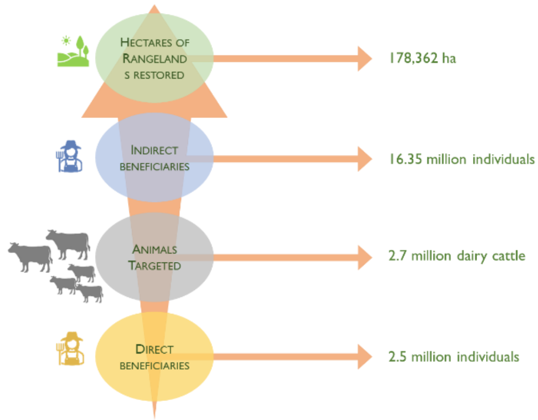


Figure 69: Programme beneficiaries and benefits (dairy herd reached, rangelands under improved management)

[231] FAO. 2024. *The unjust climate – Measuring the impacts of climate change on rural poor, women and youth*. Rome

[232] **In Kenya:** https://www.knbs.or.ke/wp-content/uploads/2023/09/2019-Kenya-population-and-Housing-Census-Volume-2-Distribution-of-Population-by-Administrative-Units.pdf and https://www.knbs.or.ke/wp-content/uploads/2023/09/2019-Kenya-population-and-Housing-Census-Volume-1-Population-By-County-And-Sub-County.pdf. **In Uganda**, https://www.ubos.org/wp-content/uploads/statistics/NPHC-2024-Preliminary-Tables-upload.xlsx, In Tanzania, https://www.nbs.go.tz/uploads/statistics/documents/sw-1705484561-Administrative_units_Population_Distribution_Report_Tanzania_Mainland_volume1b.pdf.

[233] FAO, ASL 2050, https://openknowledge.fao.org/server/api/core/bitstreams/db9e785c-7e0f-4af9-97fb-d1751ba460f8/content

[234] https://pmc.ncbi.nlm.nih.gov/articles/PMC7773236/

Table 21: Disaggregation of Beneficiaries (direct and indirect), by country

(a)

Country	Direct benef
Kenya	467,105
Rwanda	614,013
Tanzania	757,652
Uganda	665,097
Total	**2,503,866**

(b)

Country	Indirect beneficiaries (individuals)
Kenya	3,960,556
Rwanda	4,044,368
Tanzania	4,510,429
Uganda	2,907,625
Total indirect beneficiaries	**15,422,977**

Table 22: Disaggregation of number of animals, by country

Number of animals		Y1	Y2	Y3	Y4	Y5	Y6	Total
Kenya	Nbr	-	152,349	152,349	152,349	152,349	152,349	**761,743**
Rwanda	Nbr	23,591	70,771	94,362	94,362	94,362	94,362	**471,811**
Tanzania	Nbr	78,310	156,619	195,774	195,774	156,619	-	**783,095**
Uganda	Nbr	-	135,981	135,981	135,981	135,981	135,981	**679,905**
Total	Nbr	**101,900**	**515,720**	**578,465**	**578,466**	**539,311**	**382,692**	**2,696,554**

5.2 GENDER AND YOUTH TARGETING

211. Baseline information about gender is provided in Section 2.7 of this Feasibility Study. A more in-depth analysis is presented in Annex 8 “Gender Assessment and Programme-level Action Plan” (as also referred to the Gender Equality and Social Inclusion -GESI assessment and action plan).

212. Gender transformative interventions are an integral part of the Programme to increase the number of women-owned livestock farms as well as increase their involvement in more profitable activities in the value chain. To achieve this, addressing land access, labour and time barriers for women will be essential. Both practical and strategic needs of women and youth need to be identified and integrated in the design of the Programme. Among others, provision of water for livestock and household use closer to the farms is likely to mitigate the time and effort currently spent in accessing water, reducing the burden and making the enterprise more attractive to women. Some gender roles vary across the project geographies, while others remain constant, which will be considered in implementation. For example, in the Southern Highlands of Tanzania, milking is done by men, whereas both men and women traditionally milk in Tanga. In both cases, livestock ownership and sales decisions are made by men, making women’s ownership to the milk business dependant on the decision of men. Targeting will factor in opportunities and barriers to inclusion such as access to and control over land and natural resources, and finance, including access to credit. Beneficiaries will be 40% women. Affirmative action will be mainstreamed, with 40% of the budget earmarked towards gender and inclusion.

213. The socio-economic targeting strategy of the Programme will ensure the inclusion of poor and nutrition insecure households who meet the Programme selection criteria in line with **IFAD’s targeting strategy**. Women and youth-led dairy related enterprises will be targeted as well as people living with disabilities. 40% of beneficiaries will be youth – defined as men and women 35 years and younger.

214. The GESI assessment and action plan for implementation of DaIMA’s interventions in Tanzania, Kenya, Rwanda and Uganda has two parts. Part 1 provides a contextual GESI analysis of smallholder dairy farmers and MSMEs (dairy cooperatives and processors) in each respective country. Identifying the key challenges for gender equality and women empowerment, youth empowerment, nutrition, marginalized and vulnerable groups and persons living with disability (PWDs) in dairy production and associated services enterprises and proposes required interventions. Part 2 provides the gender action plan setting out proposed actions to achieve the Gender Equality and Social Inclusion (GESI) outcomes and targets.

215. Achieving the outcomes and goals described in the theory of change (ToC) requires a holistic approach to improving all aspects of the dairy sector, from improving policy, institutional and service delivery environments to building the capacity of smallholder farmers especially women, youth and the vulnerable groups. It also includes measures to facilitate access to finance and innovative technologies with mitigation and adaptation benefits. As a result, female and youth dairy farmers and processors will be motivated to adopt more efficient, climate-resilient and low carbon practices that will increase incomes and reduce production costs. To address the barriers faced by women and youth, DaIMA will contribute to gender equality and women empowerment women by: (i) increasing women economic empowerment through access to improved dairy breeds, better access to productive resources and services, marketing and value addition and access to finance by targeting women dairy smallholders in dairy production; (ii) balancing and reducing women workloads related to dairy keeping through improved technologies, climate-resilient crop and sustainable productions and greater efficiency; (iii) increased women participation, voice and decision-making in dairy farmer organizations and cooperatives (iv) influencing positive gender and social norms such as joint benefits sharing through the Gender Action Learning System (GALS) methodology and (v) contribute to policy engagement by undertaking gender analyses or developing policy briefs in the planned related policy reviews. These interventions (see section 8 - Detailed Porgramme Description) will target women involved in dairy production, young females and males and vulnerable groups, including PWDs among beneficiary communities. Gender will be mainstreamed throughout the project activities strengthening capacity of those responsible for programme delivery and strengthening of the monitoring and evaluation system to ensure sex and gender disaggregated data.

216. The socio-economic targeting strategy will comprise (i) direct targeting of the vulnerable households, including those women headed, youth, vulnerable and marginalized and PWDS to reach the 40 percent and 30 percent quota for youth (ii) self-targeting, with activities geared towards the needs of small and medium producers that are engaged in dairy.

217. As detailed in Section 7 (Implementation Arrangements), the GESI Action Plan will be implemented by PMUs through implementing partners in each country. Each PMU will appoint a GESI specialist to ensure the roll out of the GESI action plan for each country DaIMA interventions. Additional expertise will be procured under the GDFF and Technical assistance sub activities to ensure access and uptake for women and youth. The specific TA will include (i) capacity strengthening and technical support to partner staff and agents; (iii) the recruitment of experienced service providers to support outreach, gendered approaches and capacity building at the community level. The implementing partners (and or service providers) will include those with a proven commitment to community participatory approaches, gender equality, and with the relevant GESI capacity. The implementing partners shall be held accountable for delivering on GESI targets. (iv) The Monitoring and Evaluation will ensure all data is disaggregated by sex, age, location and disability, where appropriate (including targets and data on youth) using standard formats at all levels of implementation; and the inclusion of the IFAD empowerment index to measure gender transformation which applies the principles of the Women's Empowerment in Agriculture Index (Pro-WEAI) at baseline, mid-term and end-term studies and adjust project interventions as required to address any negative impacts.

6 PROGRAMME JUSTIFICATION

6.1 OVERVIEW OF INTERVENTIONS PROMOTED UNDER THE PROJECT

218. The interventions of the Programme will address the climate change adaptation and mitigation problems across the various dairy production systems and along the value-chain, while addressing the barriers identified in the Theory of Change (ToC, see Section 3. It will scale-up: (i) practices *at farm and herd levels* to increase productivity, reduce emission intensities, and decrease absolute emissions against a BAU scenario; (ii) solutions *at farm level* for manure management and nutrient recycling, to enhance circularity, resilience and reduce emissions; (iii) interventions at *landscape-level* to enhance rangelands ecosystems' resilience and services, more particularly soil carbon sequestration, and provisioning of water and biomass for feed; and (iv) *value-chain level* interventions, to reduce milk losses and increase the use of renewable energies. This holistic and sustainable approach, that will also address enablers such as access to markets, finance, knowledge and services, will lead to lower emissions from the dairy sector (when compared to "the 'business-as-usual scenario).

219. **Interventions at farm and herd levels.** Interventions will address the various climate risks and impacts, i.e. decline in milk yields, animal heat stress, cattle mortality, change in dairy cattle diseases, decrease in feed productivity, due to reduced soil or excess soil moisture and fertility, spoilage of fodder in unprotected storage due to excess moisture. **Across all the dairy systems,** the Programme will promote the combined adoption of climate-smart adaptation and mitigation practices, including improved animal genetic resources (artificial insemination with improved and indigenous, locally-adapted livestock breeds, sexed semen), improving herd health (e.g. vaccination against East Coast Fever), water recycling, harvesting and re-use for cattle watering, as well as biochar use. **In intensive and semi-intensive systems,** in addition to the above, interventions will enhance the availability of fodder grasses and legumes, feeding practices and use of conserved silage and supplementary feed resources. Interventions will also include the establishment of fodder grasses and legumes trees (Leucaena, Calliandra, etc.), the use of conserved silage and urea-molasses multi-nutrient blocks (UMMB), the use of natural methane inhibitors (e.g. tannins rich Calliandra, lipids), supplementation (use of non-conventional feed resources e.g. sweet potato vines), precision feeding and improvement in animal welfare and housing. **In extensive systems,** activities will include improving grazing management (e.g. pasture/rangeland management plans, rotational grazing), use improved pasture species and management practices to enhance forage quality and quantity, and use of multipurpose leguminous trees.

220. **Solutions at farm level for manure management and nutrient recycling.** Interventions will address CH4 and N2O emissions from livestock manure, and limitations related to crop fertilization. Interventions include the promotion of simple circular manure management practices to reduce nutrient losses and GHG emissions (covering, compaction, composting, liquid-solid separation, biochar addition). Investments will also be made into biogas units to produce energy at household and cooperative levels.

221. **Interventions at value-chain level,** will include the upgrading or equipment of milk collection centres (MCCs), and increase milk supply through the formal aggregation and processing channels. Investments will aim at reducing milk losses (and indirect emissions), and reducing GHG emissions through decarbonization with improved energy use efficiency and the use of PV systems as source of renewable energy (RE) for milk cooling (milk collection centres) and processing systems.

222. **Interventions at landscape level** will address the negative impact of climate change on ecosystem (rangeland and pastureland) degradation, which translates into reduced soil carbon sequestration capacity, r decrease in pasture quantity and quality due to changes in composition, all contributing to decreased milk yields. Interventions will focus on improved pasture management, through participatory learning and promotion of sustainable grazing practices. Land management activities will rehabilitate degraded rangelands for increased soil carbon sequestration, promote fodder access and address the natural barrier to rangeland degradation. In the four target countries, soil carbon impacts are identified to be an important strategy for carbon sequestration activities such as grazing intensity management, mowing frequency, organic inputs, biochar production from invasive species and use in fodder production, and improved agroforestry systems associated with mixed crop-livestock production systems.

223. **Interventions on the enabling environment** would focus on (i) a climate-responsive policy and regulatory environment (institutional frameworks, dairy value chain governance, and farmer awareness campaigns) for the dairy sector, (ii) enhancing proximity public and private services to the dairy sector, in particular expanded veterinary access and innovative gender-inclusive advisory services combined with input supply; (iii) strengthening dairy cooperatives and milk collection points to encourage farmers to adopt the above mentioned pathways. Enhancements in Measurement, Reporting, and Verification (MRV) capabilities will result in increased Tier 2 emissions data, which will be used to improve national inventories, as well as to inform policy, planning, and investment decisions that are based on evidence. Through regional cooperation and knowledge sharing, coordinated regional strategies will be ensured, individual country efforts will be amplified, and joint learning will be fostered.

224. These interventions are summarised in Table 23 and the additionality of GCF financing to IFAD financing is summarised in Table 24 bis.

Table 23: Summary of interventions and potential benefits on adoption, mitigation, milk production and benefit-cost ratios

Hazard/ climatic driver	**Climate Risks/ Impact**	**Emissions problem**	**Adaptation & mitigation activity promoted by the Project[235]**	**Adaptation benefit as a result of activity**	**Potential mitigation benefit[236] as a result of activity**	**Potential Milk production benefit as a result of activity**	**Benefit cost-ratio (BCR)[237]**
Practices to increase climate-change adaptation, and reduce emission intensities, and absolute emissions							
Temperature stresses Water deficit (droughts) Water excess (flooding) Increase in temperature humidity index (THI)	Decline in milk yields. Animal heat stress Cattle mortality Change in dairy cattle pathogen/ diseases, parasite, and vector development. Decrease in feed production and productivity, due to reduced soil or excess soil moisture and fertility. Decrease in pasture quantity and quality due to	Methane emissions from the dairy sector dominate the 4 countries' agricultural GHG emissions inventories. Increased CO2 concentration Emission intensities of dairy production vary a lot by system and are rather high.	Combined adoption of climate-smart practices (component 1, output 1.2; component 2, outputs 2.1, 2.2 and 2.3). *For intensive and semi-intensive systems*, establishment of fodder grasses and legumes (Calliandra, Leucaena, etc.); use of conserved silage and urea-molasses multi-nutrient blocks (UMMB); supplementation (use of non-conventional feed resources e.g. sweet potato vines); precision feeding and improvement in animal welfare and housing. *For extensive systems*, improving grazing management (e.g. rotational grazing); use improved pasture species and management practices to enhance forage quality and quantity; use of multipurpose leguminous trees. *For all systems*, improving herd health (e.g. vaccination against	Grasses and legumes contribute to soil health and fertility. Diversification with drought-tolerant fodder species allows to produce biomass in dry seasons, with temperature increases and water deficits. Conservation of fodder and supplementation allow feed access during temperature stresses and water deficits, and stabilizes milk production, which translates into sustained income generation, thereby building resilience. Better grazing management also leads to higher pasture and fodder quality. Healthy animals have better feed conversion efficiency, improved productive and reproductive performance. Well-adapted improved breeds are easier to manage as they require less inputs per unit of product produced, therefore making farming less costly. The female to male ratio in the herd increases with the use of sexed-semen and the	*By 2050, % relative to BAU, emissions from dairy cattle (all systems), entire country herd, in enteric ktCH$_4$* In Kenya: enteric CH4 emissions to decrease by up to 8 percent; enteric CH4 emission intensities to decrease by 31 percent. In Rwanda: enteric CH4 emissions will remain as BAU; enteric CH4 emission intensities to decrease by 23 percent. In Tanzania: enteric CH4 emissions to decrease by up to 29 percent; enteric CH4 emission intensities to decrease by 52 percent.	*By 2050, relative to BAU*[239] In Kenya: milk production to increase by 33 percent. In Rwanda: Milk production to increase by 30 percent . In Tanzania: milk production to increase by 50 percent. In Uganda: milk production	In Kenya: BCR for different mitigation options to range from 1.1 to 5.8 In Rwanda: N/A In Tanzania: ranged from 0.2 to 0.73 in traditional systems and from 2.4 to 2.9 in improved systems In Uganda: from -11 to 20 percent in traditional systems; from 1 to 28 percent in improved

[235] Separate studies also modeled the impact of interventions taken in isolation.
[236] Expressed in absolute emissions and emission intensities (CH4 per liter of milk)
[237] Data provided by literature. See FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2019. Options for low emission development in the dairy sector - reducing enteric methane for food security and livelihoods. Studies available for Kenya, Tanzania and Uganda. More details are provided in the Project economic and financial analysis.
[239] Ibid 4.

Hazard/ climatic driver	Climate Risks/ Impact	Emissions problem	Adaptation & mitigation activity promoted by the Project[235]	Adaptation benefit as a result of activity	Potential mitigation benefit[236] as a result of activity	Potential Milk production benefit as a result of activity	Benefit cost-ratio (BCR)[237]
	changes in composition and strengthened degradation. Spoilage of fodder in unprotected storage due to excess moisture		East Coast Fever); improved animal genetic resources (artificial insemination with improved and indigenous, locally adapted livestock breeds, sexed semen). Promoting water recycling, harvesting and reuse for cattle watering. Use of biochar (supplementation).	number of unproductive animals decreases. Multipurpose trees used for shade and reduction in heat stress. Biochar is a valuable addition to probiotic approaches that enhance effectiveness and save money for animal health management. Supplementation with biochar is a viable alternative to ionophores for achieving the dual objectives of reduced methane emissions and increased feed efficiency.	In Uganda: enteric CH4 emissions to increase 6 percent; enteric CH4 emission intensities to decrease by 47 percent. Avoided warming[238]	to increase by 100 percent.	systems Biochar in feed: 4.67 from avoided ionophores, prevention of contagious Mastitis, and premium for increased butter fat. Biochar in silage: 2.87 from shrinkage and spoilage savings
			Combined adoption of climate smart practices and change of animal population (component 1, output 1.2; component 2, outputs 2.2 and 2.3). Same as above, but with measures (*applicable to all production systems*) to increase the off-take of low producing animals while increasing the efficiency of milk production	Same benefits as above. In addition, awareness creation on the benefits of culling strategically and feed availability e.g., selling the old/ low producing animals in the herd saves feed for the better productive animals. Sales are a source of income, which increase adaptive capacity to CC.	*By 2050, % relative to BAU, emissions from dairy cattle (all systems), entire country herd, in enteric ktCH$_4$*[240] In Kenya: enteric CH4 emissions to decrease by up to 17 percent; enteric CH4 emission intensities to decrease by 32 percent. In Rwanda: N/A In Tanzania: enteric CH4 emissions to	In Kenya: milk production to increase by up to 21 percent. In Rwanda: N/A In Tanzania: milk production to increase by up to 24 percent.	In Kenya: BCR for different mitigation options to range from 1.1 to 5.8 In Rwanda: N/A In Tanzania: ranged from 0.2 to 0.73 in traditional systems and from 2.4 to 2.9 in

[238] Ibid 4.
[240] Ibid 4.

Hazard/ climatic driver	**Climate Risks/ Impact**	**Emissions problem**	**Adaptation & mitigation activity promoted by the Project**[235]	**Adaptation benefit as a result of activity**	**Potential mitigation benefit**[236] **as a result of activity**	**Potential Milk production benefit as a result of activity**	**Benefit cost-ratio (BCR)**[237]
					decrease by up to 48 percent; enteric CH4 emission intensities to decrease by 59 percent. In Uganda: enteric CH4 emissions to decrease by up to 10 percent; enteric CH4 emission intensities to decrease by 50 percent. Avoided warming[241]	In Uganda: milk production to increase by up to 80 percent.	improved systems In Uganda: from -11 to 20 percent in traditional systems; from 1 to 28 percent in improved systems
			Combined adoption of climate smart practices plus methane inhibitors[242] *for intensive systems* (e.g. tannins rich Calliandra, lipids, components 1; component 2, output 2.2).	Same benefits as above.	*By 2050, % relative to BAU, emissions from dairy cattle (all systems), entire country herd, in enteric ktCH$_4$*[243] In Kenya: relative to BAU, enteric CH4 emissions to decrease by up to 13 percent; enteric CH4 emission intensities to decrease by 35 percent. In Rwanda: relative to BAU, enteric CH4	In Kenya: Relative to BAU, milk production to increase by up to 33 percent. In Rwanda: by 2050, relative to BAU, milk production to increase by 30 percent.	In Kenya: BCR for different mitigation options to range from 1.1 to 5.8 In Rwanda: N/A In Tanzania: N/A In Uganda: N/A

[241] Ibid 4

[242] Lipid supplementation could be an effective CH4 mitigation strategy as it reduces the population of the methane producing microbes. Lipids are readily available and straightforward to implement in intensive or confined feeding systems. Supplementation of the tannin-rich plants (e.g., Calliandra trees) reduced CH4 emissions per day and per unit of feed and energy intake. Tannins reduce CH4 production in the digestive systems of ruminants by indirect inhibition of hydrogen-producing microflora and direct inhibition of methanogens.

[243] See Feasibility Study (Annex 2) and its Appendix for more details and references on the modelling.

Hazard/ climatic driver	Climate Risks/ Impact	Emissions problem	Adaptation & mitigation activity promoted by the Project[235]	Adaptation benefit as a result of activity	Potential mitigation benefit[236] as a result of activity	Potential Milk production benefit as a result of activity	Benefit cost-ratio (BCR)[237]
					emissions to decrease by up to 35 percent; enteric CH_4 emission intensities to decrease by 50 percent. In Tanzania: N/A In Uganda: N/A Avoided warming (see pre-feasibility study 2 and 4)	In Tanzania: N/A In Uganda: N/A	
Landscape interventions to increase ecosystems' resilience and carbon sequestration[244]							
Water deficit (droughts) Water excess (flooding) Temperature stresses Soil depletion Increased CO_2 concentration	Decreased access to rangelands resources/ feed (fresh grass) Contribution to ecosystem degradation Decrease in rangeland/pasture carrying capacity No ecosystem-based adaptation possible	Loss of ecosystems functions and services, including decreased soil health and capacity to store soil carbon	Enclosure (component 2, output 2.3). Area of rangeland which is enclosed by a fence with branches of native thorny Acacia trees as well as traditional rules to protect vegetation from grazing and/or browsing with the exception of calves and sick animals. Enclosure aims to conserve standing pasture for dry season. *Applicable for extensive systems.*	Interventions contribute to cope with the high seasonal variability in quantity and quality of rangeland resources accentuated by water deficit and temperature stresses.	- Rate of SOC increase: 1.77±0.18 tC/ha/yr - Initial SOC: 43.80 tC/ha	N/A.	Not available
			Rotational grazing (component 2, output 2.3), is defined as where a paddock is not stocked continuously but grazed and rested regularly either on a set calendar schedule or intermittently as needed. *Applicable for extensive systems.*	In rotational grazing, rest periods allow deeper root systems to grow enhancing plant nutrient uptake, reducing soil erosion, improving soil health and therefore increase pasture drought resilience. Rotational grazing prevents bare patches of soil which	- Rate of SOC increase: 2.2 tC/ha/yr - SOC stock: 28% higher in rotational grazing compared to control	N/A	Not available

[244] See Feasibility Study (Annex 2) and its appendix for details and references.

Hazard/ climatic driver	Climate Risks/ Impact	Emissions problem	Adaptation & mitigation activity promoted by the Project[235]	Adaptation benefit as a result of activity	Potential mitigation benefit[236] as a result of activity	Potential Milk production benefit as a result of activity	Benefit cost-ratio (BCR)[237]
	Milk yield reductions. Decrease in pasture quantity and quality due to changes in composition and strengthened degradation.			increase erosion and soil organic matter (SOM) loss, and reduce water infiltration, so avoiding bare patches will improve ecosystem water use efficiency. Furthermore, reduced grazing pressure benefits perennial grasses & legumes, which have better feed quality than annuals.			
			Improve agroforestry system (component 2, output 2.3). Integrated systems combine livestock, gardening, and fodder production. Integration of multipurpose leguminous trees and shrubs such as *Acacia anguistissima, Cajanus cajan, Gliricidia sepium, Leucaena collinsii, Sesbania sesban, Tephrosia candida and Tephrosia vogelii* and fruit trees. Use of biochar-fortified manure in tree nurseries and planting. *Applicable for extensive systems.*	Integrating multipurpose tree species in the rangelands/pastures not only provides additional feed resources for livestock, particularly during dry periods, but also contributes to improving soil quality (leguminous trees) and farmers 'income diversification (fruit trees), improving their resilience and adaptation to climate change. Using biochar increases tree survival & growth by improving soil water retention and nutrient availability, improving drought resilience of the trees and the entire system.	- Rate of SOC increase: 1.6 to 4.9 tC/ha/yr according to the system	N/A	Not available
			Improved pasture management (component 2, output 2.3). Combination of improved practices such as rotations and use of manure and fertilizers, as well as use of suitable pasture species increases biomass yields and feed availability for livestock. *Applicable for extensive systems.*	Well managed pasture avoid rangeland degradation and therefore increases the long term resilience of the grazing system to climate variability.	- Rate of SOC increase: 0.10 tC/ha/yr - Initial SOC: 5.30 tC/ha	N/A	Not available
			Management of grazing intensity and timing (component 2, output	Optimal grazing leads to improved grassland	Heavy grazing:	N/A	Not available

Hazard/ climatic driver	Climate Risks/ Impact	Emissions problem	Adaptation & mitigation activity promoted by the Project[235]	Adaptation benefit as a result of activity	Potential mitigation benefit[236] as a result of activity	Potential Milk production benefit as a result of activity	Benefit cost-ratio (BCR)[237]
			2.3). Rangeland occupied by agro-pastoralists. Paddocks established for rotational grazing. *Applicable for extensive systems.*	productivity and offers benefits in terms of adaptation and mitigation. Managing grazing intensity contributes not only to improving soil C sequestration but also sustaining diverse ecosystem services such as soil health, biodiversity conservation, and water retention improving pasture and rangeland resilience to climate change.	- Rate of SOC increase: 0.77 tC/ha/yr - Initial SOC: 32.20 tC/ha Light grazing: - Rate of SOC increase: 0.88 tC/ha/yr - Initial SOC: 36.40 tC/ha		
			Grassland restoration through removal of invasive woody species such as *Prosopis juliflora*, followed by conversion of the waste biomass into biochar, reseeding of pasture with adapted plant species (e.g. *Cenchrus ciliaris*) plus use of biochar-fortified manure to improve pasture soil fertility.	Use of biochar improves soil water holding capacity. Use of drought-adapted forage plants increases ecosystem drought resilience; use of biochar-fortified manure accelerates pasture regeneration and closing of bare soil, thereby improving rainwater infiltration and ecosystem water use efficiency. It opens opportunities for youth employment in service delivery for clearing invasive shrubs and producing biochar, partly supported by income from carbon credits.	2.2 ton CO2/ha sequestration per ton of biochar added		Biochar-enriched manure: over 2.5 in 2 years through multiple ratoons of fodder grass (forecast)
Interventions at food system level to reduce GHG emissions and increase resilience through circularity & recycling							
Heavy winds Soil depletion Water deficit (droughts)	Loss of soil fertility due to erosion, negative impact on feed crops productivity. Maladaptation risks with increased use	Reliance on fossil fuel energy or fire wood for household/ entreprise energy needs GHG emissions from manure	Simple circular manure management techniques, and small-scale (component 1; component 2, output 2.2) and medium-scale (component 1; component 3; output 3.1) biogas units.	Less reliance on ecosystems for firewood and charcoal, or less reliance on fossil fuel energy. Biogas generated in a 4m^3 (fed with manure of 5-8 cows) has a potential to cover 60% - 100% of cooking energy needs for an average household (depending on the	If charcoal used for cooking (daily consumption of around 1.5 kg dry matter charcoal) is substituted with biogas, potential benefits per household are: 2.4 tCO_{2eq}/year; retained	No quantitative data available. Increased milk production because of better feed availability	Depends on the biodigester size and type, feedstock composition and availability of feedstock

Hazard/ climatic driver	Climate Risks/ Impact	Emissions problem	Adaptation & mitigation activity promoted by the Project[235]	Adaptation benefit as a result of activity	Potential mitigation benefit[236] as a result of activity	Potential Milk production benefit as a result of activity	Benefit cost-ratio (BCR)[237]
Water excess (flooding) Changes in soil water retention capacity and infiltration	of synthetic fertilizer.	deposited on the fields	Animal waste used in biodigesters for production of energy for household consumption or processing by cooperatives/private sector. Biodigesters to be installed at farm level. 6m^3 “Flexi Biogas” system technology promoted under other IFAD-funded projects in Kenya and Rwanda[245]. Simple manure management interventions (covering, compaction, composting, liquid-solid separation, biochar addition) For intensive and extensive systems:	cooking energy demand of the household) [246]. Cost savings and/or income generation from bio-slurry; and improved soil fertility due to bio slurry application as biofertilizer. Income increase if bio-slurry is sold. Reduce manure nutrient leaching, thereby preserving manure nutrients and improving fertilizer quality of the manure. This has positive effects on nutrient retention in animal housing and during	CO_2 sequestration potential of around 6.7 tCO_2/year (if unsustainable wood harvesting is avoided)[247]; and avoidance of 280 $kgCO_{2eq}$/year due to conversion of manure to biogas (ie. Improved manure management)[248]. Improved manure management, in terms of soil fertilization and substitution/replacement of chemical fertilizers can result in further GHG emission reduction. Biochar addition reduces manure CH4	through increased farm nutrient circularity.	and water. Profitability is positive, overall, with some conditions[251]. Payback period of only 2-3 years[252] FAO Reports[253] highlighting that minimum profitable conditions (in Rwanda) are (i) 5.6m^3 min capacity, (ii) tubular technology at USD 300, and (iii) about 11 cows

[245] See https://www.ifad.org/en/web/knowledge/-/how-to-do-note-mainstreaming-portable-biogas-systems-into-ifad-supported-projects
[246] For more details, see: FAO. 2021. Biogas systems in Rwanda – A critical review. Rome. https://doi.org/10.4060/cb3409en ; Digester size of: (a) 4m3 with 20-40kg of daily fresh dung, 20-40 liter of water (daily) supplied by 2-3 cattle or (b) 6m3 (with 40-60kg of daily fresh dung, 40-60 liter of water (daily) supplied by 4-5 cattle. Both have been adopted at small-scale in targeted countries.
[247] Estimated based on: https://energypedia.info/images/4/4a/EN-Charcoal%2C_carbon_emissions_and_international_onventions%3Bprotocols-Almeida_A._Sitoe.pdf
[248] Based on Ibid. and IPCC emission factors https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf
[251] Ibid.
[252] Africa Biogas Partnership Programme (ABPP). Independent verification of these calculations is recommended as this is a key selling point and the basis of the business case to customers.
[253] FAO. 2023. Sustainable bioenergy potential from crop, livestock and woody residues in Rwanda: An integrated bioenergy and food security approach. Environment and Natural Resources Management Working Paper, No. 97. Rome. https:// doi.org/10.4060/cc7094en

Hazard/ climatic driver	Climate Risks/ Impact	Emissions problem	Adaptation & mitigation activity promoted by the Project[235]	Adaptation benefit as a result of activity	Potential mitigation benefit[236] as a result of activity	Potential Milk production benefit as a result of activity	Benefit cost-ratio (BCR)[237]
			addition of biochar to barns, feedlots, and bomas (overnight enclosures)	manure storage. This biochar-fortified manure can then be used for fodder & crop production, improving the feed availability & quality for dairy cattle. Biochar addition improves soil water holding capacity and rainfall infiltration, thereby improving system water use efficiency. Improved nutrient retention increases manure fertilizer quality and reduces the need for costly fertilizer. Biochar-fortified manure can be sold to generate income. There is also evidence that biochar addition to barns improves animal health, thereby reducing costs for drugs and reducing animal morbidity/mortality. Finally, options for carbon financing through biochar production & use.	and N2O emissions[249] and indirect emissions from manure NH3 volatilization[250] (Mazingira pilot). Furthermore, biochar addition to soils leads to SOC sequestration.		(translating into 4.8m3 biogas/ year). Biochar in bedding: 1.45 return on investment through avoided environmental pathogens, ammonia, increased hundred weight.
Temperature stresses	High temperatures compromise the safety of milk and milk products. Risk of milk losses.	Lost milk contributes to "unproductive GHG emissions", and represents a waste of resources used in production, such as land,	MCC equipped with PV energy system (component 2, output 2.1; component 3; output 3.1) Milk pasteurizers of 2, 3, 5 or 7m^3 with PV systems (component 2, output 2.1; component 3; output 3.1).	Positive. Less reliance on costly energy sources such as diesel and grid power.	GHG savings from pasteurizers of 3m^3 for Diesel vs. PV is 104.25 tCO2eq/yr for each of the 4 countries.	N/A	N/A

[249] Harrison, Brendan P., Si Gao, Melinda Gonzales, Touyee Thao, Elena Bischak, Teamrat Afewerki Ghezzehei, Asmeret Asefaw Berhe, Gerardo Diaz, and Rebecca A. Ryals. 'Dairy Manure Co-Composting with Wood Biochar Plays a Critical Role in Meeting Global Methane Goals'. Environmental Science & Technology 56, no. 15 (2 August 2022): 10987–96. https://doi.org/10.1021/acs.est.2c03467.
[250] Baral, Khagendra Raj, John McIlroy, Gary Lyons, and Chris Johnston. 'The Effect of Biochar and Acid Activated Biochar on Ammonia Emissions during Manure Storage'. *Environmental Pollution* 317 (15 January 2023): 120815. https://doi.org/10.1016/j.envpol.2022.120815.

Hazard/ climatic driver	Climate Risks/ Impact	Emissions problem	Adaptation & mitigation activity promoted by the Project[235]	Adaptation benefit as a result of activity	Potential mitigation benefit[236] as a result of activity	Potential Milk production benefit as a result of activity	Benefit cost-ratio (BCR)[237]
		water and energy. Higher energy demand from MCC and pasteurizers to cope with higher temperatures. MCCs and pasteurizers rely on diesel/ GHG-emitting generators as their primary energy source due to frequent power interruptions. Very few MCC and pasteurizers utilize renewable energy (RE) sources.			GHG savings from pasteurizers of $5m^3$ for Diesel vs. PV is 173.7 tCO2eq/yr for each of the 4 countries. GHG savings from pasteurizers of $3m^3$ for grid vs. PV ranges between 9.7-41.8 tCO2eq/yr, depending on country. GHG savings from pasteurizers of $5m^3$ for grid vs. PV ranges between 16.2-69.8 tCO2eq/yr, depending on country.		

Table 24 bis: Additionality of GCF financing to IFAD financing

DaIMA's financier	Country			
	Kenya	Rwanda	Tanzania	Uganda
IFAD co-financing (baseline investments: INReMP in Kenya, RDDP-2 in Rwanda, C-SDTP in Tanzania and ReLIV in Uganda)	- Enhanced extension services for the dairy sector - Enhanced animal health and veterinary services - Dairy production-enhancing solutions, including breeding, feed and fodder - Smallholders' dairy cooperatives development - Market access, productive alliances along the dairy value-chain - Awareness campaigns on milk nutritional benefits - Milk food safety and strengthening of milk inspection services - National policies and regulations on sustainable dairy production - Gender-related activities (GALS+)			
Remarks	In *Tanzania*, animal health activities are financed by the GCF In *Rwanda and Tanzania*, the support to extension services is co-financed by the GCF			
GCF financing (additionality)	- Regional centres of excellence for technology validation and database on practices and GHG indicators - Regional cooperation platform and participation in regional/ global networks for knowledge exchange and policy dialogue on low-carbon, climate-resilient dairy sector - GHG monitoring, reporting and verification (MRV) systems - Climate risk and vulnerability assessments - Carbon certification system - Renewable energy technologies for reduced GHG emissions - Promotion of climate-resilient, low-carbon and production-enhancing practices: breeding, feed and fodder, manure management (including biodigesters and biogas) - Land tenure security - Regional & national policies and regulations on low-carbon, climate resilient dairy production - Restoration of degraded pastures for improved soil C sequestration, and enhanced access to water - Green Dairy Financing Facility (GDFF)			
Remarks	In *Kenya*, land tenure security activities are financed by IFAD *In Kenya*, Carbon certification system financed by IFAD *In Uganda*, IFAD is financing (i) the promotion of climate-resilient low-carbon and production-enhancing practices, (ii) the restoration of degraded pastures (through GEF co-financing)			

6.2 SCENARIO ANALYSIS FOR A LOW-CARBON DAIRY SECTOR

225. Nationally Determined Contributions and development projects report their impacts on emissions compared to a situation Business As Usual (BAU), meaning without interventions. It is therefore necessary to project the development of the dairy herd, milk production and the associated impact on GHG emissions, particularly CH_4 associated with various scenarios. For the 4 countries, various scenarios have been identified.

226. The scenario analysis shows that the dairy cattle population in Kenya will increase by 35 percent between 2024 and 2050, except in the S7 scenario, which will increase by 23 percent. The sub-sector has the potential to boost milk production to reach an annual production of 3 548 million liters of milk, mainly through the combined adoption of climate-smart livestock practices and improvement of feed availability, feeding strategies, and milk markets. To achieve this, efforts will be needed to support dairy farmers of all sizes to better optimize their practices, particularly the formulation of dairy diet, the management of reproduction, as well as the conservation of forage. However, absolute CH_4 emissions will increase from the 2019 baseline levels due to increased animal numbers. However, absolute CH_4 emissions will be slightly lower than the BAU for all scenarios in 2050. Table 25 provides a description of the scenarios, and Table 26 presents the relative changes between BAU and the other scenarios in 2050.

Table 25: Description of the scenarios for the dairy sector and comparison between the reference year (2019) and targeted year (2050) in Kenya

Scenario	Narratives
Scenario 1 (S1) – Business-as-usual, BAU	It assumes the growth of the dairy cattle population will follow past trends. By comparing the reference year (2019) and 2050, the number of dairy cattle will increase by 35 percent by 2050, in which intensive system will increase by 27 percent, semi-intensive by 13 and extensive by 62 percent. Feed and feeding interventions will be implemented to improve animal nutrition and on-farm management practices. Milk production will increase by 43 percent, whereas enteric CH_4 emissions will increase by 36 percent. However, enteric CH_4 emission intensity will decrease by 5 percent. This scenario assumes that the current investments will be sustained until 2050. Moreover, Capacity building will be provided to farmers to improve on-farm management practices. At least 20 percent of dairy farmers will be willing to adopt the best practices outlined in KCSAS.
Scenario 2 (S2) – Animal health	It assumes the dairy cattle population's growth will follow BAU trends (S1). By comparing the reference year (2019) and 2050, animal health improvement will increase milk production by 79 percent and absolute enteric CH_4 emissions by 42 percent. However, enteric CH_4 intensities will reduce by 21 percent. In S2, it assumes the adoption of animal health practices such as helminthic control, use of acaricides, and vaccination to control East Coast Fever by half of the dairy farmers in Kenya. Moreover, feed and feeding based on existing technologies will improve. It is assumed that continuous investment in veterinary and extension services will be strengthened. The change between BAU and S2 in 2050 is illustrated in Table 26.
Scenario 3 (S3) – Feed and feeding strategies	It assumes that half of the dairy farmers will adopt the best feed production and diet formulation in intensive and semi-intensive systems. The population of dairy cattle will increase, as per BAU. By comparing the reference year (2019) and 2050, milk production will increase by 60 percent by 2050, whereas enteric CH_4 emissions will increase by 35 percent. The enteric CH_4 emission intensity will decrease by 15 percent. In S3, it is assumed aadoption of the use of improved forages, fodder trees (Leucena or Calliandra), and supplementation with legumes and sweet potato vine silage. It also assumes that 50 percent of dairy farmers will improve their diet formulation using machinery for the preparation of total mixed rations. Finally, it is assumed that 50 percent of farmers have access to water resources. The change between BAU and S3 in 2050 is illustrated in Table 26.

Scenario	Narratives
Scenario 4 (S4) – Use of urea-treated crop residues	It assumes that half of the dairy farmers in both intensive and semi-intensive will adopt this practice. By comparing the reference year (2019) and 2050, milk production will increase by 73 percent by 2050. Meanwhile, enteric CH_4 emissions are expected to rise by 37 percent, but enteric CH_4 emission intensity will decrease by 21 percent. This scenario (S4) also assumes that farmers will be trained in the preparation of feed using urea-treated crop residues, ensuring they can mitigate any health risks associated with this practice. Additionally, it presumes that the price of urea will remain stable on international markets, facilitating its accessibility for formers. The change between BAU and S4 in 2050 is illustrated in Table 26.
Scenario 5 (S5) – Artificial insemination	It assumes that the breeding programme will be strengthened across all dairy production systems and that farmers will have access to sexed semen and embryo transfer services. By comparing the reference year (2019) and 2050, milk production will increase by 61 percent. The enteric CH_4 emissions will increase by 34 percent, but enteric CH_4 emission intensity will decrease by 17 percent. It also assumes that at least 50 percent of dairy farmers will benefit from sexed semen and embryo transfer services. It also assumes that more technicians will be trained and equipped to provide this service in rural areas. The change between BAU and S4 in 2050 is illustrated in Table 26.
Scenario 6 (S6) – Climate-smart practices	It assumes the establishment of best feed production and diet formulation in intensive and semi-intensive systems (improved forages, fodder trees, supplementation with legumes and sweet potato vine silage). It also assumes that adoption of animal health practices (use of acaricides and vaccination to control East Coast Fever) will be achieved by half of the farmers in all systems. Dairy farmers in both intensive and semi-intensive will adopt the use of urea-treated crop residue and will access sexed semen and embryo transfer services. By comparing the reference year (2019) and 2050, milk production will increase by 90 percent. Enteric CH_4 emissions will increase by 25 percent, but enteric CH_4 emission intensity will decrease by 35 percent. It assumes that all climate-smart practices will be adopted by at least 50 percent of dairy farmers in all systems and more investments will be made to improve feed and feeding interventions. This scenario also assumes that farmers will have continuous access to L-FFS and extension services. The change between BAU and S6 in 2050 is illustrated in Table 26.
Scenario 7 (S7) – Climate-smart practices and change of animal population	It assumes that the climate-smart practices, as in S6, will be adopted by at least 50 percent of farmers in all systems. These farmers will be willing to increase the off-take of low-producing animals while increasing the efficiency of milk production to satisfy the demand and increase farm productivity and profitability. By comparing the reference year (2019) and 2050, milk production will increase by 73 percent. Enteric CH_4 emissions will increase by 12 percent, but enteric CH_4 emission intensities will decrease by 35 percent. It assumes that at least 50 percent of farmers in all systems will adopt climate-smart practices and integrate them into their day-to-day farm management. Investments will be made to improve feed and feeding interventions. This scenario also assumes that farmers will have continuous access to L-FFS and extension services. The change between BAU and S7 in 2050 is illustrated in Table 26.

Scenario	Narratives
Scenario 8 (S8) –Climate-smart practices and CH_4 inhibitors	It assumes that the climate-smart practices as per S6 will be adopted by at least 50 percent of dairy farmers in all systems and 30 percent of farmers in intensive systems will adopt CH_4 inhibitors (feed additives) based on their market availability and will adopt the best climate-smart practices. By comparing the reference year (2019) and 2050, milk production will increase by 90 percent as a result of climate-smart practices. Enteric CH_4 emissions will increase by 18 percent, but enteric CH_4 emission intensity will decrease by 38 percent. This scenario assumes that farmers will integrate climate-smart practices into their day-to-day management of the farms. It also presumes that CH_4 inhibitors will be authorized for commercialization by Kenya Veterinary Medicines Directorate. Moreover, it assumes that farmers in intensive will be trained on the benefits and safety of CH_4 inhibitors and will adopt feeding practices that facilitate the application of CH_4 inhibitors. The change between BAU and S8 in 2050 is illustrated in Table 26.

Table 26: Impact of the different scenarios on population, milk production, absolute enteric methane emissions and emission intensities relative to the BAU in 2050 in Kenya.

	Percentage change between BAU and different scenarios in 2050						
	S2. Feed and feeding strategies	S3. Use of urea-treated crop residue	S4. Improvement of animal health	S5. Artificial Insemination	S6. Climate-smart practices (CSPs)	S7. CSPs and change of animal population	S8. CSPs and CH_4 inhibitors
Population	0%	0%	0%	0%	0%	-9.2%	0%
Milk production	11%	21%	25%	12%	33%	21%	33%
Enteric CH_4	-0.6%	0.4%	4%	-2%	-8%	-17%	-13%
Enteric CH_4 intensity	-11%	-17%	-17%	-13%	-31%	-32%	-35%

227. The scenario analysis shows that **Rwanda** has the potential to boost milk production and reduce absolute methane emissions and enteric methane emission intensities. To achieve this, efforts will be needed to support dairy farmers of all sizes in optimizing their practices, particularly the formulation of a dairy feed diet **combined with** the management of reproduction. Currently, most farmers don't have a defined feeding strategy and utilise any available resources without specific feed formulation. Table 27 provides a description of the future scenarios, and Table 28 shows the relative changes between BAU and different scenarios in 2050.

Table 27: Description of the scenarios for the dairy sector and comparison between the reference year (2019) and targeted year (2050) in Rwanda

Scenario	Narratives
Scenario 1 (S1) – Business-as-usual, BAU	It assumes that the growth of the dairy cattle population will follow past trends. By comparing the reference year (2020) and 2050, the number of dairy cattle will increase by 46 percent by 2050, in which the local breed will increase by 21 percent, the crossbreed by 73 percent, and exotic by 92 percent. Feed and feeding interventions will be implemented to improve animal performance and on-farm management practices. Milk production will increase by 64 percent, whereas enteric CH_4 emissions will increase by 59 percent. However, enteric CH_4 emission intensity will decrease slightly by 3 percent.

Scenario	Narratives
	It assumes that investments will continue to improve feed and feeding interventions and that farmers will continue to access capacity-building programmes focusing on-farm management practices through L-FFS.
Scenario 2 (S2) – Animal breeding	It assumes that targeted artificial insemination and improved farm management practices will drive the growth of the dairy cattle population. By comparing the reference year (2020) and 2050, the number of dairy cattle will increase by 42 percent. Within this population, local breeds will decrease by 27 percent, while crossbreeds will increase by 124 percent, and exotic by 149 percent. Milk production is anticipated to rise by 95 percent during the same period. Absolute enteric methane will increase by 82 percent. Enteric CH_4 emission intensity will decrease by 6 percent. The scenario also assumes significant investments in artificial insemination using high-yield semen, enhanced training and AI services, and improved accessibility of AI technology for dairy farmers. Additionally, it presumes that the capacity of milk collection centers will be expanded. Animal health and feed policies will support this development by ensuring the availability of high-quality veterinary products and feed materials. Furthermore, it is assumed that government and livestock stakeholders will establish market-based incentives, such as premium prices for high-quality, low-emission milk. The adoption rate of these practices is expected to be 50 percent among the targeted farmers. Table 28 illustrates the changes between the BAU scenario and Scenario S2 in 2050.
Scenario 3 (S3) – Climate-smart practices	This scenario assumes that concentrates will be more widely used in zero-grazing and pasture-grazing systems. It also includes promoting legume forage species and legume trees and improving crop residue digestibility. Farmers will ensure optimal pasture and grazing management, and targeted artificial insemination will drive the growth of the dairy cattle population. Additionally, 50% of dairy farmers will adopt health practices such as deworming and helminth control across all systems. Moreover, dairy farmers will have continuous access to L-FFS and extension services. The government and dairy stakeholders will establish market-based incentives, such as premium prices for high-quality and low-emission milk. By comparing the reference year (2020) to 2050, the dairy cattle population is expected to increase by 46 percent, driven by a 73 percent increase in crossbreed cattle and a 92 percent increase in exotic breeds. Milk production is projected to rise by 113 percent, while absolute enteric methane (CH4) emissions will increase by 59 percent. The enteric CH4 emission intensity will decrease by 25 percent. Table 28 illustrates the changes between the BAU scenario and Scenario S3 in 2050.
Scenario 4 (S4) – Climate-smart practices and CH_4 inhibitors	This scenario assumes that at least 50 percent of farmers in all systems will adopt all climate-smart practices outlined in S3. Additionally, technical innovations and policies will be implemented to facilitate the use of feed additives, condensed tannins (such as Calliandra), lipid supplementation, and high-starch forages. The use of feed additives is assumed to be approved by the Rwanda Food and Drugs Authority (FDA). It is expected that 30 percent of targeted dairy farmers will adopt feed additives and use Calliandra and other tannin extracts. The scenario also assumes improved dairy farm management and a high adoption rate of fodder production and storage practices. By comparing the reference year (2020) to 2050, milk production is projected to increase by 113 percent due to these climate-smart interventions, while enteric methane (CH4) emissions will increase by 4 percent. The intensity of enteric CH4 emissions will decrease by 51 percent. Additionally, the interval between first calving and subsequent calving will be reduced. Table 28 illustrates the changes between the BAU scenario and Scenario S4 in 2050.

Table 28: Impact of the different scenarios on population, milk production, absolute enteric methane emissions and emission intensities relative to the BAU in 2050 in Rwanda

	PERCENTAGE CHANGE RELATIVE TO BAU in 2050		
	S2. Animal breeding	**S3. Climate-smart practices**	**S4. Climate-smart practices and CH_4 inhibitors**
Population	-3%	0%	0%
Milk production	19%	30%	30%
Enteric CH_4	15%	-19%	-35%
Enteric CH_4 intensity	-4%	-23%	-50%

228. In **Tanzania**, overall, the results of the scenarios analysis are summarized below. Livestock numbers will increase in all scenarios as well as milk production and absolute CH_4 emissions. But, except for the BAU, other scenarios will reduce the enteric CH_4 emission intensities. Table 29 provides a description of the future scenarios and Table 30 the relative changes between BAU and scenarios.

Table 29: Description of the scenarios and comparison between the reference year (2019) and the targeted year (2050) in Tanzania

Scenario	**Narratives**
Scenario 1 (S1) – Business-as-usual, BAU	This scenario assumes that the growth of the dairy cattle population will continue to follow historical trends. It also assumes that current investments will be maintained through 2050 and that feed and feeding interventions will improve within enhanced dairy systems. To enhance animal management practices, capacity-building initiatives will be provided to farmers in pastoral and agro-pastoral systems. By comparing the reference year (2019) to 2050, the number of dairy cattle is expected to double (an increase by 118 percent), with improved dairy systems reaching a population of 2 million heads. Based on existing practices, feeding interventions will ensure better animal nutrition and on-farm management practices. Milk production is projected to increase by 120 percent, reaching approximately 8 billion liters. Absolute enteric CH_4 emissions are expected to rise by 117 percent, while the intensity of enteric methane emissions will decrease slightly by 2 percent.
Scenario 2 (S2) –Climate-smart practices and change in animal population	This scenario envisions significant advancements in the traditional dairy cattle systems through the use of high-quality semen for artificial insemination (AI) and the importation of crossbreed heifers in alignment with the Tanzania Livestock Master Plan (TLMP). It also anticipates enhancements in animal health programs, including vaccinations for East Coast Fever (ECF), Foot-and-Mouth Disease (FMD), and Rift Valley Fever (RVF). Additionally, the scenario assumes that half of the farmers will adopt improved animal health practices, such as helminthic control, acaricides, and vaccinations. Farmers are also expected to enhance forage cultivation and conservation, expand legume production, and gain better access to water and rural infrastructure, including feeder roads. By comparing the reference year (2019) to 2050, the number of improved dairy cattle is projected to increase six-fold, reaching 5.1 million by 2050. The population of traditional animals is expected to grow modestly by 43 percent. Milk production is anticipated to rise by 173 percent, reaching 10 billion liters. Enteric CH_4 emissions are projected to increase slightly by 12 percent, while the enteric CH_4 emission intensity is expected to decrease by 59 percent. Table 30 illustrates the changes between the BAU scenario and Scenario S2 in 2050.
Scenario 3 (S3) – Feed strategy – Legumes intercropping	This scenario assumes that the growth of the dairy cattle population will follow historical trends. It anticipates improvements in feed and feeding practices based on existing technologies, including the adoption of improved forages, fodder trees such as Leucaena or Calliandra, and supplementation with legumes and sweet potato vine silage. It also presumes that farmers will enhance diet formulation by using machinery to prepare total mixed rations in 50 percent of improved dairy systems. Comparing the reference year (2019) to 2050, the dairy cattle population is expected to increase as projected in scenario S1. Milk production is expected to rise by 196 percent, and absolute enteric CH_4 emissions are anticipated to increase by 117 percent. However, enteric CH_4 intensity is expected to be reduced by 27 percent. Table 30 illustrates the changes between the BAU scenario and Scenario S3 in 2050.

Scenario 4 (S4) – Urea-treated crop residues	This scenario assumes that half of the dairy farmers will adopt the best feed production and diet formulation practices in improved systems, utilizing urea-treated crop residues to maximize available resources. It also assumes good access to water and affordable urea from international markets. Additionally, it presumes that farmers will be well-trained in safely using urea to avoid any issues with toxicity. The dairy cattle population is expected to increase as projected in scenario S1. Comparing the reference year (2019) to 2050, milk production will increase by 132 percent, whereas enteric CH_4 emissions will increase by 112 percent. The enteric CH_4 emission intensity will decrease by 9 percent. Table 30 illustrates the changes between the BAU scenario and Scenario S4 in 2050.
Scenario 5 (S5) – Improving dairy breeds	This scenario assumes that at least 50 percent of farmers will benefit from improved and sexed semen and embryo transfer services. It anticipates that more technicians will be trained and equipped to provide these services in rural areas, ensuring that animals are well-fed and have adequate feed and water resources, which aligns with the Tanzania Livestock Master Plan (TLMP). By comparing the reference year (2019) to 2050, the dairy cattle population is expected to increase as projected in scenario S1. Milk production is expected to increase by 235 percent. Enteric CH_4 emissions are projected to rise by 111 percent. However, the enteric CH_4 emission intensity is anticipated to decrease by 37 percent. Table 30 illustrates the changes between the BAU scenario and Scenario S5 in 2050.
Scenario 6 (S6) – Package of climate-smart practices	This scenario assumes that at least 50 percent of farmers will adopt and integrate climate-smart practices into their daily farm management. Dairy farmers will continuously access strengthened Livestock Farmer Field Schools (L-FFS) and extension services. By comparing the reference year (2019) to 2050, the dairy cattle population is expected to increase as projected in scenario S1. Milk production is anticipated to rise by 235 percent. At the same time, absolute enteric methane (CH4) emissions are projected to increase by 110 percent, while enteric CH4 emission intensity is expected to decrease by 37 percent. Table 30 illustrates the changes between the BAU scenario and Scenario S6 in 2050.

Table 30: Impact of the different scenarios on population, milk production, absolute enteric methane emissions and emission intensities relative to the BAU in 2050 in Tanzania

	Percentage change between BAU and different scenarios in 2050				
	S2. CSPs and change of animal population	S3. Legumes intercropping	S4. Urea-treated crop residue	S5. Improving dairy breeds	S6. Package of CSP
Population	-30%	0%	0%	0%	0%
Milk production	24%	34%	6%	52%	50%
Enteric CH_4	-48%	0%	-2%	-2%	-29%
Enteric CH_4 intensity	-59%	-26%	-8%	-36%	-52%

229. The assumptions used in these scenarios have been obtained from previous analysis in **Uganda** by FAO (FAO & NZAGRC, 2019b[254]) and were supplemented by different mitigation identified in Uganda dairy NAMA (MAAIF & UNDP, 2017[255]) as follows:

- *Production of Improved Animal Feed*: The feed intake of dairy cattle determines its health, as well as the amount and quality of milk produced. Improving the quality of livestock feed increases the content of dry matter and total digestible nutrients in their intake, leading to increased dairy productivity, as well as reducing CH4

[254] FAO, & NZAGRC. (2019b). Options for low emission development in the Uganda dairy sector—Reducing enteric methane for food security and livelihoods (p. 39). https://www.fao.org/3/ca3375en/ca3375en.pdf
[255] MAAIF, & UNDP. (2017). *Nationally Appropriate Mitigation Action on: Climate-Smart Dairy Livestock Value Chains in Uganda*. United Nations Development Programme. https://www.undp.org/publications/nama-climate-smart-dairy-livestock-value-chains-uganda

emissions from enteric fermentation. This component concentrates on integrating the informal sector in the production of high-quality feeds.

- *Production and Supply of Hay*. Using hay is a cost-effective source of nutrients for livestock, especially during the dry season when feed supply is not enough. It can be made from grass and legumes which are abundant during the rainy season. The NAMA aims to promote the production and supply of hay for the farmers to utilize during shortages in feed supply, mainly during the dry season. This ensures the productivity of the dairy livestock all year round.
- *Livestock manure management and biogas production*. In consideration of the NAMA's holistic approach, it also aims to address the proper treatment of livestock manure. This is done by introducing the use of anaerobic biodigesters to treat animal waste from livestock operations. Using closed-type anaerobic digesters allows for collecting its by-products, biogas, and sludge. The collected biogas serves as an additional source of fuel that farmers can use to replace their existing fossil fuel-based needs such as for drying, electricity, cooking, and other purposes. The sludge can be used or sold as fertilizer.

230. Table 31 describes the future scenarios, and Table 32 shows the relative changes between BAU and scenarios in 2050. Results show that the combined adoption of climate-smart practices (rather than measures taken in isolation) has the best impacts at the country level.

Table 31 Description of the scenarios for the dairy sector in Uganda

Scenario	Narratives
Scenario 1 (S1) – Business-as-usual, BAU	This scenario assumes that the growth of the dairy cattle population will follow past trends, with the number of dairy cows increasing by 81 percent by 2050 across all systems. Feed and feeding interventions will be implemented to ensure better animal nutrition and on-farm management practices will be improved. It also assumes that current investments will be sustained through 2050, and capacity building will be provided to farmers to enhance on-farm management practices. At least 20 percent of farmers are expected to adopt the best practices outlined. By comparing the reference year (2020) to 2050, the cattle population is expected to rise by 82 percent. Milk production is projected to increase by 80 percent. At the same time, absolute enteric CH_4 emissions are anticipated to increase by 82 percent. It is assumed that enteric CH_4 intensity will remain constant during this period.
Scenario 2 (S2) – Feed strategy – Use of improved tolerant forages	This scenario assumes that the growth of the dairy cattle population will follow S1 trends. It also anticipates improvements in feed and feeding based on existing technologies, including adopting improved forages, legume grass intercropping, and increasing feed availability during the dry season through fodder conservation as silage. It assumes that 50 percent of farmers in improved systems will enhance diet formulation. By comparing the reference year (2020) to 2050, improving animal feeding using high-yielding, drought-tolerant forages is expected to result in a 118 percent increase in milk production. Absolute enteric CH_4 emissions are projected to rise by 86 percent, while overall enteric CH_4 intensity is anticipated to decrease by 15 percent. Table 32 illustrates the changes between the BAU scenario and Scenario S2 in 2050.
Scenario 3 (S3) – Use of urea-treated crop residues	This scenario assumes that the growth of the dairy cattle population will follow S1 trends. It also assumes that half of dairy farmers in intensive and semi-intensive systems will adopt this practice. Farmers will be trained in the preparation of feed based on urea-treated crop residues to avoid health risks associated with this practice. Additionally, it assumes that the price of urea will remain stable on international markets to facilitate access. By comparing the reference year (2020) to 2050, milk production is expected to increase by 82 percent, while enteric CH_4 emissions are projected to rise by 82 percent. The enteric CH_4 emission intensity is anticipated to remain stable during this period, with small changes between production systems. Table 32 illustrates the changes between the BAU scenario and Scenario S3 in 2050.
Scenario 4 (S4) – Water harvesting technologies	This scenario assumes that water harvesting will improve and that farmers will have access to new technologies. It also assumes that farmers will receive incentives through integrated support systems and avenues for joint learning. Additionally, it assumes the presence of technical and social support infrastructure, as well as access to labor and innovation. By comparing the reference year (2020) to 2050, enhancing water harvesting is expected to provide a greater supply of fresh water, increasing milk production by 110 percent. Absolute enteric CH4 emissions are projected to rise by 84 percent, while enteric CH4 emission intensity is anticipated to decrease by 13 percent. Table 32 illustrates the changes between the BAU scenario and Scenario S4 in 2050.
Scenario 5 (S5) – Livestock health	This scenario assumes that the growth of the dairy cattle population will follow the trends in S1. It also assumes that half of the farmers will adopt animal health practices to control diseases and parasites such as helminths, East Coast Fever (ECF), mastitis, foot-and-mouth disease, and lumpy skin disease. Additionally, it assumes improvements in feed and feeding based on existing technologies and continuous investment in veterinary and extension services. By comparing the reference year (2020) to 2050, the improvement of animal health is expected to result in a 135 percent increase in milk production and an 88 percent increase in enteric CH4 emissions. Overall, enteric CH_4 intensity is anticipated to be reduced by 20 percent. Table 32 illustrates the changes between the BAU scenario and Scenario S5 in 2050.
Scenario 6 (S6) – Improving Dairy Breeds	This scenario assumes that at least 50 percent of farmers will benefit from sexed semen and embryo transfer services. It also assumes training for veterinarians, importing high-quality genetic material, semen, and embryos, and building infrastructure in all regions. Additionally, it assumes that more technicians will be trained and equipped to provide these services in rural areas. By comparing the reference year (2020) to 2050, interventions targeting the improvement of dairy breeds in all extensive systems are expected to result in a 132 percent increase in milk production. Enteric CH4 emissions are projected to rise by 86 percent, while enteric CH4 emission intensity is anticipated to decrease by 20 percent by 2050. Table 32 illustrates the changes between the BAU scenario and Scenario S6 in 2050.

Scenario 7 (S7) – Package of climate-smart practices	This scenario assumes that farmers will integrate climate-smart practices into their daily farm management. It also addresses market access challenges for both local and export markets by improving and adopting international food standards, as well as enhancing market information systems and advertisements. By comparing the reference year (2020) to 2050, boosting the improvement of dairy cattle through a combination of interventions aimed at enhancing feed availability and quality, water availability, genetic potential, and herd health is expected to result in a 264 percent increase in milk production. Absolute enteric CH4 emissions are projected to rise by 92 percent, leading to a reduction in enteric CH4 emission intensity by 47 percent. Table 32 illustrates the changes between the BAU scenario and Scenario S7 in 2050.
Scenario 8 (S8) – Adoption of CSPs and change in population	This scenario assumes a high adoption of artificial insemination (using improved semen and embryo transfer) and enhanced animal health programs, such as vaccinations for East Coast Fever (ECF), Foot-and-Mouth Disease (FMD), and Rift Valley Fever (RVF). It also assumes that half of the farmers will adopt animal health practices, such as helminthic control, acaricides, and vaccinations to control East Coast Fever. Additionally, it assumes improvements in forage cultivation and conservation, widespread production of legumes, better access to water, and infrastructure development in rural areas. Boosting the improvement of dairy cattle in traditional systems with improved semen (AI) and the import of crossbreed heifers is implemented in line with Dairy NAMAs. By comparing the reference year (2020) to 2050, the total cattle population is expected to increase by 52 percent. The intensive dairy herd is projected to increase by 127 percent, while the number of traditional animals will rise slightly by 36 percent. Milk production is anticipated to grow by 227 percent, reaching 6.2 billion liters. Absolute enteric CH4 emissions are expected to increase by 63 percent, while enteric CH4 emission intensity is projected to decrease significantly by 50 percent. Table 32 illustrates the changes between the BAU scenario and Scenario S8 in 2050.

Table 32: Impact of the different scenarios on population, milk production, absolute enteric methane emissions and emission intensities relative to the BAU in 2050 in Uganda

	Percentage change between BAU and different scenarios in 2050						
	S2. Use of improved tolerant forages	**S3. Use of urea-treated crop in dry season**	**S4. Water harvesting technologies**	**S5. Livestock health technologies**	**S6. Improving Dairy Breeds**	**S7. Package of CSPs**	**S8. Adoption of CSPs and change in population**
Population	0%	0%	0%	0%	0%	0%	-16%
Milk production	20%	0.3%	12%	16%	29%	100%	80%
Enteric CH_4	2%	0%	1%	3%	2%	6%	-10%
Enteric CH_4 intensity	-15%	-0.3%	-13%	-20%	-20%	-47%	-50%

6.3 SOLUTIONS FOR SOIL CARBON SEQUESTRATION

231. Assessing SOC sequestration potential in pasture and rangeland is central for climate action project as regenerative forms of grazing can remove carbon from the atmosphere and store it in the soil. More important carbon sequestration potential is observed in degraded rangeland or in grassland soils that have not yet reached their optimum potential for carbon sequestration (Dondini et al., 2023[256]). At the global scale, it has been estimated that Sub-Saharan Africa presented the highest potential for soil carbon storage (0.41 tC/ha/yr) compared to the other regions of the world (Dondini et al., 2023[257]). In the four target countries, the potential annual increase is estimated at 0.57, 0.53, 0.52, and 0.51tC/ha/yr, respectively, for Kenya, Tanzania, Rwanda, and Uganda. These values indicate the great potential of these rangeland ecosystems to sequester C in the soil if improved managements are implemented or degraded rangelands are correctly restored. Although the average SOC stock per hectare is the lowest in Kenya, Kenyan rangelands have the greatest carbon sequestration potential compared to the other countries. The ASAL areas, whether associated with grassland-based or mixed crop-livestock production systems, have the highest potential to sequester C in the soil if improved management is implemented (up to 0.58 tC/ha/yr).

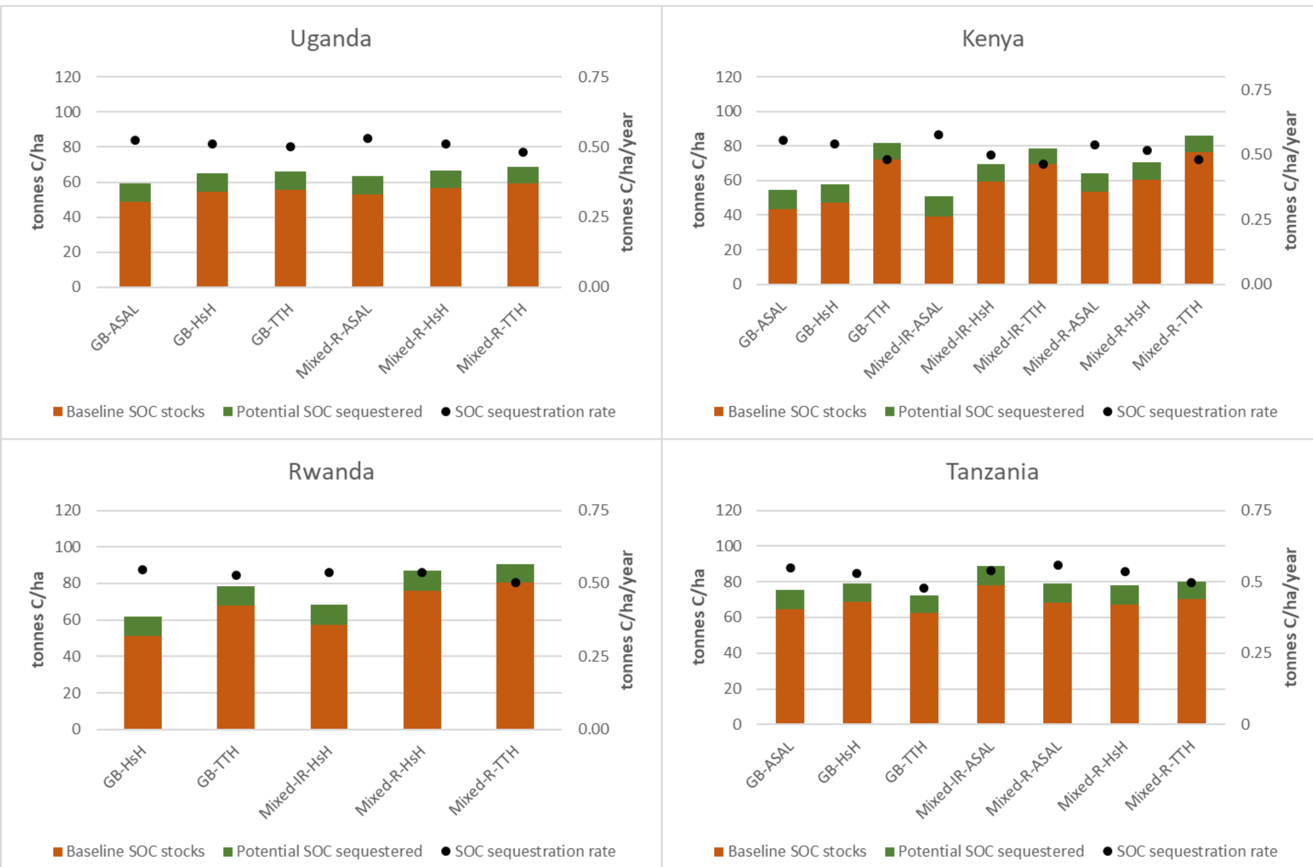


Figure 70: Rangelands carbon sequestration potential in Kenya, Rwanda, Tanzania and Uganda

GB-ASAL: Grassland-based / Arid and semi-arid tropics and subtropics; GB-HsH: Grassland-based / Humid and sub-humid tropics and subtropics; GB-TTH: Grassland-based / Temperate and tropical highlands; Mixed-IR-ASAL: Mixed / Irrigated / Arid and semi-arid tropics and subtropics; Mixed-IR-HsH: Mixed / Irrigated / Humid and sub-humid tropics and subtropics; Mixed-IR-TTH: Mixed / Irrigated

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[257] Ibid.

/ Temperate and tropical highlands; Mixed-R-ASAL: Mixed / Rainfed / Arid and semi-arid tropics and subtropics; Mixed-R-HsH: Mixed / Rainfed / Humid and sub-humid tropics and subtropics; Mixed-R-TTH: Mixed / Rainfed / Temperate and tropical highlands.

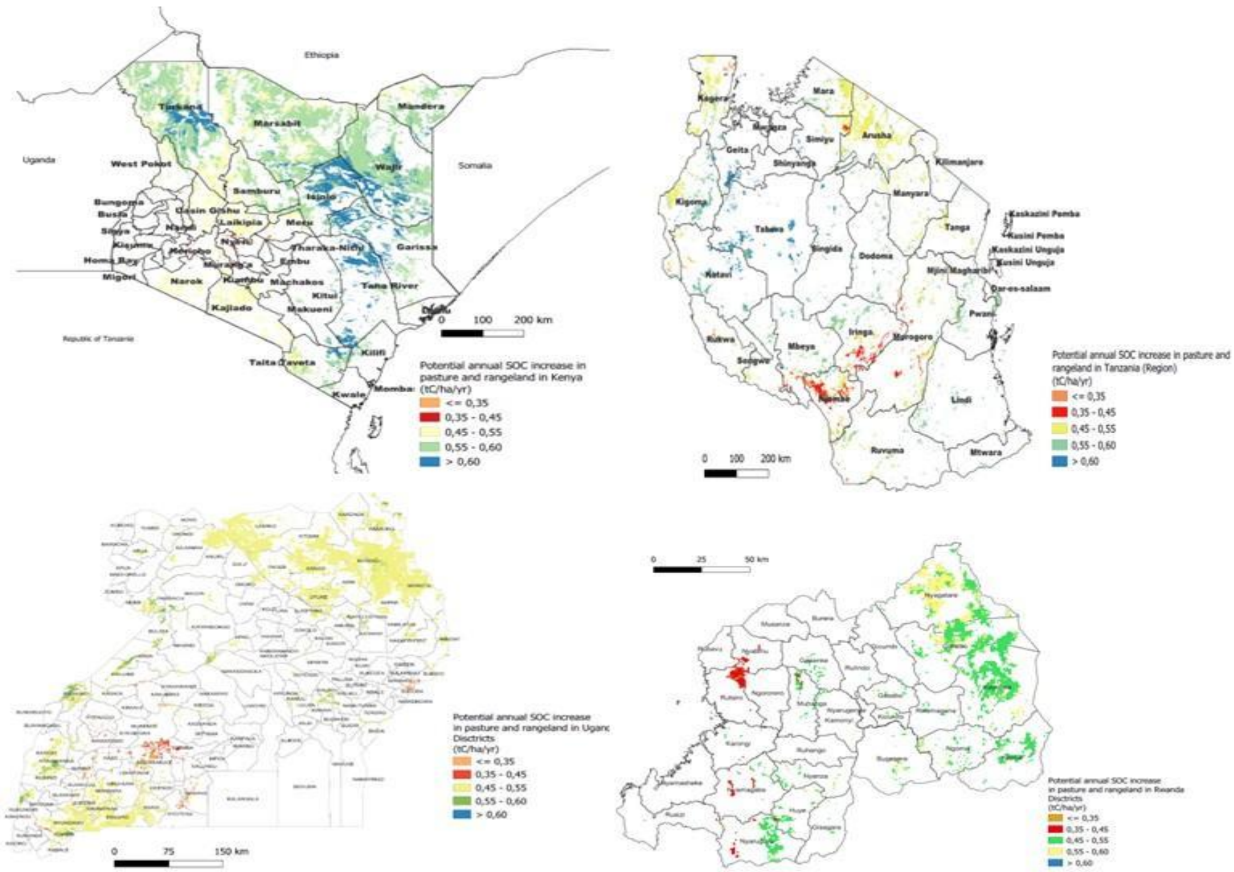

Figure 71: Potential annual increase of soil organic carbon in pastures and rangelands

232. Effective implementation of improved management over time is the primary means to achieve SOC sequestration in pastures and rangelands, contributing to the project's net-zero target. Table 33 presents the identified improved practices according to the country and the local context such as pedoclimatic condition and the livestock production systems. In the four target countries, more data and information on soil C impacts are identified on the grazing intensity management, the mowing frequency, the organic inputs, and fertilizers use in fodder production, and the improved agroforestry system associated with mixed crop-livestock production systems.

Table 33: Potential of improved practices to store carbon or avoid soil carbon loss in pasture and rangelands

Practices and interventions	**Description**	**Geographical and Livestock production system context**	**SOC sequestration**	**References**
Enclosure	Area of rangeland which is enclosed by a fence with branches of thorny Acacia trees as well as traditional rules to protect vegetation from grazing and/or browsing with the exception of calves and sick animals. Enclosure aims to conserve standing pasture for dry season grazing.	-LPS: Grassland based -Arid and semi-arid rangelands (Ethiopia) -Annual precipitation: 238- 896 mm -Soil: HAC -Control: Enclosure vs open-grazed area	-Rate of SOC increase: 1.77±0.18 tC/ha/yr -Initial SOC: 43.80 tC/ha -Soil layer: 0-30cm	Feyisa et.al. (2017)[258] Wairore et al. (2015)[259] Tessema (2020)[260] Coppock (1994) Angassa et al. (2008)[261]
		-LPS: mixed crop-livestock system -Arid and semi-arid rangelands (Kenya – West, Pokot County) -Rainfall: 280 mm between mid-October and January and 570 mm between mid-March and July -Control: Enclosure vs open-grazed area	SOC concentration increase of 27% compared to open-grazing rangeland	Oduor et al. (2018)[262]
Rotational grazing	Rotational grazing, defined as where a paddock is not stocked continuously but grazed and rested regularly either on a set calendar schedule or intermittently as needed	Western Kenya -Mean annual precipitation: 1200 mm -LPS: mixed rainfed crop-livestock -Soil: HAC -Control: continuous grazing area	-Rate of SOC increase: 2.2 tC/ha/yr -SOC stock: 28% higher in rotational grazing compared to control -Soil layer: 1m	Ambaw et al. (2020)[263]

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Cut-and-carry system		Western Uganda -LPS: small-scale mixed crop-livestock, agropastoralism along Lake Albert -Mean annual precipitation: 1400mm -Soil: LAC	-Rate of SOC increase: 4.9 tC/ha/yr -SOC stock: 80% higher in cut-and-carry system compared to control -Soil layer: 1m	Ambaw et al. (2020)[264]
Improved agroforestry systems	Integrated systems combine livestock, gardening, and fodder production Integration of multipurpose leguminous trees and shrubs such as *Acacia anguistissima, Cajanus cajan, Gliricidia sepium, Leucaena collinsii, Sesbania sesban, Tephrosia candida* and *Tephrosia vogelii* and fruit trees	Northeastern Tanzania: -Mean annual precipitation: 900-1300mm -LPS: mixed crop-livestock -Soil: HAC Western Kenya: -Mean annual precipitation: 1200 mm -LPS: mixed rainfed crop-livestock -Soil: HAC Western Uganda: -Mean annual precipitation: 1400mm -LPS: small-scale mixed crop-livestock, agropastoralism along Lake Albert	-Rate of SOC increase: 1.6 to 4.9 tC/ha/yr according to the system -Soil layer: 1m	Ambaw et al. (2020)
Improved pasture management	Combination of improved practices such as rotations and addition of inputs such as manure and fertilizers		-Rate of SOC increase: 0.10 tC/ha/yr -Initial SOC: 5.30 tC/ha	Girmay et al. (2008)[265]
Management of grazing intensity	Rangeland occupied by pastoralists Paddocks established for rotational grazing	-LPS: Grassland based -Arid and semi-arid rangelands of Ethiopian Rift Valley Mean annual precipitation: 277 – 653 mm	<u>Heavy grazing:</u> -Rate of SOC increase: 0.77 tC/ha/yr -Initial SOC: 32.20 tC/ha <u>Light grazing:</u> -Rate of SOC increase: 0.88 tC/ha/yr -Initial SOC: 36.40 tC/ha -Soil layer: 0-10 cm	Tessema et al (2011)[266]

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6.4 INTEGRATED MANURE MANAGEMENT AND NUTRIENT CIRCULARITY

233. Livestock manure is a source of CH_4 and N_2O emissions as well as contamination and eutrophication of surface and ground water mainly with nitrate. High nitrate concentrations in drinking water detrimentally affects health of especially infants and elderly persons and is common in southern Africa (Tredoux and Talma, 2006[267]; Martinez et al., 2009[268]). Poor manure management might also lead to transfer of zoonotic diseases to humans and may pose a public health threat especially where livestock is kept in urban and peri-urban areas (Manyi-Loh et al., 2016[269]; Ström et al., 2018[270]).

234. At the same time, manure contains essential plant nutrients and is often the primary source of crop fertilization in smallholder farms because mineral fertilizer is either too expensive or not available (Sheahan and Barrett 2017[271]). Moreover, its costs have further increased due to recent political events (COVID-19 pandemic, Ukraine war) (Alexander et al. 2022[272]). Many smallholder farms are nutrient limited, which restricts crop yields (Mueller et al. 2012[273]; Leitner et al. 2020b[274]). The circular management of farm nutrients via livestock manure is the best scalable option to overcome these limitations and improve on-farm productivity. This positively affects livestock productivity because better manure management also improves the nutrient availability for feeds and forages, which increases their production and nutritional quality and ultimately improves dairy production. In addition, manure application reduces soil nutrient mining and soil degradation and prevents additional CO_2 emissions from loss of soil organic carbon.

235. The IFAD-funded "Greening Livestock" Project, has shown that smallholder dairy farmers in Kenya and Tanzania practice manure heaping as their primary manure management strategy (Ndambi et al. 2019[275]; Sifael 2020[276]; Owino et al. 2020[277]). While this practice is cost-effective, it leads to high nutrient losses of up to 75% of nitrogen, phosphorus, and potassium during storage (Tittonell et al. 2010[278]). Research also found that nutrient-poor diets of Kenyan cattle result in nutrient-poor manure (Leitner et al. 2021[279]). Taken together, poor feeding practices and inadequate manure management result in low manure fertilizer quality and comparably high GHG emissions intensities. ILRI has developed manuals and training materials for simple manure management interventions that help to reduce nutrient losses and GHG emissions (e.g., ILRI 2019[280]) and have successfully used them in capacity building events (e.g., Owino 2018). Some of these interventions (covering, compaction, composting, liquid-solid separation, biochar addition – as referred in table 23) are good-bet options for this programme.

6.5 BIOCHAR TECHNOLOGY

236. Biochar has "cascading Benefits" for livestock – including dairy - and crop systems. The use of biochar, i.e., organic material heated under oxygen-limited conditions, in animal and food production has gained global prominence as a powerful tool for sustainable intensification and climate change mitigation, owing to its multiple and incremental benefits that increase economic viability and environmental protection (Schmidt et al. 2019)[281]. In dairy and livestock herds, based on research from ILRI, biochar can improve animal health and milk production, and reduce morbidity and manure GHG emissions whereby bringing down its climate impact. By enhancing nutrient circularity, the biochar cascade can increase feed and fodder production without land expansion, protecting natural habitats and biodiversity, and avoiding emissions from land conversion and deforestation.

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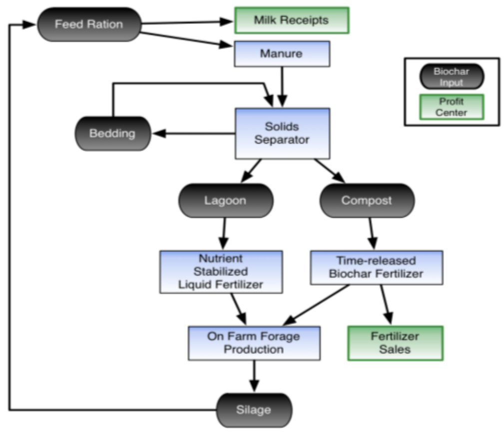

Figure 72: Input points and revenue source of biochar use in dairy system (Source: Wilson 2014)[282]

237. Quality biochar, produced at high temperature or activated with steam or chemicals, is a non-toxic edible feed supplement that has been shown to increase feed efficiency by 0.6 to 2% and reduce contagious mastitis and *E. coli*, diminishing costs of herd replacement while retaining nutritional values (Wilson 2014). When combined with silage, biochar decreases mycotoxin formation, binds pesticides, suppresses butyric acid formation, enhances the quantity of lactic bacteria, and prevents the accumulation of toxins that cause botulism (Calvelo Pereira et al., 2014)[283]. Adding biochar to bedding in animal housing at 5 to 10% is very effective for sanitation purposes, reducing the number of bacteria and absorbing water that limit hoof rot disease (O'Toole et al., 2016)[284].

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238. Due to its ability to absorb nutrients, biochar can reduce ammonia volatilization and nitrate leaching from manure, which benefits animal health by preventing respiratory diseases from aggressive NH_3 fumes and environment by curbing groundwater pollution. Mixing biochar with cattle manure and maize stover during composting has shown to reduce losses of nitrogen and organic matter, enhancing the fertilizer potential of the final product (Bello et al., 2019)[285]. Spreading biochar in bomas can also help reduce N_2O emissions, which are estimated to account for as much as 32% of total N_2O at farm-scale on a Kenyan cattle ranch (Fang et al., 2024)[286]. A pilot study from ILRI's Mazingira Centre in collaboration with the International Institute of Tropical Agriculture (IITA), found that manure mixed with biochar at 10 to 30% weight ratio had a lower CH_4 emission intensity by 10 to 44%, lower N_2O emission intensity by 50%, and less NH_3 volatilization by 50 to 84%.

239. Through cascades in the animal production system, biochar becomes enriched with nutrients and functional groups, while the cation exchange capacity and redox activity increases, pH decreases, and surfaces are coated (Hagemann et al., 2017; Joseph et al., 2018)[287]. Biochar that has been charged with manure nutrients acts as a slow-release fertilizer and prevents nitrogen losses from short-term nutrient excess, which can occur after fertilization, particularly following rainfall (Liu et al., 2022)[288]. When judiciously produced and applied, biochar has several positive impacts on key soil health functions, including soil carbon, water holding capacity and infiltration, pH, nutrient availability, and even microbial activity and pathogen suppression (Joseph et al., 2021)[289]. Because biochar itself is stabilized in the soil organic matter pool, studies have found 60% recovery of carbon in the soil after a decade of intensive cropping (Kätterer et al., 2019).

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240. *Readiness for scaling.* Enterprise development around cascading use of biochar in livestock-crop systems is showing hyperbolic growth in East-Africa. For example, PlantVillage+, with support from IITA, leads the commercialization in Kenya, Uganda and Tanzania and generates revenue from carbon credits[290]. For intensive crop-livestock systems, this involves production of biochar from excess crop residues that is supplied to dairy farmers that utilize it in barns and manure heaps which is subsequently used as fertilizer on forage grass, field crops, and tree nurseries. As example of market potential, the largest proportion of biochar in Europe and United States is sold as animal feed, bedding and manure treatment. Specific biochar certification standards for animal feed exist that to allow for quality control, as well as conformity with regulations on animal feed. For extensive systems, recent pilots with pastoral communities by PlantVillage+ in Baringo, Kenya have demonstrated the potential to create significant positive changes within a short time (Achieng, 2023)[291]. There, biochar is produced from *Prosopis juliflora*, which is cut during pasture restoration, then charged with livestock manure from livestock enclosures ("bomas") and used during reseeding to improve soil water retention and fertility. In only 10 months, more than 28 hectares was converted into lush green pasture using *Cenchrus ciliaris*, a drought-tolerant nutrient-rich grass, and biochar-fortified manure that promoted grassland regeneration and improved drought resilience as an adaptation co-benefit. This showcases the economic viability, environmental benefits and public demand, and offers a launchpad for validation and scaling.

241. Biochar is the leading carbon removal strategy and favoured by credit markets due to affordability, permanence, ease of certification, scalability and benefits for communities. Artisanal or automated kiln system can be employed for in-field production by famers or service providers, and cottage style setup that capture heat for value addition processes, like milk pasteurization or fertilizer granulation. PlantVillage developed a robust chain-of-custody app that tracks all steps of the process from sourcing to conversion, and mixing and sinking, which is utilized by major producers. On the side of biomass supply potential from crop residues, upscaled modelling by IITA found that excess maize stover and shank residue in Kenya, after deducting needs for cattle fodder and soil mulching, can generate 358 thousand ton of biochar per year (Roobroeck, 2024)[292]. Bundling these innovations can build farming systems that harness local natural, societal, and economic resources, and create operationally and financially viable models that are scalable and deliver short-term tangible gains in productivity. Doing so, biochar cascades can achieve effective mitigation and adaptation that helps stave off mounting pressures of climate change on communities reliant on livestock.

6.6 LOW CARBON TECHNOLOGIES

242. The electrification rates of the studied countries are still limited. In 2020, in Kenya 62.7[293] percent of rural population had access to electricity, while in the other observed countries less than 50 percent of rural population had access to electricity: 38.2 percent in Rwanda[294], 32.8 percent in Uganda[295] and only 20 percent in Tanzania[296]. Integrating affordable renewable energy (RE) systems like PV and bioenergy can lower energy costs for dairy farmers, making production economically viable in remote areas. These systems offer lower operational costs and environmentally friendly waste management practices, leading to long-term savings for stakeholders. At the production level, the dairy sector significantly contributes to greenhouse gas emissions, primarily through methane emissions from manure management and consumption of fossil-based energy.

243. Furthermore, by transitioning to RE, the dairy sector can reduce its carbon footprint and mitigate its environmental impact. Manure produced by animal which is a major source of global methane emissions can be used sustainable to produce energy through anaerobic digestion, which can augment local energy supply as well as reduce methane emissions. Solar power and biogas systems offer clean and sustainable alternatives that help reduce greenhouse gas emissions, decarbonize value-chains, and align with the countries' NDCs to address climate change.

6.6.1 Biogas systems

[290] https://plantvillage.psu.edu/blogposts/366-plantvillage-hosts-the-artisanal-c-sink-biochar-study-tour-in-kenya

244. The organic waste generated in dairy farms, including cow dung, leftover feed, and other organic residues, is an ideal feedstock for biogas production, due to high content in organic matter. These residues can be collected and then fed into an anaerobic digester, which is a sealed, oxygen-free container. Inside the digester, microorganisms break down the organic matter through a natural process called anaerobic digestion. This process converts the organic waste into biogas and digestate. Biogas is the main product of this process, and it is primarily composed of CH_4 and CO_2, along with traces of other gases. Biogas can be used directly in boilers, stoves or other appliances for heating or cooking purposes, as well as to generate electricity. The by-product of anaerobic digestion, called digestate, is rich in nutrients and it can be used as an organic fertilizer to improve soil quality (EPA, 2022[297]).

245. Biogas systems have been promoted through a number of IFAD-funded Projects in East Africa. Lessons learnt from IFAD[298] show that there is good replication potential under the DaIMA Project. Biogas systems can vary in nature (e.g. fixed dome or flexi biogas) and size, depending on the scale of operation and the amount of waste/ manure that is available.

246. Small-scale biogas systems are designed for individual households or small farms. They typically have a capacity ranging from 4 m^3 to 6 m^3 of biogas production per day. These systems are suitable for managing the organic waste generated by a few cows (3-4 cows, producing between 20 and 40kg of manure per day) and they can provide cooking fuel and, in some cases, lighting for the household, with the potential to cover between 60% and 100% of cooking energy needs.

247. Medium-scale biogas systems are commonly used in community settings, agricultural cooperatives, or small-scale industries. The capacity of these systems typically ranges from 10 m^3 to 100 m^3 of biogas production per day. They can process a larger quantity of organic waste from multiple sources, such as several farms or a community's organic waste stream. Medium-scale systems can provide energy for cooking, heating, and small-scale electricity generation.

248. Large-scale biogas systems are designed for industrial or commercial applications, such as large livestock farms and food processing plants. These systems are typically integrated with combined heat and power systems for electricity and heat generation, and are less (or not) relevant in the context of this Programme (Energypedia, 2015[299]; NIDECO, 2022[300]).

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[296] World Bank. 2022. Changing Lives and Livelihoods in Tanzania, One Electricity Connection at a Time. In: *The World Bank*. [Cited June 28 2023]. https://www.worldbank.org/en/news/feature/2022/06/28/changing-lives-and-livelihoods-in-tanzania-one-electricity-connection-at-a-time#:~:text=Despite%20this%20progress%2C%20a%20large,or%20connectivity%20rate%20(37.7%25)

[297] EPA. 2022. Anaerobic Digestion on Dairy Farms. In: *United States Environmental Protection Agency*. [Cited 18 July 2023]. https://www.epa.gov/agstar/anaerobic-digestion-dairy-farms

[298] IFAD How to do Note: Mainstreaming portable biogas systems into IFAD-supported projects. 51f35bfa-54f5-435a-857c-3da0f175e07d (ifad.org)

[299] Energypedia. 2015. Sizing of the Biogas Plant. In: *Energypedia*. [Cited 18 July 2023]. https://energypedia.info/wiki/Sizing_of_the_Biogas_Plant

[300] NIDECO. 2022. Family Size Rural Biogas System. In: *Norwegian International Development Company*. [Cited 18 July 2023]. https://nideco.no/products/biogas%20plants/family%20size%20rural%20biogas%20system

Figure 73: Flexi Biogas system with surplus gas storage balloon and IFAD project beneficiaries in Nakuru, Kenya

249. The production of electricity from biogas allows for a decreased reliance on fossil fuels (see Figure 75 and Figure 76. In terms of overall country potential, Kenya and Uganda display the highest environmental benefits from the use of available manure for biogas and electricity production. When comparing to diesel options, the utilization of manure is estimated to result in savings of up to 94 thousand tonnes CO2eq/year in Kenya and up to 81 thousand tonnes CO2eq/year in Uganda. Similarly, biogas use for electricity production can result in up to 42 thousand tonnes CO2eq/year of GHG savings in Kenya, when comparing to grid-electricity options. Potential GHG savings are at around 1 thousand tonnes CO2eq/year in Tanzania and Rwanda.

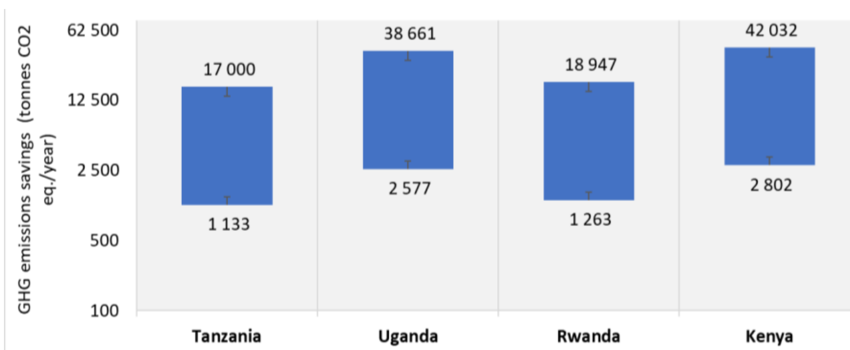

Figure 74: GHG savings (tonnes CO2eq/year), grid + unmanaged manure vs biogas – biogas systems

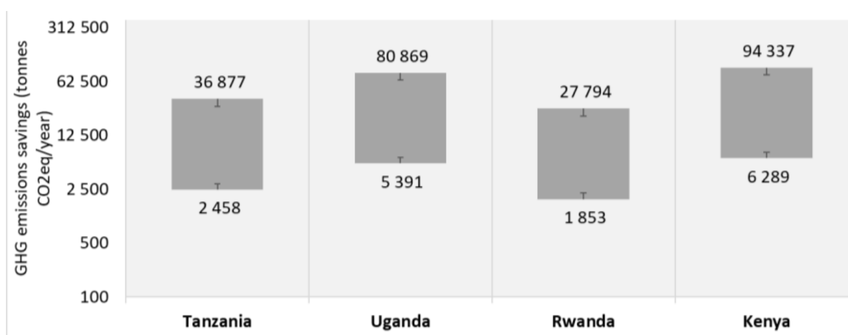

Figure 75: GHG savings (tonnes CO2eq/year), diesel + unmanaged manure vs biogas – biogas systems

250. Kenya and Uganda showcase the highest manure availability among the four countries, with approximately 58 million m^3 and 52 million m^3 of biogas annually. Therefore, to reach the potential, it would be possible to generate 96 GWh and 87 GWh, requiring a total investment that can potentially reach 37.6 million USD and 24.8 million USD respectively. Rwanda and Tanzania follow, with a potential to generate 20 million m^3 biogas and 11 million m^3 biogas, resulting in 33.2 GWh and 18.2 GWh respectively. The necessary investment would reach up to 7.98 million USD and 4.85 million USD respectively. It is expected that DaIMA contributes to these investments needs and effort, to cover the electricity gap, and reduce GHG emissions.

6.6.2 Renewable energy-powered equipment along the value-chain

251. *Milking machines* can be powered by electricity, either from the grid or through renewable sources such as solar power. Solar-powered milking machines can be particularly beneficial in rural or remote areas where electricity infrastructure is limited. In this regard, solar PV panels can be installed on the roof or in the vicinity of the dairy farm to capture sunlight and convert it into electricity. The electricity generated can be used to power the vacuum pump and other electrical components of the milking machine.

252. The use of PV-powered milking machines brings significant mitigation benefits, as it reduces the use of fossil fuels and thus leads to GHG emissions reductions. Figure 77 below present the potential GHG emission savings from using PV systems at scale (full potential), compared to grid electricity and diesel options to power the milking machines. Tanzania displays the highest potential savings, which can reach up to 322 thousand tonnes CO_2eq/year, when comparing to diesel alternatives. On the contrary, Uganda and Rwanda show somewhat more limited potential savings at less than 1 thousand tonnes CO_2eq/year each, in the case of PV vs grid options.

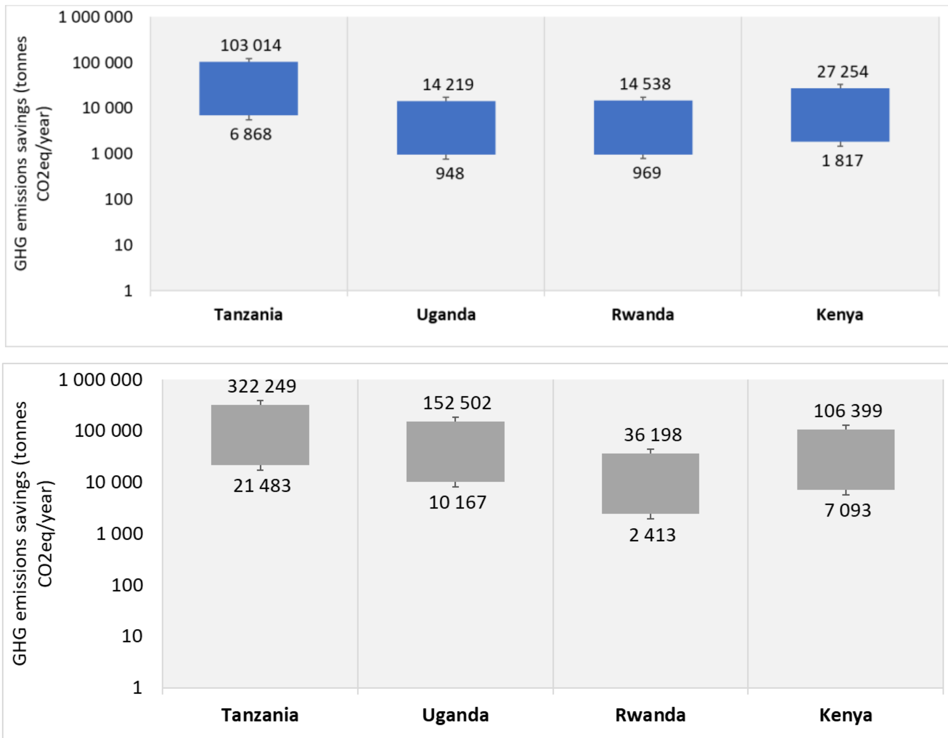

Figure 76: potential GHG emission savings from using PV systems at scale, compared to grid electricity and diesel options to power the milking machines

253. *Milk transfer tanks* come in various capacities, ranging from small on-farm tanks to larger tanker trucks (Techwin, 2023). In certain situations, milk transfer tanks are coupled with cooling systems to maintain the temperature of the milk during transportation. These cooling systems can be powered by electricity or diesel engines, ensuring that the milk remains at the desired temperature, especially in warmer climates or for longer transport durations. In this case, it is possible to introduce renewable energy solutions to power these systems, so that the reliance on fossil fuels can be reduced and operational costs can be decreased. For example, solar panels can be installed on the transfer tank to generate electricity that powers the cooling system. Similarly, liquid biofuels can substitute the use of diesel (Freecold, 2023).

254. Figure 78 and Figure 79 showcase the potential GHG emission savings from using PV systems at scale, compared to grid electricity and diesel options to power milk coolers. Tanzania displays the highest potential savings, which can reach up to 425 thousand tonnes CO_2eq/year, when comparing to diesel alternatives, and 136 thousand tonnes CO_2eq/year, in the case of comparing to grid options. Uganda has the lowest potential savings vs grid options at 948 tonnes CO_2eq/year, while in the case of diesel options Rwanda displays the least promising results, at 2 thousand tonnes CO_2eq/year.

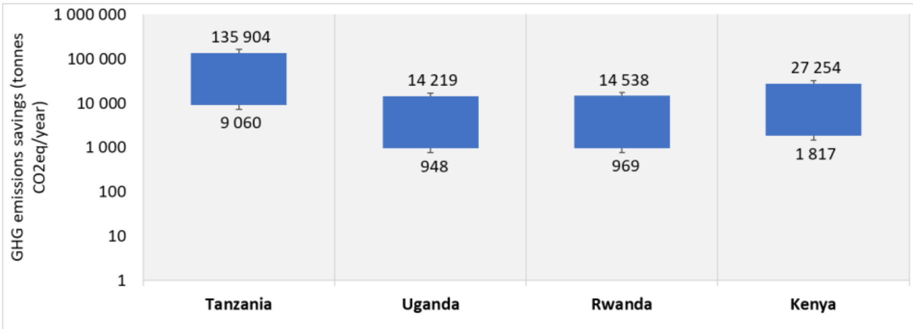

Figure 77: GHG savings (tonnes CO2eq/year) grid vs PV – milk coolers (farm-level)

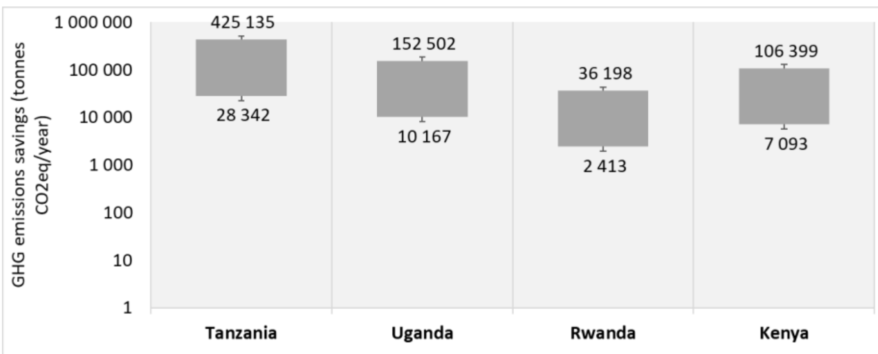

Figure 78: GHG savings (tonnes CO2eq/year) diesel vs PV – milk coolers (farm-level)

255. *Milk coolers (milk collection centres – MCCs)* are typically powered by electricity. Farmers in rural and remote areas usually have limited access to the grid, therefore also a limited capacity to cool their milk, resulting in significant losses. PV panels can potentially be installed on a rooftop or nearby area to generate electricity to power the refrigeration system, compressor, and other electrical components of the milk cooler. In this regard, solar coolers can ensure that farmers can cool their produce even in remote areas and thus reduce their losses and improve their incomes.

256. The potential GHG emission savings, compared to grid electricity and diesel options to power milk coolers, are presented in Figure 80 and Figure 81. It can be seen that Kenya shows by far the most promising results when comparing to diesel options, with GHG savings that can reach up to 12 thousand tonnes CO_2eq/year. In the case of PV vs grid electricity, Kenya and Rwanda display the highest savings at 3.1 thousand tonnes CO_2eq/year and 1.8 thousand tonnes CO_2eq/year respectively. A somewhat more limited potential can be seen in Rwanda at 17 tonnes CO_2eq/year, when comparing to grid-electricity options.

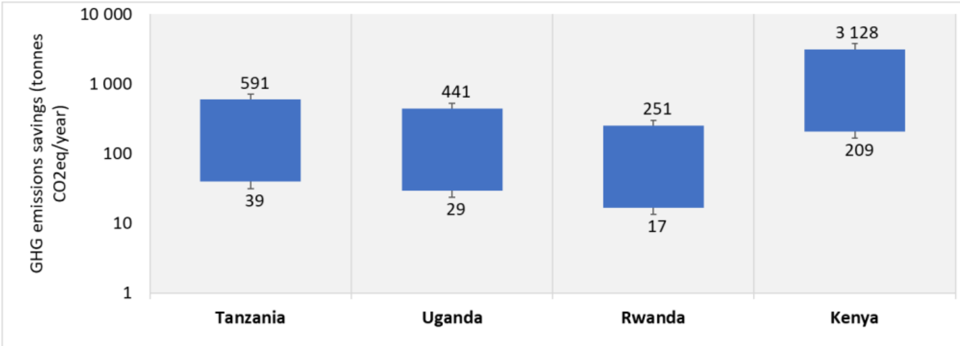

Figure 79: GHG savings (tonnes CO2eq/year) grid vs PV – milk coolers (farm-level)

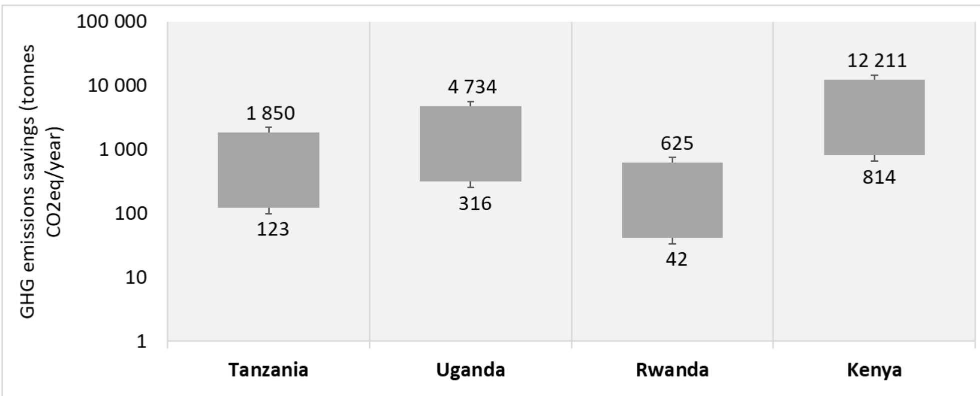

Figure 80: GHG savings (tonnes CO2eq/year) diesel vs PV – milk coolers (farm-level)

257. Solar energy can be utilized to power milk pasteurizers, providing a sustainable and renewable energy source for dairy processors. Solar panels can be installed to capture sunlight and convert it into electricity that powers the heating elements and electrical components of the milk pasteurizer. By utilizing solar energy to power milk pasteurizers, dairy processors can reduce their reliance on conventional energy sources and potentially lower operating costs.

258. For example, the use of PV systems for small-scale milk pasteurizers can lead to GHG savings that reach up to 822 tonnes CO2eq/year in Kenya and 611 tonnes CO2eq/year in Tanzania, when comparing to diesel options. Similarly, the use of PV systems over grid electricity can potentially save up to 211 tonnes CO2eq/year in Kenya. It is estimated that Rwanda displays the most limited potential GHG savings for PV vs grid-electricity options, at only 1 tonne CO2eq/year.

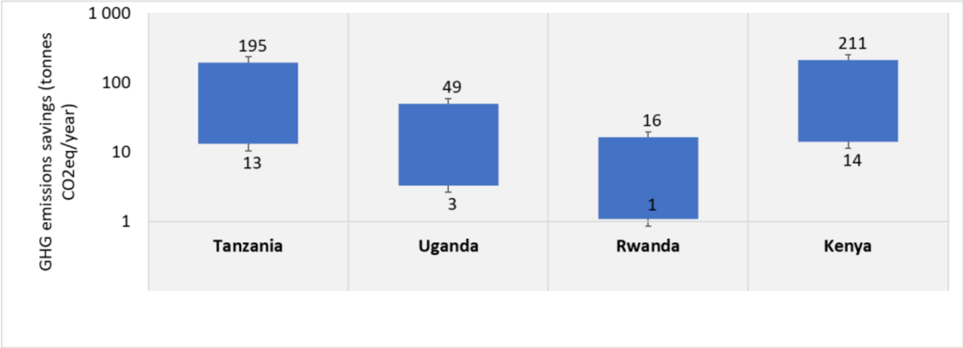

Figure 81: GHG savings (tonnes CO2eq/year) grid vs PV - milk pasteurizers (small-scale)

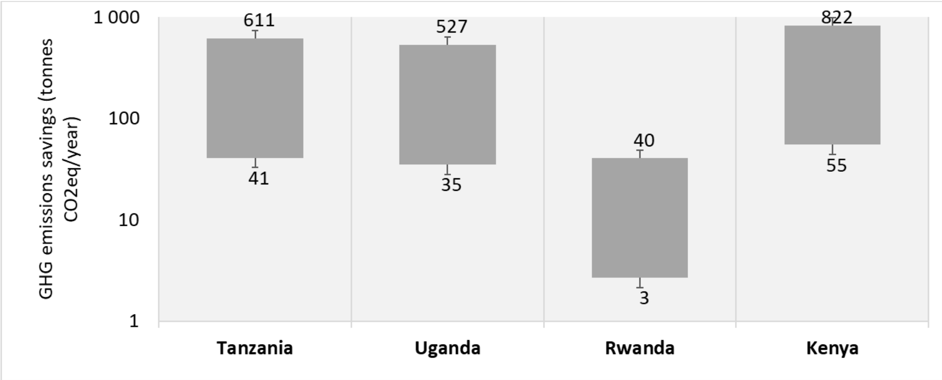

Figure 82: GHG savings (tonnes CO2eq/year) diesel vs PV - milk pasteurizers (SS)

259. *Ultra-High Temperature (UHT) treatment* equipment is used to pasteurize milk at very high temperatures, typically above 135 °C, for a very short time, usually 2 to 5 seconds. This high-temperature treatment eliminates bacteria and yeasts, therefore ensuring the milk remains free from spoilage and pathogens. After the heat treatment, the milk is rapidly cooled to ambient temperature and then packaged in aseptic conditions to maintain its sterility. This process enables the production of UHT milk, also known as long-life milk, which can be stored at room temperature for an extended period, while maintaining its nutritional value and quality. This type of equipment is commonly used in large-scale dairy processing plants (Pharos, 2021[301]; TetraPak, 2023a[302]).UHT treatment equipment can be powered from PV panels, which can potentially be placed on the roof of the processing plant.

260. The potential GHG savings from the use of PV-powered UHT pasteurizers are depicted in Figure 84 and Figure 85 It can be seen that Kenya and Uganda display the highest potential savings, which reach up to 431 tonnes CO_2eq/year and 232 tonnes CO_2eq/year respectively, when comparing to diesel options. Similarly, for PV vs grid-electricity, the potential GHG savings for Kenya were estimated at around 111 tonnes CO_2eq/year. On the contrary, the lowest savings are calculated at only 1 tonne CO_2eq/year, for the low adoption rate in Tanzania, Uganda and Rwanda.

[301] Pharos. 2021. Ultra-high temperature (UHT) technology. In: *Pharos Dairy*. [Cited 19 July 2023]. http://dairy.pharosnavigator.com/ultra-high-temperature-dairy-industry
[302] TetraPak. 2023a. UHT Milk. In: *TetraPak*. [Cited 19 July 2023]. https://www.tetrapak.com/solutions/aseptic-solutions/uht-faq

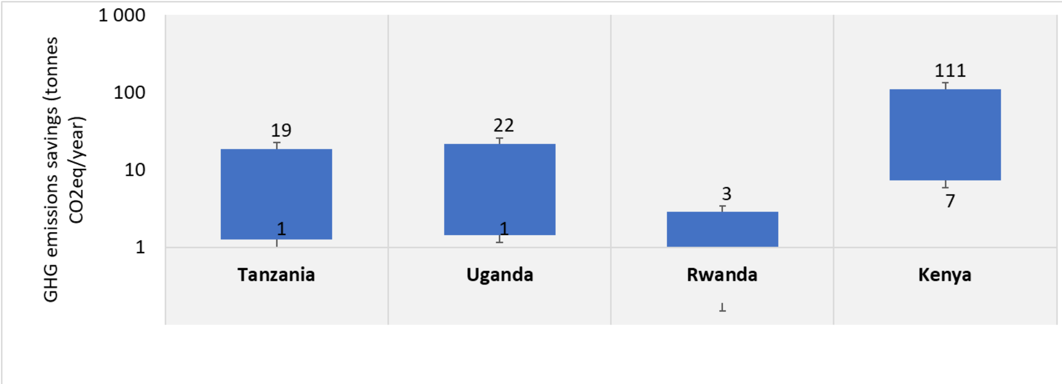

Figure 83: GHG savings (tonnes CO2eq/year) grid vs PV - milk UHT pasteurizers

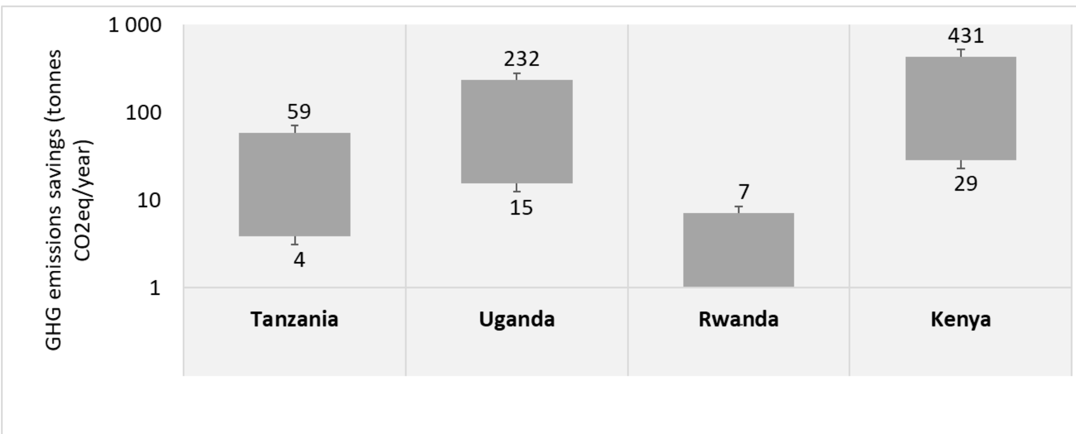

Figure 84: GHG savings (tonnes CO2eq/year) diesel vs PV - milk UHT pasteurizers

261. *Milk cream separators* are used to separate raw milk into cream and skim milk fractions. They work on the principle of centrifugal force. The size of a cream separator depends on its processing capacity, typically measured in litres per hour (Avedemil, 2020[303]; Neologic, 2023[304]). As milk cream separators are powered by electricity, the use of solar panels can help to power milk cream separators, providing a sustainable and renewable energy source for dairy processors.

262. Solar energy can be used to power *cheese production equipment*, offering a sustainable and renewable energy solution for dairy processors. Solar panels can be installed to capture sunlight and convert it into electricity. This electricity can then power the motors, pumps, cutting devices, and other electrical components of the cheese production equipment.

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[303] Avedemil. 2020. Cream separators for small and large volumes, and self-cleaning separators. In: *Avedemil*. [Cited 19 July 2023]. https://www.avedemil.com/en/ecremeuse-4

[304] Neologic. 2023. How Does a Centrifugal Milk Cream Separator Function. In: *Neologic Engineers*. [Cited 19 July 2023]. https://www.neologicengineers.com/blogs/how-does-a-milk-cream-separator-work.php

263. Figure 86 and Figure 87 display the potential GHG savings from using PV-panels to power cheese-making equipment at medium- and large-scale producers. It can be seen that the highest potential is shown when comparing to diesel options. More specifically, Kenya displays the most promising results, with GHG savings that can reach up to 423 tonnes CO_2eq/year. For each of the other countries, GHG savings are estimated to be at a maximum of 53 tonnes CO_2eq/year for the high adoption rate. When comparing with grid-electricity options, Kenya again displays the highest potential at 108 tonnes CO_2eq/year, while the rest of the countries show savings that are around 1 tonne CO_2eq/year, for the low adoption rate.

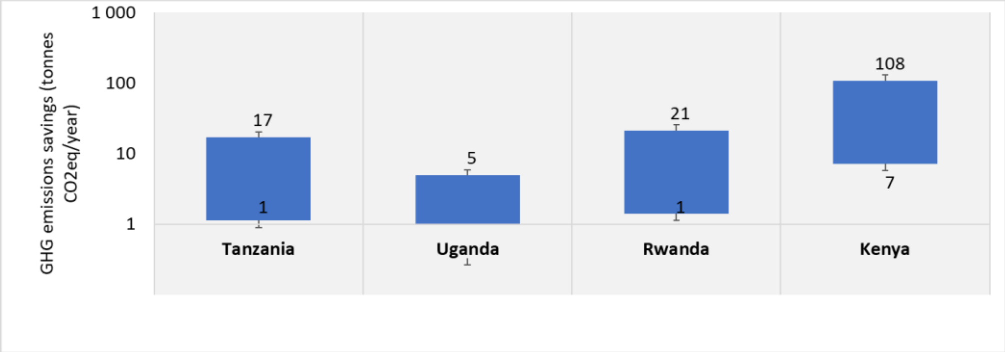

Figure 85: GHG savings (tonnes CO2eq/year) grid vs PV - cheese makers

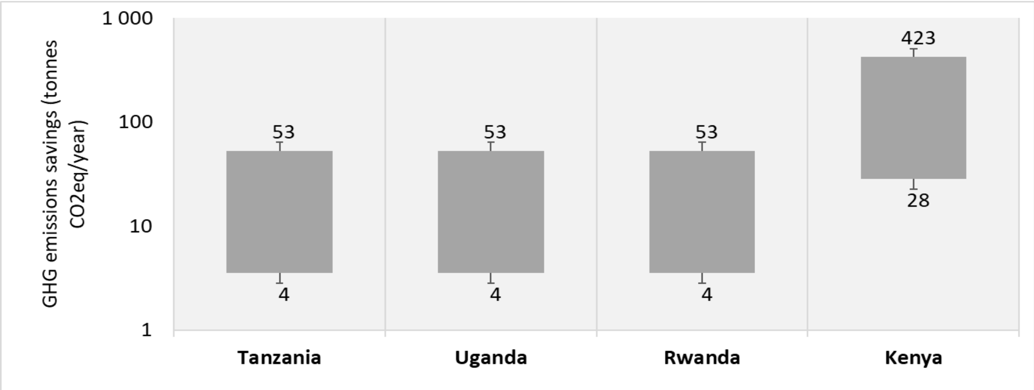

Figure 86: GHG savings (tonnes CO2eq/year) diesel vs PV - cheese makers

264. Refrigeration plays a vital role in the retail step of the dairy value chain, ensuring the proper storage and preservation of dairy products in supermarkets, grocery stores, and other retail outlets. It helps maintain the freshness, quality, and safety of dairy products for consumers. Refrigeration units for retail typically use a vapor compression refrigeration cycle. This cycle involves a compressor, condenser, expansion valve, and evaporator to circulate refrigerant and remove heat from the stored dairy products. Retail refrigeration often includes open or closed display cases designed to showcase dairy products. These cases provide easy access for customers while maintaining proper temperature and humidity levels to preserve the freshness of the products. Retail refrigeration units come in various sizes to meet the requirements of different retail environments. Solar energy can be used to power retail refrigeration units, with PV panels installed on the rooftop or nearby areas of the retail store to capture sunlight and convert it into electricity.

Table 34: GHG emissions savings per solar milk pasteurizer unit

Capacity (m3)	Dairy Parameter	Unit_Dairy	Tanzania	Uganda	Rwanda	Kenya
2	GHG Savings Grid vs. PV	tCO2eq/yr	22.21	6.48	27.90	17.79
2	GHG Savings Diesel vs. PV	tCO2eq/yr	69.47	69.47	69.47	69.47
3	GHG Savings Grid vs. PV	tCO2eq/yr	33.31	9.72	41.85	26.69
3	GHG Savings Diesel vs. PV	tCO2eq/yr	104.20	104.20	104.20	104.20
5	GHG Savings Grid vs. PV	tCO2eq/yr	55.52	16.19	69.75	44.48
5	GHG Savings Diesel vs. PV	tCO2eq/yr	173.67	173.67	173.67	173.67
7	GHG Savings Grid vs. PV	tCO2eq/yr	77.72	22.67	97.65	62.28
7	GHG Savings Diesel vs. PV	tCO2eq/yr	243.13	243.13	243.13	243.13

6.7 ACCESS TO DAIRY SECTOR FINANCE IN EAST AFRICA

265. The following section describes the market for finance for green investment in dairy in East Africa and provides rationale for key design decisions and the financing request for GCF.

6.7.1 Dairy value chain actors and market size

266. The dairy value chain structure varies across the four countries, but can be disaggregated into five key segments: (1) Production (includes key stakeholders such as pastoralists, medium and large scale extensive farmers, small holder dairy farmers (SHF), and medium to large scale commercial farmers), (2) Aggregation (includes milk traders, and milk collection points), (3) Processing (includes informal processors, and Large/medium/small processors), (4) End Market (includes informal outlets, general trade, and modern trade) and (5) Supporting Enterprises (includes agri-input providers who serve the dairy market).

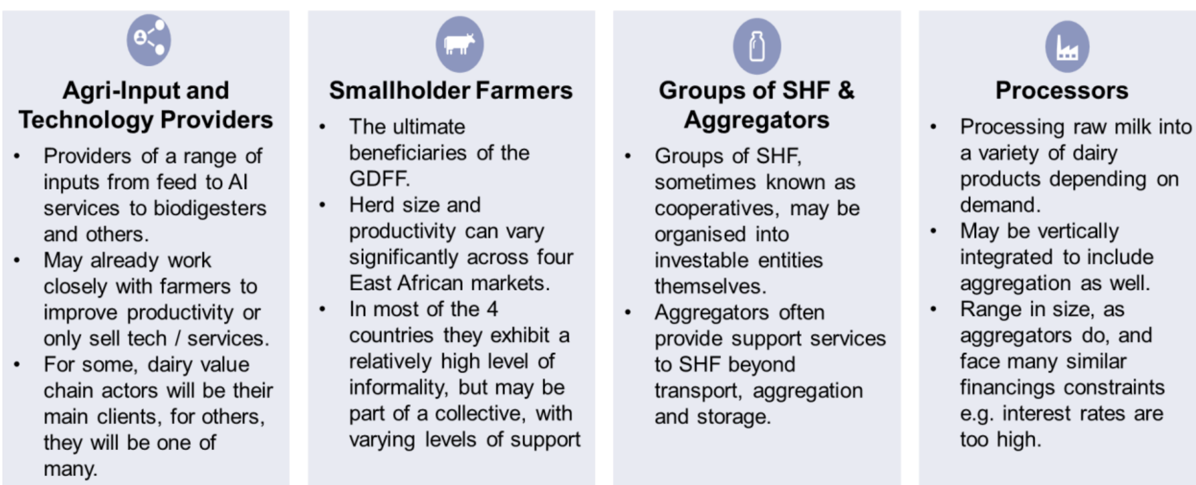

Figure 87: Core dairy value chain actors. Evidence has been tested and reviewed in Key Informant Interview with Ripple Effect

267. The level of informality of the dairy value chain also varies across the four countries, ranging from Tanzania, where the market is characterized with a high degree of informality, to Kenya, where the degree of informality is lower. The following points capture key formality characteristics for each country, as presented in the Market Study (Appendix 1).

268. **Kenya:** While at-scale processors (those with 40,000 liters processing capacity per day or more) dominate the formal market, less than 20% of the countries estimated annual production volume of 4.6 billion litres is sold in formal markets. According to the Bain and ILRI analysis, 71% of annual domestic cow milk production volume is delivered through small holder farmers with only 16% of it channelled to formal processing through milk traders or cooperative-owned MCCs. There is a relatively concentrated and developed processing market with the top five processers representing 70% of the country's processing capacity;

269. **Tanzania:** When dairy industry is highly fragmented across the value chain with only 3% of the annual estimated production volume of 3.1 billion litres channelled through formal processing channels, similarly to Kenya the processing sector is relatively concentrated with the top five processors representing 70% of processing capacity in country. Traditional farmers are responsible for the majority (70%) of domestic milk production and tend to either consume that milk on-farm or sell it to informal outlets via cooperatives and informal processors.

270. **Rwanda:** Smallholder dairy farmers are responsible for 68% of the annual estimated milk production volume of 1 billion litres, with medium- to large-scale commercial farmers responsible for 27% of the annual estimated production volume. The remaining 5% are produced by open grazing framers in Gishwati plateau and extensive farmers. Rwanda has a more developed collection and aggregation network than other East African countries. The network channels 22% of produced milk to formal processing via MCCs and milk traders. Large processors represent 80% of the country's processing capacity, with Inyange covering >50% of the processing capacity.

271. **Uganda:** Research by ILRI estimates that 3.85 billion litres of milk are produced annually, with 1 billion litres of it going through formal processing channels via milk collection centres, equivalent to 34% of the market. According to ILRI's research, Uganda exhibits larger number of aggregators (MCCs) due to farmers being encouraged to join cooperatives to reduce the issue of substandard milk quality. The market sizing outlined in Table 35 below captures the fragmentation and concentration of the different dairy value chain actors. Whilst the market is dominated by smallholder production there are significant volumes of aggregators and processors operating downstream that provide opportunities for growth in productivity and supporting greening of their value chain, and who face financing constraints (see 6.7.3). Larger processors represent a small segment of the market (10% of the processor market). The size of the agri-input and equipment providers is less well documented than dairy value chain actors and has not been estimated at this point. It is assumed to be much smaller and likely less localised.

Table 35: Estimated number of businesses within market segments across the four countries (source: Market Study)

	Kenya	Rwanda	Tanzania	Uganda(*)	Total
Smallholder Farmers	N/A(**)	89,000	90,000	166,000	345,000
Aggregators (inclusive of MCCs)					
Small (1-10K L per day)	130	66	183	353	733
Medium (10-50K L per day)	84	0	18	160	261
Large (>50K L per day)	121	66	15	34	235
Processors					
Small (1-10K L per day)	14	8	62	84	168
Medium (10-50K L per day)	9	3	6	38	56
Large (>50K L per day)	13	1	5	8	27
Total excluding SHFs	**370**	**144**	**289**	**677**	**1480**

(*) Of the processors listed, research from Bain records that only 59 are registered and licensed by the DDA.
(**) Missing data from market studies makes it difficult to provide an estimated figure for the number of small holder dairy farmers in Kenya.

272. Despite high levels of observed market informality, the dairy value chains across East Africa exhibit strong linkages between value chain actors that can be leveraged to support the sector as a whole. “Farmer-allied enterprises” provide additional extension services to farmers to support productivity and enable greater volumes of milk at a higher quality to be produced. Actors higher up the value chain have a vested interest in receiving high quality milk in a timely manor to facilitate their businesses. As a result, they are a key route to supporting SHFs in improving productivity and reducing GHG emissions intensity. Figure 89 below illustrates how the adoption of key practices and technologies will benefit the entire value chain, including direct and indirect impact on SHFs.

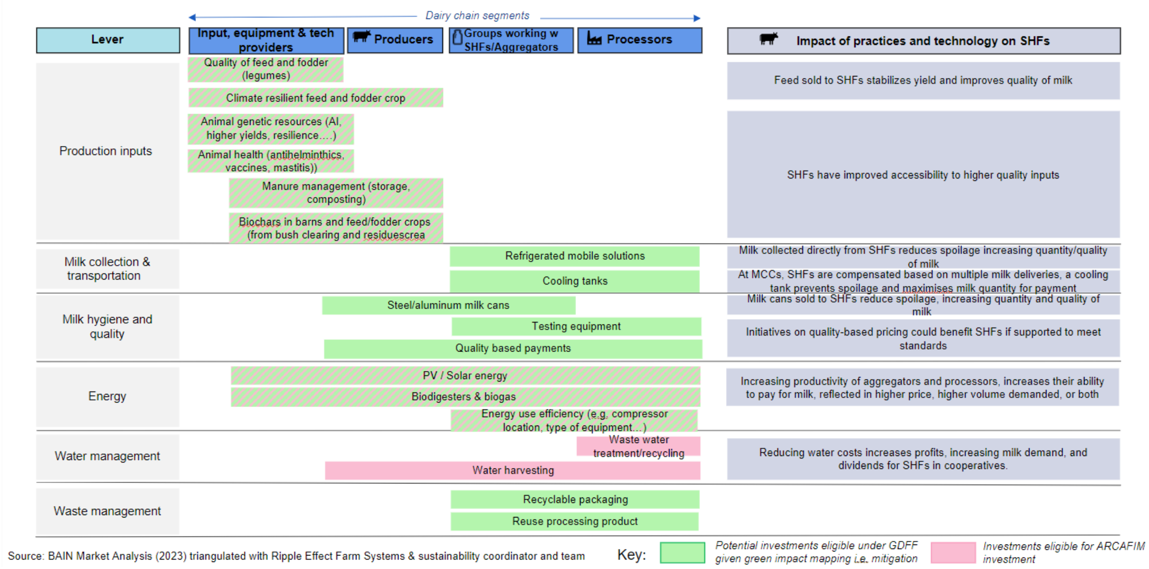

Figure 88: Key practices and technologies impact across the dairy value chain

6.7.2 Demand side analysis: Articulating the finance need for the adoption of climate-smart practices and technologies

273. The adoption by dairy value chain actors of the climate-smart practices is critical to enabling pathways to a low carbon dairy sector. Survey data from market analysis indicate that aggregator and processor stakeholders across the four countries have a stated interest in adopting these approaches, however low observed adoption levels suggest that there are barriers to uptake that need addressing[305]. The figure below summaries the gap between interest and adoption across the four countries.

274. Businesses across the four countries have both capital expenditure and working capital requirements in order to adopt climate smart technologies and practices. The following paragraphs summarise the respective financial needs.

[305] 2023 PADNET Aggregator and Processor Survey, conducted by BAIN

275. **Capital expenditure needs:** Dairy value chain actors will require up-front capital to adopt new technologies and practices that can deliver emission mitigation and productivity benefits. Market research across the region indicates that the costs of climate-smart technologies can range between USD50 and USD250,000, depending on the technology type, country context, and business size and requirements. Table 36 below provides an estimated unit cost breakdown by technology.

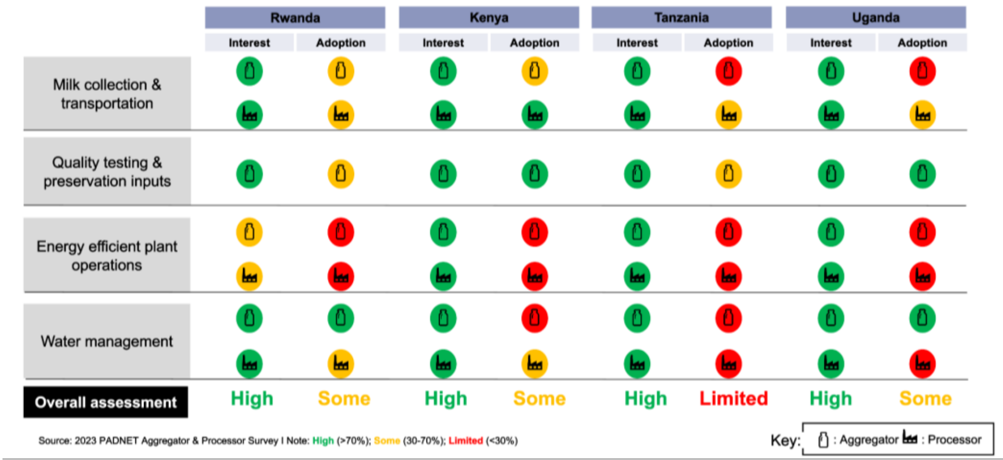

Figure 89: Interest and adoption rates of key technologies and practices across the value chain

Table 36: Estimated costs for range of climate-smart technologies (source: Market Study)

Climate-smart practice/technology	Cost per unit (USD
Milk cans	50
Cooling tanks	5,000
Heifers	1,200
Insulated vehicles	15,000
Large cooling tank	10,000
Small cooling tank	4,000
Large scale PV/Solar panel solutions	250,000
Medium scale PV/Solar panel solutions	150,000
Small scale PV/Solar panel solutions	60,000
Small scale water purifiers	1,100
Medium scale water purifiers	4,500
Large scale water purifiers	26,100
Small rainwater harvesting system	3,500
Medium rainwater harvesting system	15,000
Large rainwater harvesting system	40,000

276. **Working capital needs:** The provision of shorter-term working capital can also provide a route for value chain actors to promote emission mitigation in the dairy value chain. For example, easier access to working capital can ensure that businesses can purchase key inputs like emissions efficient fodder and other agri-inputs like veterinary services that may be more expensive. However, market consultations have highlighted the cashflow constraints of aggregators and processors who must pay suppliers on delivery.[306] Working capital is needed primarily to bridge payment gaps as well as enabling check-off systems and credit provision to SHFs. Check off systems are used by aggregators and cooperatives to enable smallholder farmers to pay for services through the monthly income they earn through milk sales as opposed to paying with cash at point of use, which can inhibit their ability to purchase high-quality inputs. Based on a regional market sizing analysis of working capital demand and supply conducted by Bain, the total estimated working capital need for processors over a two-week period is USD14.1 million (including USD4.9 million in Kenya, USD1.7 million in Rwanda, USD1.1 million in Tanzania and USD6.4 million in Uganda), indicating significant potential constraints on cashflow for these businesses that could be alleviated by working capital support.

277. Green investment is deprioritised by businesses in favour of productivity boosting investments. When faced with prioritising investments, businesses will focus on improving productivity in the first instance followed by climate resilience and climate mitigating investments. In responses to a market survey of aggregators and processors, many businesses said they would be interested to invest in climate-smart technologies and practices in the first instance if they could see a clear productivity and revenue boosting impact alongside the climate impacts.[307]

6.7.3 Supply side analysis: Current routes to accessing finance

278. There are a number of key pathways to accessing finance for dairy value chain actors, driven by the variety of business types operating across the value chain and the type of financing needed. The key routes to accessing debt financing are through Non-Banking Financial Institutions (NBFIs), commercial banks, agriculture-focused investment funds and development finance institutions (DFIs).[308]

279. **NBFIs:** Smallholder farmers and cooperatives typically access financing through SACCOs (Savings and Credit Cooperatives) and MFIs (microfinance institutions) that operate close to communities. These institutions are reliant on credit lines from commercial or development banks or from group savings initiatives. They provide loans to households and to micro and small businesses in the agriculture value chain. Analysis of NBFIs conducted by Acelia Africa indicate that NBFIs serve the lower-end of the agri-SME segment with a high-frequency and low loan-size model.[309]

280. **Commercial Banks:** The commercial banking system provides different agriculture financing products to value chain actors, including asset-based financing and working capital loans, dependent on the specific bank's offering. These banks will assess a business's bankability based on collateral, business maturity and ability to repay, to ensure they are obtaining a return on their loans. Typical products offered by commercial banks across the four countries are collateralised loans for agri-SMEs with loan tenors of 1-10 years for asset finance with interest rates ranging from 8-21%. Table 37 and Table 38 offer a summary of some of the working capital and capital expenditure loans offered by local financial institutions in the four countries as well as the indicative interest rates.

Table 37: Examples of CAPEX loans provided to local FIs (source: bank websites)

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[306] This constraint was confirmed by consulted agricultural and agricultural finance experts at Ripple Effect (Meshark Sikuku), Absa Bank (Simon Kinuthia, Daniel Muyambu, and Kevin Mwandau), Aceli Africa (Richard Midikira), Heifer Internation (Kevin Gituma), Rabo Foundation (Titus Osewe), and MCE Social Capital (Elena Pons).
[307] Aggregator and processor surveys conducted by Bain and ILRI as part of the market study for DaIMA, validated by Ripple Effect
[308] Research by ISF into Agri-SME financing captures a broader range of financing channels, including Public development banks and Private equity and Venture Capital funds, they are omitted as their presence in the dairy sector is more limited – report available: isfadvisors.org/wp-content/uploads/2022/04/ISF_AgriSME-Finance-state-of-the-sector-report.pdf
[309] For more information, see https://aceliafrica.ams3.digitaloceanspaces.com/wp-content/uploads/2020/09/08173725/Aceli-Africa_Full-Benchmarking-Report.pdf

	Equity Bank	ABSA Bank	Bank of Kigali	CRDB Bank	Uganda Development Bank
Location	**HQ in Kenya but presence in all 4 countries**	**Kenya, Uganda**	**Rwanda**	**Tanzania**	**Uganda**
CAPEX loan products	Commercial Agriculture Loan: For medium- to large-scale farmers to purchase additional land, buy livestock and support construction	Business loan: To finance developmental projects, business expansion or business purchases	Asset Finance Loan: For SMEs to access assets needed to modernise products/services.	SME Malikia Loan: Customised products to enable SMEs to meet their investment capital needs.	Term loans: Loans for capital investment (e.g. agricultural mechanisation or irrigation systems) Asset Finance: This product finances the acquisition of assets for production
Interest rates	17-19%	~19%	8-21%	14-17%	Max. 10%
Repayment terms	Between 1 - 10 years depending on loan, repayments matched to crop cycle or income patterns	Asset finance up to 10 years,	Up to 5 years	Up to 60 months depending on loan type, flexible fixed collateral requirements	Between 4-15 years inclusive of a 3-36 month grace period, with monthly payments, concessions on collateral and other requirements
Requirements	Demonstrated ability to repay, relevant licensing, Security, 2 years experience	Affordability (financial statements), credit assessment, security	Security requirements, trade license, board resolutions	Min. 6 months business expertise, registered business	Security requirements, Annual Turnover of up to UGX 100M for small enterprises and Medium up to UGX 360M.

Table 38: Examples of Working Capital loans provided by local FIs (source: bank websites)

	KCB Bank	ABSA Bank	Bank of Kigali	CRDB Bank
Location	**Kenya**	**Kenya, Uganda**	**Rwanda**	**Tanzania**
Working Capital loan products	Dairy loan: This is a loan product designed to cater to the needs of dairy producers and other actors in the dairy value chain by providing finances for working capital	Trade & Working Capital: Help businesses manage risks and reduce pressure on cash flow and trade confidently and efficiently	Agriculture Inventory Finance: To support business in Agriculture to pay products/commodities from supplier that are not intended for immediate sale	SME Loan: Standard Working Capital and Investment capital loan. Includes an asset financing loan for up to TZS 3 billion Malkia Proposition: Providing Working Capital, investment loan and asset financing to women for loans up to TZS 3 billion. Includes Retail Agribusiness
Interest rates	10.5%	~19%	8-21%	14-20%
Repayment terms	Repayment window between 24-26 months	Working capital short term loans between 45-60 days depending on milk collection	12 months' repayment period, inventory serves as collateral	Between 6-60 months depending on loan, flexible collateral requirements
Requirements	Security, 1 year experience, credit history	Affordability (financial statements), credit assessment, security	2 years' experience, audited financial statements, tax clearance, warehouse standards report	License or permit, 3 years' experience, security

281. **Agriculture-focused investment funds:** There are a number of agriculture-focused funds internationally that provide private investment (both debt and equity) into agriculture businesses specifically. They typically invest in fewer businesses but with larger ticket sizes and in hard currency, but are also able to provide higher touch support to businesses. These funds mobilize financing from DFIs and private investors providing commercial or just sub-commercial rates of capital and so target agri-businesses with operating experience, scalability potential, and typically serving the export market. This means that many of the smaller and medium sized businesses outlined in Table 35 are out of scope for these investments. Aceli Africa's research indicates that the social mandate and potential risk tolerance of funds allows them to be more flexible in their loans and makes them important players in agri-SME lending.[310]

282. **DFIs:** The largest dairy businesses—typically processors—with clear routes to scale primarily through access to export markets, are able to access financing from DFIs. For example, Uganda's largest dairy processor, Pearl Dairy Farms in Uganda, secured USD35 million in investment from IFC and the Dutch Entrepreneurial Development Bank (FMO)[311] to support their regional expansion plans. Market consultations, facilitated by Ripple Effect agricultural experts, revealed that there are few dairy businesses working at the scale required to meet DFI minimum ticket size requirements. For example, IDH's FarmFit Fund's minimum ticket size is USD 1 million, and can take no more than 30% of a deal. This means the smallest investments the Fund can consider are USD3 million. Furthermore, these larger investments are often not climate-smart technology specific.

[310] Bridging the Financing Gap: Unlocking the Impact Potential of Agricultural SMEs in Africa. 2020. Aceli Africa. Accessible: Aceli-Africa_Full-Benchmarking-Report.pdf (aceliafrica.ams3.digitaloceanspaces.com)
[311] FMO's approved co-investment summary can be found here: https://www.fmo.nl/project-detail/62064

283. Financing for the dairy sector could be provided through one of these established agricultural financing routes. However, these channels face a number of challenges, such as lack of local currency, limited data on interest rates, lack of pipeline, and limited TA resources. These challenges are outlined in more detail below.

284. **Lack of local currency debt:** Market research into the dairy sector finds there is a lack of affordable local currency debt within the market. The Market Study (Appendix 1) finds that small processors also typically operate with low liquidity and reserves, limiting their capability to invest climate-smart technologies and practices as well as shorten farmer payment cycles and enable farmer access to climate-smart inputs through check-off systems. For these smaller businesses debt financing is essential to fund investments as they are not able to from their own cash reserves. Without external debt finance, these actors would struggle to upgrade cold chain storage systems, implement new transport solutions (especially for small aggregators), or solarise operations that would all unlock important mitigation outcomes. In the case of medium-to-large-scale businesses, namely processors, the financing gap is lower, owing to higher profitability and creditworthiness meaning they can more readily access finance.

285. Table 37 and Table 38 outline specific loan products available in the market across the four countries. The following paragraphs refer to findings from a broader market research conducted for the DaIMA project. They capture the range of interest rates in the markets made available to dairy businesses and indicate that the market varies with interest rates ranging from 8-21%, with the majority between 14-19%. The discrepancy between the data points potentially indicates the difference between reported offerings and what is available in reality.

286. **Kenya**: There is limited availability of affordable debt with interest rates ranging from 15-20% and stringent collateral requirements up to 150%.

287. **Tanzania**: Financial products have interest rates as high as 15- 20%, which puts them out of reach for most agri-SMEs and small technology developers. Collateral requirements are also as high as 150% of asset value, and the lack of grace periods and payback periods also present an issue for dairy investors as this does not match seasonality of the business.

288. **Rwanda**: The dairy sector has received significant investments (of about USD160 million), mostly via the Rwanda Dairy Development Program (RDDP 1; 2016-23, RDDP-2; 2024-29), which is financed by government and international development funds, such as IFAD and Heifer International. The current commercial debt landscape has offerings that are not tailored to sector needs with prohibitively high collateral requirements (up to 200%), inflexible payment terms (3-5 years, not accounting for seasonality of cashflows), and exceptionally high interest rates (16-19%).MCCs are supported through RDD-P2, but processors, especially those that are privately-owned, continue to need affordable working capital lending that can enhance cashflow stability and grow operations. Additionally, asset financing is needed if businesses are to increase climate-smart technology adoption and broaden their outreach to smallholder farmers. The Market Study (Appendix 1) finds that investor interest in Rwanda is low due to a relatively small market, high government involvement in the dairy sector, and higher investor exposure of neighbouring Kenya. This is demonstrated by limited financing flows to processors (less than USD1M compared to USD5M in Tanzania and USD25M in Kenya) and supporting enterprises (USD3M compared to USD950M in Kenya)**.**

289. **Uganda**: In Uganda, less than 10% of dairy farmers have access to financing facilities from the government and commercial banks. Dairy farmers can access finance through SACCOs, but the product offering (loans, insurance and advice) is still low due to the same constraints as described in the context of Tanzania, in particular. The investments in chilling plants in Uganda by the impact investment fund Heifer Impact Capital demonstrates how investment funds can fill in financing gaps in the local financial sector while delivering greening impact. Heifer extended long-term (10 year) loans, unavailable from local commercial banks, to chilling plants for the purchase of solar energy systems. The long maturity was to allow for the costs of on-going maintenance and battery replacement. These investments reduced the energy intensity of the plants and resulted in 50% savings on energy purchases.[312]

290. For international agriculture focused impact funds, foreign exchange (FX) risk remains an unsolved challenge. Over 50% of the funds surveyed identified foreign exchange challenges as a significant concern. Acumen, currently investing in hard currency, identified the lack of access to local currency debt as a critical challenge within the agricultural sector.[313] AHL Venture Partners highlighted their preference for lending in local currency for businesses which generate revenue in local currency. However, due to risks associated with currency depreciation, they often find it necessary to resort to US dollar loans.[314] Of the funds lending in local currency like Heifer Impact Capital and Root Capital,[315] significant grant funding is required and it is a key differentiator in their offering and their ability to deliver impact.

291. **Lack of pipeline:** International/regional fund managers report having challenges in identifying dairy businesses of sufficient scale to meet their required minimum loan sizes. Funds face higher costs in comparison to banks due to their sub-scale nature. They are often located internationally so face currency risks as well as challenges with higher cost structures in higher-cost geographies. Larger loans typically deliver higher profitability, so as a result, funds tend towards offering larger loans. Data from Aceli Africa's portfolio shows that in 2023, the total average loan size in 2023 across all funding routes was USD 97,000 but when focusing on social lenders only (a designation that includes impact-first funds), the average loan size increased to USD 305k.[316] This suggests that many dairy businesses may struggle to secure investment from existing agricultural funds. Also, funds generally have a continent-wide focus and a cross-sector portfolio. According to the ISF Advisors Fund Database[317], only 6% of Africa focused debt funds have a niche focus, and only 6% specialise in East Africa. This was validated by a number of fund managers which, because of their experience, believed that having a narrowly defined investment strategy such as investing in the dairy sector in one sub-region, compared to investing in agriculture across multiple countries, would be more challenging.[318]

292. **Lack of TA:** There are technical barriers to accessing finance as well as financial barriers. Many businesses face technical barriers to identifying financial needs and being able to develop investment plans to request funding.[319] These technical barriers are acknowledged in the agricultural sector and numerous funds provide TA support to improve impact and returns by enhancing the capacity of investees. For instance, Root Capital, in addition to providing credit, offers five free advisory services to SHFs including modules on financial management, agronomy, policy and political issues, gender, and internships.[320] Similarly, AgriFi provides TA and advisory services to enhance the financial, environmental, and social performance of its investees. These services, delivered by specialist advisors, may include expert advisory during due diligence, and TA on strengthening governance and conducting impact evaluation studies.[321] Aceli specifically highlighted that TA is crucial for investment in the agriculture sector, emphasising the significant effort required to build capacity across the entire dairy value chain to ensure the adoption of climate-smart technologies and practices.[322] Table 39 below summarises the key financial and technical barriers in the market.

Table 39: Key barriers to accessing finance for climate smart practices and technologies (evidence tested and reviewed with Ripple Effect)

	Barrier
Financial barriers	Real and perceived high risks of financing investments into dairy value chain actors, which results in higher interest rates and high collateral requirements. Note: 10 of 17 supply side interviewees referred to a high leve ofl risk in agriculture investments including, ABSA, Aceli, AHL, Emata, Equity Bank, FMO, Oikocredit, Pearl Capital, Root Capital and Samawati Capital.
	Financial products are off the shelf and not tailored to the needs of the dairy value chain actors (source: Market Study)
	Enterprises are operating at low margins with cashflow challenges that reduce investability with low ability to repay (source: key informant interview with AgriFI)
	In the case of international impact funds, enterprise revenue is in local currency yet investments made by funds are typically made in hard currency posing FX challenges that are assumed by the borrower. Note: Over 50% of key supply-side informants with international agri-funds identified foreign exchange (FX) challenges as a significant concern. Including Acumen, AHL partners, ABSA, ARAF, AgriFI, FMO, IDH, Root Capital & Heifer International.
Technical barriers	Agri-businesses require high levels of engagement and support per investment which drives up the transaction costs of lending to them. Note: Over 50% of key supply-side informants referred to the need for local presence to support businesses and identify pipeline for the fund. Research from Aceli Africa outlines the high transaction costs associated with lending to the agri-sector driven by informal/semi-semi formal borrowers who struggle with record-keeping and financial management.
	Enterprises lack capacity and business skills to identify green investments, manage and scale investment effectively

[312] Discussions with Kevin Gituma of Heifer International.
[313] Data collected during key informant interview with Acumen
[314] Data collected during key information interview with AHL Venture Partners
[315] Based on discussions with Heifer International and Root Capital
[316] Profitability of Agricultural Lending in East Africa. Financial Benchmarking Report. 2024. Aceli Africa. Report available here: https://aceliafrica.ams3.digitaloceanspaces.com/wp-content/uploads/2024/02/01171121/2024-Aceli-Africa-Financial-Benchmarking-Report.pdf
[317] https://isfadvisors.org/fund-database/
[318] Including discussions with Acumen and Pearl Capital Partners.
[319] Discussions with Heifer International which provides in house technical engineering expertise to support development of business cases for investments
[320] Data collected during key informant interview with Root Capital.
[321] Data collected during key informant interview with AgriFI.
[322] Data collected during key informant interview with Aceli Africa.

	Note: 6 of 17 supply side informants referred to enterprises often lacking capacity and skills to manage investment. A key recommendation in The Market Study (Appendix 1) is to provide technical assistance and capacity building to potential borrowers to support them to build investment cases and loan applications.
	For businesses prioritizing the use of debt capital, investment into climate -smart practices and technologies is deprioritized compared with productivity enhancing investments (source: Market Study)

6.7.4 Solutions currently in the market

293. All four countries have programmes in place to tackle different challenges in the market and fill the financing gap for the agriculture sector, and the dairy sector in particular. Whilst they are complimentary, they do not necessarily offer a whole market solution. The GDFF has been designed to be additive to the existing market solutions and will leverage the existing work being done to support the broader ecosystem.

Table 40: GCF and IFAD funded initiatives with GDFF complementary potential in East Africa

Country	Initiative	Areas of differentiation / complementarity with GDFF
Rwanda, Kenya, Uganda, Tanzania	ARCAFIM (GCF financed). Currently in implementation phase. Programme to catalyse and scale up private sector climate change adaptation financing targeting smallholder food producers and MSME in the agricultural sector in Africa. It de-risks commercial banks to offer loan products to food producers and MSMEs to adopt CCA technologies that support adaptation and resilience to climate risks including water deficit, water excess, heavy winds and soil depletion.	• GDFF can complement the standardised loans and TA offered to SHFs by ARCAFIM by providing additional resources and support for larger dairy chain actors to adopt climate-smart technologies, ensuring comprehensive support across the entire dairy value chain.
Rwanda	Rwanda Dairy Development Project (RDDP, IFAD-funded) Current phase completing at end of 2023, Phase 2 currently under design. Phase 2 will include promoting access to finance for dairy producers and fostering productive alliances. Phase 2 will focus in formalising the sector and will target and scale the key coop-run MCC hubs and offer SHF segments access to extension, inputs, services and finance.	• GDFF will benefit from the experience and lessons learnt from the RDDP 1 & 2 • GDFF could benefit members of productive alliances • Potential pipeline for GDFF investments, particularly for Green Dairy Partnerships with coop-run MCC hubs that will be targeted through RDDP-2.
Rwanda	Resilient and Inclusive Small Livestock Markets Programme (PRISM, IFAD funded). Duration from 2021 to 2026. Aims to reduce poverty and enhance resilience by empowering rural populations to transform their livestock sector, focusing on the pork, poultry, and animal feed value chains through private sector investment, market growth, and climate change resilience, while improving access to information, technology, and finance, and fostering a conducive environment for growth and investment.	• Potential to share learnings from the small livestock sector targeted through PRISM and the GDFF. • Potential pipeline for GDFF investments includes agri-input providers within animal feed value chains.
Kenya	Rural Kenya Financial Inclusion Facility (RK-FINFA, IFAD-funded): Capacity building for rural finance institutions, combined with Business Development Services, and a Green Financing Facility (GFF) and Rural Credit Guarantee Scheme. Also awaiting approval for supplementary funds for separate technical assistance and de-risking facility for green financing for youth employment.	• GDFF can complement GFF climate-smart funding for smallholder and microenterprise investments in the livestock and dairy production systems and vice versa • Project will develop taxonomy of green finance models for youth that can be used by GDFF
Kenya	Kenya Livestock Commercialization Project (KeLCOP, IFAD funded). Duration from 2020-2027. Aims to increase small-scale farmer incomes and improve opportunities for rural poor to access them to increase their output, access markets and increase their resilience. It focuses on value chains that have the potential to provide employment and food security for women, youth and marginalised people.	• GDFF finance can complement climate-smart dairy production across the whole value chain and vice-versa
Kenya and Uganda	FP078: Acumen Resilient Agriculture Fund (GCF-funded). Currently under implementation. Support innovative private social entrepreneurs by providing aggregator, digital platform, and innovative financial services to smallholder farmers, with the aim of enabling smallholders to	• Digital technologies and aggregators can complement GDFF investments and vice-versa • Opportunities for cross-learning on approach and best practices

	respond to climate change more efficiently and effectively	
Uganda	IFAD-funded project ReLIV (Resilient Livestock Value Chains) Currently under design phase. Aims to enhance smallholder beef and dairy production by increasing productivity and resilience, improving market and financial access, and strengthening the policy and regulatory framework.	• GDFF finance can complement climate-smart dairy production across the whole value chain and vice-versa
Tanzania	Tanzania Agriculture Climate Adaptation Technology Deployment Programme. Duration from 2021-2027. Facilitate access to agricultural climate adaptation technologies through a lending/de-risking facility, plus technical assistance. Strengthen also awareness of climate threats and risk reduction for government, industry actors and financial sector.	• Awareness raising can complement GDFF activities • Technical Assistance provided by this programme provided to agricultural enterprises can support GDFF objectives
Tanzania	Climate smart Smallholder Dairy Transformation Project (C-SDTP, IFAD-funded).Duration 2023-2029. C-SDTP aims to transform the dairy value chain by boosting productivity and resilience, promoting inclusive climate-smart practices and investments, and enhancing food safety, while mitigating climate impact through policy support and project management.	• GDFF finance can complement climate-smart dairy production and vice-versa • GDFF could benefit members of productive alliances • Potential pipeline for GDFF investments through PCUs

294. GDFF has been designed to respond to the above survey findings and reported investment and financing challenges in the dairy market in East Africa, while not duplicating existing solutions. The Component 3 of DaIMAI approach, green dairy finance activities and targets are described later in this Annex as a part of the detailed description of the three DaIMA components.

Figure 90: Technical assistance spending overtime

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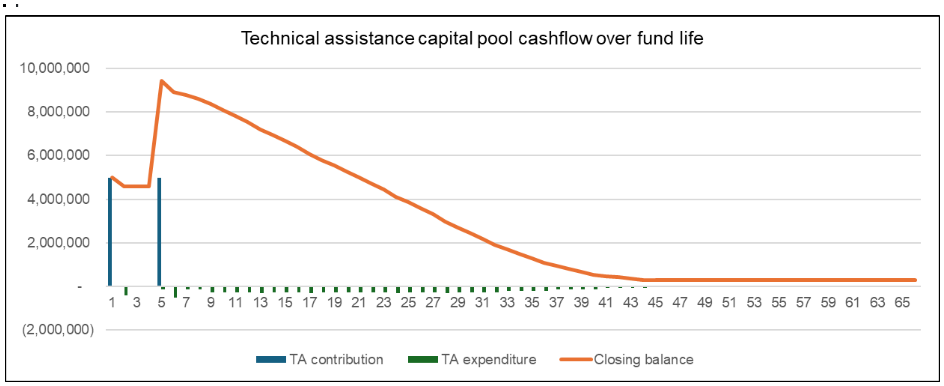


1. COUNTRY OWNERSHIP

296. The Nationally Determined Contributions (NDCs) and other national strategies outline the countries approaches to reduce GHG emissions and adapt to climate change. The proposed Programme is aligned with these national strategies the include measures proposed such as: climate-resilient crops, climate-resilient livestock, expansion of crop and livestock insurances, more resilient animal breeds, improved husbandry, and windrow composting to reduce enteric fermentation emissions from livestock, and more efficient manure management systems. In general, the Programme will support the Ministries responsible for the dairy sector to review and formulate national policies, strategies, and regulations that are essential for a sustainable transformation of the dairy sector aligned with the NDCs.

Table 41: Alignment with key national climate priorities and Livestock MRV status

Kenya	Rwanda	Uganda	Tanzania
National Climate Change Action Plan (NCCAP) (2018): Incorporates ways to reduce GHG emissions, enhance carbon sinks, and strengthen climate resilience into the National Climate Change Response Strategy (NCCRS).	National Climate Change and Environment Policy (2019) Mainstreams climate change concerns across all sectors and outlines the country's priorities for adaptation and mitigation measures.	National Adaptation Plan (NAP) (2016): A framework for adapting Uganda's livestock sector to climate change, including enhancing veterinary services and improving water management.	National Climate Change Strategy **(2012):** Provides a strategy for tackling climate change across all sectors, including climate change adaptation measures and measures for sustainable livestock management.
Kenya Climate Smart Agriculture Implementation Framework (2018–2027): Provides a roadmap for promoting climate-resilient agriculture, including improved animal feeding and watering, pasture management, and manure management.	National Adaptation Plan for the Agricultural Sector (2017): Provides a framework for adapting the livestock sector to climate change impacts, through drought-tolerant livestock breeds, improved water management, and veterinary services.	Climate Change Policy 2015): Encourages Uganda's livestock sector to incorporate climate change considerations. The policy includes measures to increase climate change resilience, reduce GHG emissions, and promote sustainable development.	Tanzania Climate Smart Agriculture Program (TCSAP) (2017): A framework for promoting climate-smart agriculture in Tanzania. Measures include increasing animal feeding and watering, managing pastures, and managing manure.
Kenya Livestock Master Plan (KLMP) (2013): Roadmap for the livestock sector to mainstream climate-resilient livestock management practices and livestock productivity.	Rwanda Livestock Master Plan (210077): Climate-resilient livestock management practices promoted along with strategies for improving livestock productivity.	Livestock Development Strategy and Investment Plan (LDSIP) (2015): Livestock sector roadmap, based on climate-resilient livestock management, enhanced livestock productivity and value chains.	Livestock Development Master Plan (LDMP) (2013): Tanzania's livestock sector roadmap, based on improved livestock productivity, enhanced value chains, and adaptation to climate change.
Kenya Vision 2030: Emphasizes sustainable rangeland management to mitigate climate change impacts in pastoral areas, efficient resource use, value addition, research and innovation, and market access for livestock products.	Rwanda Green Fund (FONERWA) (2012): Finance for climate change mitigation and adaptation projects in Rwanda. Funds support renewable energy, sustainable agriculture, and ecosystem management projects.	National Delivery of Veterinary Services Policy (2003): Prioritizes a sustainable increase in the production of live animals and livestock products, such as milk, meat and other by-products.	Tanzania Livestock Modernization Initiative (TLMI) (2020): Aimed at transforming the livestock sector through the adoption of new technologies, including climate-smart feeds, breeding heat-tolerant

			livestock, and improving disease management.
National Adaptation Plan (2016): Aims to enhance the adaptive capacity and resilience of livestock production systems, through drought-tolerant livestock breeds, improving water management, and enhancing veterinary services.	National Dairy Strategy and Strategic Plan (2013): Guides dairy sector development, through policy support, research, extension services, infrastructure development, and capacity building.	National Organic Agriculture Policy (2019): Guidelines for organic livestock, poultry, fisheries, and related subsectors like feed, fodder, veterinary services, especially given the significant number of domestic livestock.	National Adaptation Plan (NAP) (2015): Provides a framework for adapting livestock to climate change, including measures for enhanced livestock production resilience such as drought-tolerant breeds, veterinary services, and water management.
Livestock MRV status: currently using Tier 2 methodology for the dairy sector, and Tier 1 methodology with default emission factors for other livestock	Livestock MRV status: currently using Tier 1 methodology with default regional emission factors.	Livestock MRV status: currently using Tier 1 methodology with default regional emission factors.	Livestock MRV status: currently using Tier 1 methodology with default regional emission factors.

6.8 EFFICIENCY AND EFFECTIVENESS

For details, see Annex 3

297. The Programme net cash flows are based on the incremental approach, which results from comparing the With Programme Situation and Without Programme situation[2]. The selection criterion for the IRR is to accept all Programmes for which the IRR is above the opportunity cost of capital. By using the IRR as the measure, the models' sensitivity to the changes in parameters can be assessed by varying the costs and revenues. The financial analysis demonstrates that financial performance indicators are satisfactory. The regional financial analysis, based on an average discount rate of 8.25 per cent, yields a FIRR of 21 per cent and a NPV of US$278.26 million, indicating sound performance of the Programme.

298. The analysis shows that DAIMA represents an economically viable investment for the society. Disaggregated by country, economic performance indicators for Tanzania, Uganda, Rwanda, and Kenya, individually confirm economic viability, and therefore showing that the proposed pathways to low-emission and resilient dairy farming – as described in the theory of change – are fully justified. At regional level, the aggregated Economic NPV of the countries' incremental net benefit streams, discounted at 13.25 per cent (economic discount rate), is US$ 117.44 million, with an Economic EIRR of 22.0 per cent for the baseline scenario. Additionally, two additional economic performance scenarios are included, by integrating the economic value of the Programme's GHG emissions balance with a low carbon price (LCP) assumption and a high carbon price (HCP) assumption, in line with the World Bank guidelines on the social price of carbon[323]. Under the LCP scenario, the EIRR is 24.8 per cent and the ENPV is approximately US$ 154.30 million. Under the HCP scenario, the EIRR is 27.5 per cent and the ENPV is approximately US$ 190.26 million. In both cases, for the four countries, integrating the reduced and avoided emissions further enhance the economic justification of DaIMA.

[323] https://documents1.worldbank.org/curated/en/099553203142424068/pdf/IDU1c94753bb1819e14c781831215580060675b1.pdf

7 IMPLEMENTATION ARRANGEMENTS

299. This section details DaIMA's institutional arrangements, namely (i) regional programme governance, (ii) executing entities, (iii) national steering committees and (iv) programme coordination at country level. It is based on an institutional assessment which is found in Textbox 2.

Textbox 3: Institutional assessment

In **Kenya**, implementation of the Programme will be mainstreamed into the Government systems, both at national and county levels. The Programme will be executed in part,by the State Department of Crops of the Ministry of Agriculture and Livestock Development (executing entity, EE), the same Ministry as implementing the related IFAD-financed Integrated Natural Resources Management Programme (INReMP). The Ministry formulates, implements and monitors agricultural policies, regulations and legislations; IFAD has long-standing experience working with the Ministry, namely though the State Department of Livestock, which implements the Livestock Commercialization Project (KeLCoP) that will complete in 2027. For example, the IFAD/Government of Kenya Supervision report of that project from April 2023 states that the implementation structures of the project have been fully established and are functional, along with the County, sub-county and Ward structures, and that full support is being provided by the projects PSC. As per the Kenya's decentralization process with power devolved to the Councils, a multi-sectoral County Programme Steering Team (CPST) will be an integral part of this.

Day to day implementation will be delegated to a PCU reporting directly to the Principal Secretary, State Department for Agriculture and Livestock Development who will be accounting officer for INReMP and DaIMA. This avoids lengthy and bureaucratic processes at the line Ministry, with a similar arrangement established at the county level.

The implementation will be supported by a number of government agencies including the Kenya Dairy Board (KDB), Kenya Agricultural and Livestock Research Organization (KALRO) and Kenya Animal Genetic Resources Centre (KAGRC). The SDLD through PCU will enter into MoUs and/or subsidiary agreements with the implementing partners for implementation of respective activities.

In **Rwanda,** the Programme will be executed by RAB within the MINAGRI as EE, along with other EEs. MINAGRI has the Government mandate for the activities within the DaIMA scope and *the close alignment of project national policies will ensure a strong GoR ownership during and beyond its implementation.*

RAB is the Rwanda Agriculture and Animal Resources Development Board, an autonomous body to develop agriculture and animal resources through research, agricultural extension and animal resources extension in order to increase agricultural and animal resources productivity and quality, as well as their derived products. RAB implements the RDDP-2 and also implemented the predecessor RDDP-1 as well as other four other IFAD projects including the Partnership for Resilient and Inclusive Small Livestock Markets Programme (PRISM), through the *Single Project Implementation Unit (SPIU). For the RDDP-2 design, IFAD highlighted that this poses a challenge in the sense that implementation of many projects may hinder the SPIU availability to properly focus on all the specific activities across the different projects, in a broadened geographic area. Moreover, the limited technical capacity, governance and institutional capacities of project stakeholders can lead to slow disbursement, lower project benefits as well as delays in implementation. To mitigate this risk, the SPIU has been (and will be) strengthened by RDDP-2 and DaIMA, with the inclusion of several key experts such as Dairy VC Specialists, Access to Finance Specialist, Monitoring and Evaluation Specialist, Youth/Gender and Social Inclusion Specialist, Nutrition Specialist, Environmental Specialist, Knowledge Management & Communication Specialist, Procurement Officer reporting to SPIU Procurement, as well as a* Head of Corporate Services and a Logistics Officer and Archivist. MoUs will be signed between RAB and envisaged implementing partners, including the Rwanda Environment Management Authority (REMA). The project has a strong network already established with service providers etc.

The project will create partnerships with the Local Government Authorities in each targeted District, building on the existing networks established through the ongoing projects RDDP and PRISM. District project coordinators will be hired and assigned to targeted districts and, in some cases, may be in charge of both PRISM, RDDP-2 and DaIMA activities.

In **Tanzania,** the programme will be executed in part by the Ministry of Livestock and Fisheries, one of the EEs. The Programme will be an integral part of the approved C-SDTP. The other implementing agencies will be the Vice President Office (VPO), Climate Change Adaptation and Mitigation (CCM&A), Tanzania Dairy Board (TDB) and the Tanzania Livestock Research Institute (TALIRI) which all form an integrated part of the C-SDTP project and are longstanding partners with IFAD. The IFAD Country Strategic Opportunities Programme (COSOP) highlights the Ministry of Livestock and Fisheries as a critical partner for engaging in policy and influencing agendas. More and better politics and public investments have been seen, to be scaled up. Other critical partners for DaIMA include TALIRI, ZALIRI and SUA for research, LITA/SUZA for training of technicians, Veterinary Services/DLD for animal health and animal identification, NAIC/DLD for genetics, breeding and AI, Districts for extension (including L-FFS) and milk inspection, TVLA for disease surveillance, TDB/DLD for sector monitoring, milk quality/safety control and milk consumption promotion, TADB for access to finance, NIC/ZIC for mortality and accident insurance coverage. The project will also benefit from the achievements of previous projects with regard to (i) programming and results-based management, (ii) implementation manuals, including the administrative and financial management manual. The project will create partnerships with the Local Government Authorities in each targeted District, building on the existing networks established through the on-going projects.

In **Uganda,** the Programme will be managed by MAAIF, which has the public mandate of the livestock sector. Implementation will be supported by the same public entities as those for ReLIV, as well as Uganda Development Bank (UDB). According to the ReLIV Project Desing Report, these have strong management structures for financial management and procurement, besides their core mandates. This will ensure adequate alignment with existing Government structures and mandates. The entities are:

- Directorate of Animal Resources (DAR) in MAAIF. DAR is the directorate with overall responsibility for guiding development of animal resources in the country; in particular it will: (i) work with Department of Policy and Planning to propose/ review/ finalize necessary laws, regulations, policies or strategies; (ii) support local governments in provision of extension services to farmers; (ii) lead and coordinate local governments in animal vaccination campaigns; (iii) promote herd recording in collaboration with NAGRC&DB for traceability.

- National Animal Genetic Resources Centre and Data Bank, NAGRC&DB was established with a two-fold mandate, namely, to play a leading role in the commercialization of animal breeding activities in Uganda and to carry out development activities that enhance animal genetic improvement and productivity. It runs fifteen ranches and farms regionally distributed across the country, with huge chunks of land. The key roles for NAGRC&DB will include the following: (i) management and delivery of animal genetic resources; (ii) dissemination of improved breeding stock (local or crossed) that are suitable for extensive or semi-intensive production systems; (iii) Offer specialized training to technicians dealing in animal breeding, including supporting community breeding; (iv) multiplication of feed and fodder species, in collaboration with NaLiRRI; (v) promotion of Artificial insemination (AI) services, including training a cadre of AI technicians.

- Dairy Development Authority (DDA). DDA was established by an Act of Parliament, the Dairy Industry Act, 1998 to develop and regulate the dairy industry in Uganda. Its vision is to: "increase productivity and competitiveness of the dairy sector enhancing its contribution to population health and wealth of all Ugandans". DDA has a fairly adequate staffing capacity with nine regional offices across the country. It has experience in farmer capacity building through cooperatives and in inspection, registration and enforcing compliance to food safety standards for milk and its production, and in linking dairy farmers to processors. DDA has one central and four regional laboratories, plus mobile ones, for testing and calibration. The key roles for DDA include: (i) support to mobilisation and capacity building of dairy farmers in groups/ cooperatives/associations, around milk collection centres (MCCs); (ii) inspection and quality assurance of milk and milk products; (iii) take the lead in review and refinement of policies related to milk and milk products; (v) conducting awareness campaigns promoting consumption of milk and its products (iv) collaborating with other implementing agencies on activities that could ideally be implemented through MCCs or dairy cooperatives. The construction and rehabilitation of MCCs and MCPs will be entirely under the responsibility of the Dairy Development Authority (DDA) which has a long experience in the domain and since this is entirely part of its mandate. DDA will be responsible for selection of sites and groups, feasibility studies, procurement of equipment, commissioning of civil works.

- Local Governments: District Local Governments (DLGs) together with sub-county local governments at lower levels have the made of provision of extension services to farmers. Each district has a District Veterinary Officer (DV) and most of the sub-counties have Veterinary Officers. The DLGs will ensure that ReLIV activities are coordinated within the District and Sub- County Development Plans. The DVO will be the project's focal person in each DLG, who will coordinate the implementation and technical supervision of the project. The key roles of local governments will include: (i) provision of extension services to famers; (ii) work with DAR of MAAIF in provision of major vaccination services, and disease control in general; (iii) monitor project performance and prepare district periodic progress reports for the PMU and DAR.

In each of the four participating countries, a GDFF line of credit will be established to channel green funding to eligible dairy sector borrowers. In each country, this line of credit will be managed by a local Public Development Bank (PDB), which will act as a <u>Wholesale Bank</u> for the GDFF intervention. The Wholesale Banks will at national level manage the financial DaIMA services to the programme target group based on eligibility criteria and other terms and conditions, agreed upon in the programme design and included in the financing agreements between IFAD, the Governments, and the Wholesale Banks.

Based on IFAD's rural finance experience in East-Africa and reviews of financial markets in the targeted countries as well as interviews with several candidate banks, the following PDBs were selected as candidates for the Wholesale Banks for GDFF: Agricultural Finance Corporation (AFC) for Kenya, Uganda Development Bank (UDB) for Uganda, Rwanda Development Bank (BRD) for Rwanda, and Tanzania Agricultural Development Bank (TADB) for Tanzania. The criteria for Wholesale Bank identification included: (a) status of a leading PDB in the targeted countries, (b) solid institutional and financial conditions, (c) strong interest in agriculture and rural finance operations, (d) corporate objective to develop and scale-up the bank's climate finance portfolio, (e) corporate mandate and operational capacity to provide wholesale financing products, and (f) strong expressed interest to manage the DaIMA wholesale financing operations in the dairy sector. All the four proposed PDBs, as leading development banks with rural orientation in their respective country, fulfil the conditions operate as Wholesale Banks in the GDFF operation.

7.1 ACCREDITED ENTITY

300. IFAD will serve as AE for this Programme. As such, IFAD will be responsible for the overall management of the Programme, including: (i) all aspects of Programme appraisal; (ii) administrative, fiduciary and technical oversight and supervision throughout Programme implementation towards achievement of the expected Outputs and Outcomes; and (iii) Programme closure and final evaluation. IFAD will carry out these responsibilities in accordance with the detailed provisions outlined in the Funded Activity Agreement (FAA) to be signed between IFAD and GCF.

301. IFAD's role as AE will be attributed to the relevant offices and divisions in IFAD Headquarters located in Rome, Italy, the IFAD East and Southern Africa regional office located in Nairobi, Kenya and the IFAD Country Offices in Kenya, Rwanda, the United Republic of Tanzania and Uganda. In order to fulfil the AE functions, IFAD will work through its established Project Development Teams that will jointly form the DaIMA Development Team, together with any technical specialists that will be invited to cover specific areas.

7.2 REGIONAL PROGRAMME GOVERNANCE

302. The Regional Steering Committee (RSC) will be constituted by Permanent Secretaries from the Executing Entities. Each national steering committee will appoint 6 members to the committee, including 3-4 Government representatives (representing the Permanent Secretary of the Ministry responsible for livestock; a senior technical Director of the same Ministry or a related agency, a representative of the NDA and of the public development bank implementing Component 3), and 2 representatives of relevant farmers organisations and/or private sector or civil society. The RSC meeting shall be conducted on an annual basis, on rotational basis between countries. Each country will host the chairmanship of the RSC for a twelve -month period, entailing preparing for the physical RSC meeting with agenda, reports to be reviewed and other preparatory activities as required, and the minutes. Knowledge Management events for technical officers may proceed the physical meeting. Additional virtual meetings may be held, as needed. The RSC will specifically oversee (i) the progress on regional aspects of the Programme and regional additionality; (ii) timeliness and quality of reporting to the GCF, and high quality programme level reports are being produced for reporting to IFAD, GCF and the National Designated Authorities (NDAs) including both Annual Workplans and budgets (AWPBs), progress reports and M&E; (iii) coherence in approach between Components and implementers ; (iv) oversight of regional aspects including MRV, regional policy harmonization and exchanges, and (v) ensuring the quality of Programme monitoring and regional M&E and knowledge management, to ensure that, for example, data collection is carried out in a streamlined manner through join development of data collection and reporting tools to be used in each country, as well as review of consolidated reporting to be provided to IFAD and further to GCF. Specific regional activities under the purview of the RSC include Output 1.1 (regional policy harmonization and dairy market integration, harmonization of dairy market protection), Output 1.3 (capacity building in MRV GHG, carbon certification system) and Output 1.4 (regional exchange platform, regional knowledge management and exchange). Regarding Output 1.4, the RSC will oversee the development of learning materials and knowledge products and support the establishment of a knowledge platform specific to each country. This platform will provide opportunities for exchange visits (farmers, private sector, and ministries), development and sharing of studies, technical work, trainings, and financial initiatives between the four countries.

303. To further support regional aspects, a senior regional coordinator and policy dialogue expert would be recruited in each country, using similar TORs, responsible to support the functions of the RSC and any regional activities. This team of four officers will constitute the regional coordination umbrella of the Programme. They will also support Programme reporting activities which are to be at a regional level, supported by regional . They will specifically, in each country, (i) support preparation of the RSC meetings including knowledge sharing events; (ii) lead the preparation of regional policy sharing events on a rotational basis; (iii) organize and facilitate meetings amongst implementers across the countries on a regular basis for purposes of harmonization and information sharing on relevant topics (e.g. policy and MRV reporting) and (iv) based on reports from implementers, consolidate reporting on activities with regional relevance for presentation and discussion at the steering group.

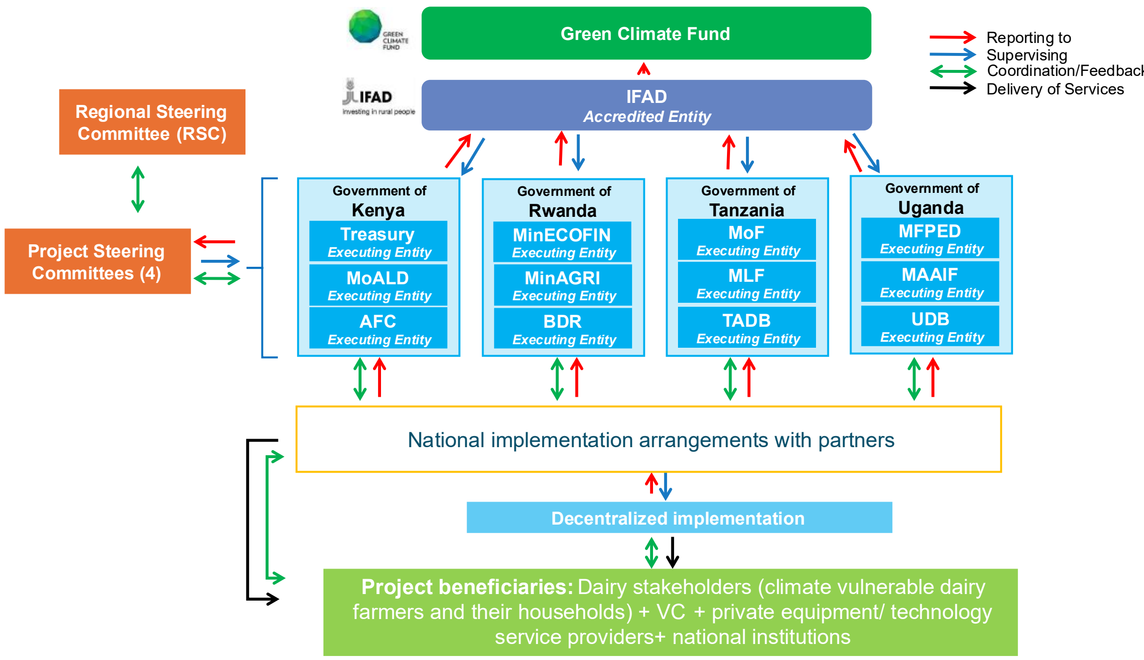


Figure 91: Regional implementation arrangement

7.3 EXECUTING ENTITIES

304. The Programme will be executed in each country by the Government through its Ministries and Agencies. This is further elaborated below and visualised in Figure 92: Regional Implementation arrangement Day to day management will happen through the national Programme Coordination Units (PCUs) of the related IFAD-financed projects, hosted within the EEs, achieving synergy both through co-financing and through implementation efficiency. The set-up per country is described below.

305. In **Kenya**, the Programme will be executed by the Government of Kenya through its National Treasury, the MoALD, and the Agricultural Finance Cooperation. Day to day management and coordination will be by the PCU implementing the Integrated Natural Resources Management Programme (INReMP) within the State Department of Crops. The Programme will be an integral part of INReMP, which was approved in 2024. Implementation will be in coordination with the State Department of Livestock, which implemented KeLCoP among others.

306. In **Rwanda,** the Programme will be executed by the Government of Rwanda through its Ministry of Finance and Economic Planning, RAB within the MINAGRI and the Development Bank of Rwanda. It will be an integral part of the ongoing RDDP-2. Implementation will build on the existing networks established through the ongoing projects namely RDDP-2,the Partnership for Resilient and Inclusive Small Livestock Markets Programme (PRISM) and supported by RAB, the Rwanda Environment Management Authority (REMA), and others.

307. In **Tanzania,** the Programme will be executed by the Government of the United Republic of Tanzania, through its Ministry of Finance, the MLF and the Tanzania Agricultural Development Bank. The Programme will be an integral part of the approved C-SDTP. The other implementing agencies will be the Vice President Office (VPO), Climate Change Adaptation and Mitigation (CCM&A), Tanzania Dairy Board (TDB) and the Tanzania Livestock Research Institute (TALIRI).

308. In **Uganda,** the Programme will be executed by the Government of Uganda through its Ministry of Finance and Economic Planning, through the MAAIF and through the Uganda Development Bank. It will be an integral part of the IFAD-funded ReLIV which is to be approved in 2024. Implementation will be supported by the Dairy Development Authority (DDA), the National Animal Genetic Resources Centre and Data Bank (NAGRC&DB), NARO, Ministry of Local Government (MoLG).

7.4 NATIONAL PROGRAMME STEERING COMMITTEE

309. In each country, Programme Steering Committees (PSC) of the linked IFAD-financed projects will also perform the oversight function of the Programme at national level. In this function, it will: (i) provide overall guidance and direction to Programme implementation; (ii) address Programme issues as raised by the national Programme coordinator; (iii) monitor Programme risks and the effectiveness of mitigation measures, and provide guidance on new Programme risks, and agree on possible countermeasures and management actions to address specific risks; (iv) review the Programme progress and effectiveness, and provide direction and recommendations to ensure that the agreed deliverables are produced satisfactorily according to plans; (v) review National annual work plan and budget (AWPB)including proposals to build on achievements and address any shortcomings, recommend it to the RSC for approval and provide necessary strategic guidance for its implementation; (vi) appraise the annual Programme implementation report, including the quality assessment rating report including lessons learnt and good practices; (vii) make recommendations for subsequent work plans to build on achievements and address any shortcomings; (viii) provide *ad hoc* direction and advice for exceptional situations, (ix) identify lessons learned and good practices. In each country, the PSCs will be expected to meet formally at least once every 12 months. The PCU coordinator acts as a secretary to the PSC and organises regular meetings, including any additional consultations as requested by PSC members (with tentative dates for the following meeting to be agreed under the “any other business” point of the agenda). Extraordinary meetings of the PSC on can be requested by any of its members. Detailed membership at country level is presented below. Extraordinary meetings of the PSC o can be requested by any of its members. Detailed membership at country level is presented below. Extraordinary meetings of the PSC can be requested by any of its members. Detailed membership at country level is presented below.

310. PSCs are supported by Programme Technical Committees (PTCs) which are constituted by the same members as the PSCs, but at technical level. These meetings usually precede the PSC and serve to discuss the matters at a technical level.

311. In **Kenya**, the PSC and PTC to be established for InREMP will also oversee DaIMA. It will be chaired by the Principal Secretary or his appointed representative, the State Department for Livestock (SDLD) under MoALD will be established. Other members of the PSC will be drawn from National Treasury and Economic Planning; Agricultural Financing Facility, State Department for Cooperatives; State Department of Micro, Small and Medium Enterprises (MSME) Development; State Department for Environment and Climate Change; KDB; KALRO, the Council of Governors as well as two Executive Committee Members from the Programme Counties and private sector and civil society representation. The structure will be cascaded to County level.

312. In **Rwanda**, the RDDP-2 PSC will also serve as PSC for DaIMA, and similarly the PTC. It is chaired by the PS of MINAGRI, co-chaired by the Director General of RAB. The meteorology services, Ministry of Environment, Ministry of Infrastructure, REMA, private sector and civil society are also members of the committee, along with the Rwanda Development Bank, to be added.

313. In **Tanzania**, the C-SDTP PSC will also serve as PSC for DaIMA. It is chaired by Permanent Secretary MLF, and Co-chaired by the Principal Secretary, MAINL, Zanzibar and will be composed by the Permanent Secretaries of the ministries finance and planning, Vice President's Office (VPO) and President Office-Regional Administration and Local Government (TAMISEMI) for mainland; and First Vice President Office in Zanzibar (VP1), Ministry of Finance and Planning President's Office for Zanzibar, and the Tanzania Agricultural Development Bank, as well as representatives from the private sector and farmers' organizations. The NTAC is known as the Technical Advisory Committee (TAC) and serves a similar function to the PTCs in other countries. It is established by MLF to advise the PSC and the Project Coordination Office Unit (PCO) on technical issues. The TAC will be chaired by the Director of Production and Marketing, MLF and Co-chaired by the DLD, MAINL and will be composed of the relevant Directors from MLF and MAINL on areas of Policy and Planning, Veterinary services, Extension services, Animal feed resources, Animal breeding, Research & Training, Chief accountant, Procurement, as well as Chief executive officers of each participating implementing partner in the mainland and Zanzibar. It will also comprise a representative from participating Districts and representatives from private sector involved in the Project.

314. **In Uganda**, a PSC will be established for the strategic oversight of the ReLIV; along with the PTC. This PSC and PTC will also oversee and support DaIMA. It will be chaired by the PS of MAAIF and co-chaired by Ministry of Finance, Planning and Economic Development (MFPED) as GCF National Designated Agency (NDA) and EE. The following will be members: the Director of Animal Resources (MAAIF), Executive Directors of MAAIF semi-autonomous Agencies (DDA, NAGRIC&DB, NaLRRI and NARO); Director responsible for climate change (MWE), Chief Accounting Officers of selected District Local Governments (DLGs); Uganda Development Bank and representatives from the Ministry of Energy and Mineral Development, Ministry of Local Government (MoLG), and the Uganda National Meteorological Agency (UNMA).

7.5 PROGRAMME COORDINATION AND MANAGEMENT

315. The Programme management and coordination, and M&E functions of DaIMA will be fully integrated in the Project Coordination Units (PCU) of INReMP, RDDP-2, C-SDTP and ReLIV in the four countries. The PCUs will be responsible for overseeing and implementing both the national projects and DaIMA.

316. The PCUs comprise competitively recruited Government staff with appropriate project management skills, subject to IFAD No Objection at the key stages of developing terms of reference (ToRs), shortlisting, interviewing and contracting. These PCUs are planned and mostly financed through the IFAD financing proceeds[324].

[324] Tentative budget subject to revisions

317. In each of the four countries, PCUs (with slightly different names in each country) will be responsible for overall coordination and day-to-day management of the Programme, as well as facilitating a conducive environment. Specifically, the units' responsibilities will include: (i) the development of annual work plans and budgets (AWPB), including the organization and facilitation of AWPB validation workshops with stakeholders; (ii) the coordination of the implementation of Programme activities among EEs and implementing agencies and partners; (iii) the development of operational strategies and establishment of effective tools (e.g. monitoring information systems - MIS) for Programme implementation, (iv) fiduciary management (prepare project withdrawals requests for disbursement, track and monitor of project costs and deliverables to plan, prepare of financial management reports, handle audit requests as needed); (v) the mobilization, contracting and coordination of implementation partners, (vi) the monitoring, evaluation, knowledge management and learning (M&E –KM&L) - including dissemination of lessons learned and good practices and providing guidance for effective Programme implementation, (vii) management of the environmental and social management framework (ESMF), (viii) the procurement of goods and services (i.e. prepare procurement plans, validate ToRs for implementing partners and review/ approve procurement packages) in accordance with financing agreements, (ix) the communication and visibility of the Programme, including inception workshops, at national and regional levels and (x) regional events with the involvement of all four countries, including regional workshops for knowledge sharing and learning with all four participating countries (with GCF proceeds, under output 1.4, see Section 8).

318. During implementation, the EEs, as represented by the PCUs, will engage relevant and specialized government agencies, academia and research institutions. Several partners (NGOs/ non-profit organizations, service providers, private sector, ILRI, FAO, and other international development organizations etc.) will also be engaged in the Programme either to ensure complementarity with their activities and/or delivery of goods works and services. Upon approval of the Steering Committee, the EEs will enter into Memorandum of Understanding (MoUs) and/or subsidiary agreements with the implementing partners for implementation of respective activities. The MoU/contractual agreement shall clearly specify, the scope of the work to be undertaken, staffing and institutional arrangements, budget, reporting and fiduciary requirements, implementation records, and performance evaluation criteria, where relevant. Details are provided below for each of the countries.

7.5.1 Kenya

319. In **Kenya,** at national level, a PCU will be established within the State Department of Livestock Development (SDLD) in MoALD. Synergies will be explored to implement in partnership with, or through, the coordination and management unit of the IFAD-financed IINReMP, implemented within the State Department of Agriculture in the same Ministry. Regional structures may be established on need. The programme will thus be implemented, as much as possible, through existing Government structures at National and County levels.

320. Implementation will happen through number of actors drawn from government agencies, international research organizations and the private sector. Government partners will include KDB and KALRO, KAGRC and NEMA which the EE will enter into MoUs with for the completion of activities. ILRI will be a partner for technical assistance on MRV reporting and M&E. The Programme will enter into MoUs or contractual relations with private and public sector partners, as well as ensure coordination with other projects. Service providers will be contracted as required, based on their mandate and expertise within Kenya. In selected cases, international expertise may be procured.

321. At decentralized level, a County Programme Coordination Committee (CPCC) will be established and chaired by the Governor or his/ her appointee, preferably, the CECM in charge of Agriculture and Livestock Development. The CPCC will comprise the County project Coordinator (as the Secretary), and relevant Departments such as Livestock Production and Veterinary Services, Finance, Environment, Cooperatives, the Department responsible for gender, youth and social development, representatives of the farmers' umbrella organization, the private sector and NGOs. The CPCC will review implementation progress against targets at the County level, assess management effectiveness, decide on corrective measures where appropriate, review lessons learned and good practices, approve County AWPBs and review progress reports.

322. Additionally, a County Programme Implementation Team (CPIT) will be established with the responsibility of implementation within each County as per the established MoUs with the national PCU. The CPIT will be headed by the County Project Coordinator (CPC). The CPIT will comprise mainly staff from the County Department of Livestock with participation of county staff from other relevant departments; such as, Finance, Veterinary Services, Environment, Gender Youth and Social Services, representative of livestock farmers, NGOs working in the sector, the private sector and any other entity as required. Technical Assistance will supplement in areas of agribusiness, green technology and others. The CPIT will work directly with programme beneficiaries and will report to the County CeC in charge Agriculture and Livestock Development. The CPIT will coordinate implementation of the Programme activities according to the County-level approved AWPB. Other activities include mobilization of farmers and creating awareness, extension and advisory services, supporting organization of farmers groups, leading the preparation of the County AWPBs and of implementation progress reports for submission to the PCU, coordinating extension services and M&E functions at the County level.

323. At the sub-county level, a Subcounty Programme Implementation Team (SCPIT) comprising sub-county officers from relevant departments as outlined for the CPIT will be established to coordinate implementation of activities at the sub-county.

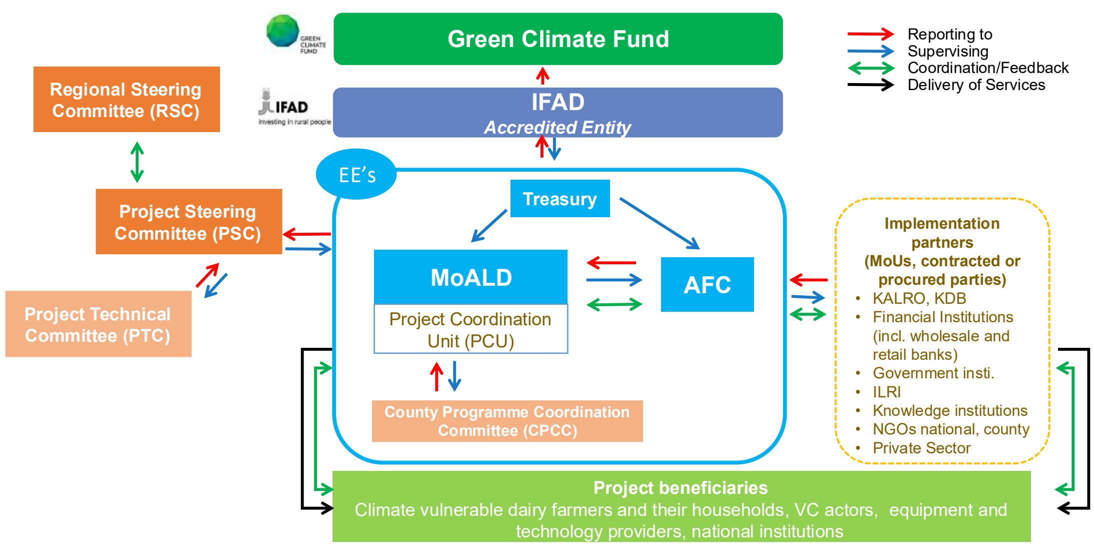


Figure 92: Programme implementation and coordination arrangements in Kenya

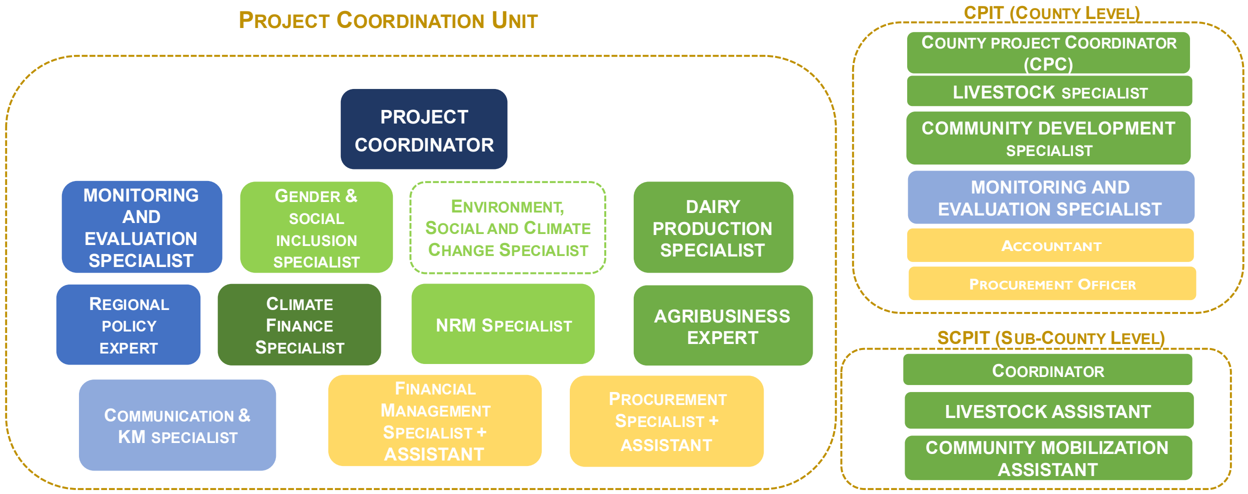


Figure 93: Programme organigram in Kenya

1.3.1 Rwanda

324. In Rwanda, the Programme be implemented through the Single Programme Implementation Unit (SPIU) under the authority of RAB. The SPIU will leverage on its long-standing experience with IFAD. At local level, the Programme will create partnerships with the Local Government Authorities (LGA) in each targeted District, building on the existing networks established through the ongoing projects RDDP and the Project for Inclusive Small Livestock Markets (PRISM). District project coordinators will be hired and assigned to targeted districts and, will be in charge of the Programme activities. The EEs, as represented by the SPIU, will enter into MoUs or contracts with implementing partners (e.g. Government specialized agencies, NGOs), including potential domestic co-financiers for the implementation of specific activities detailed in AWPBs.

325. At District level, the District Manager will assume the role of District Project Coordinator; District stakeholder platforms will feed into the AWPB development processes.

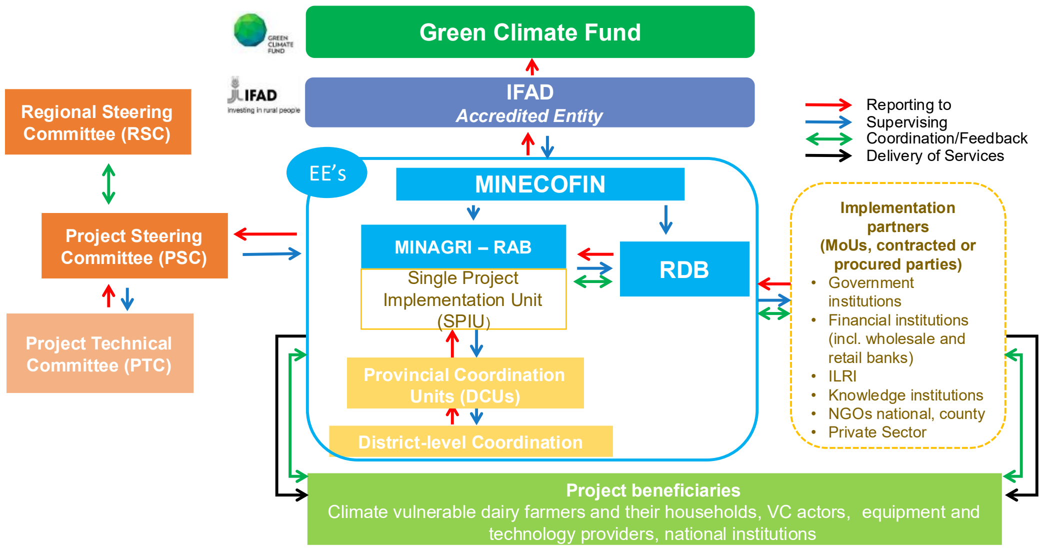


Figure 94: Programme implementation and coordination arrangements in Rwanda

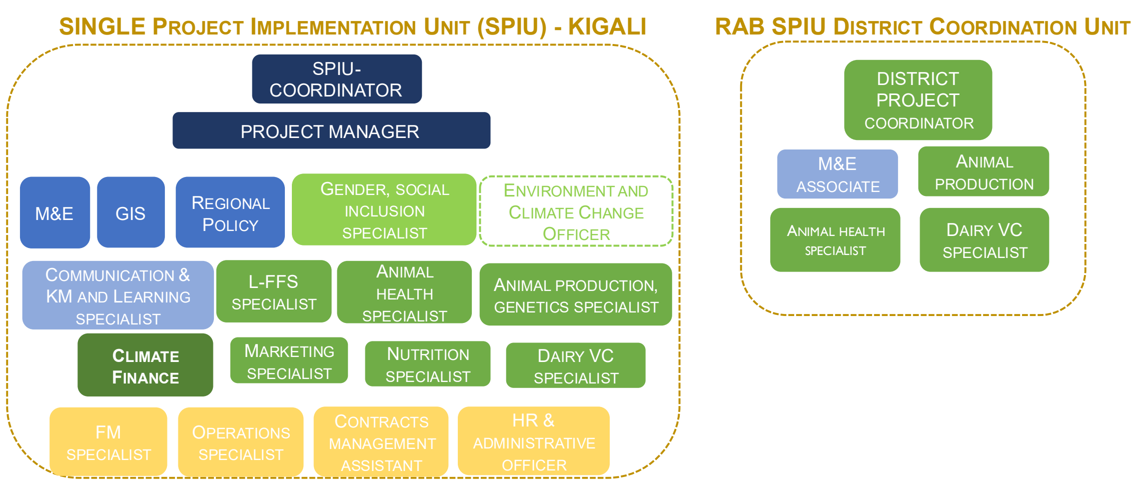


Figure 95: Programme Organigram in Rwanda

7.5.2 Tanzania

326. In Tanzania, the Programme is an integral part of the C-SDTP, proposed to the IFAD Board in December 2023. A Project Coordination Office (PCO, for mainland) and Project Coordination Team (PCT, for Zanzibar)[325] will be established under the MLF, which is also an EE for this Programme. The C-SDTP will be placed under MLF as lead agency, with. The will facilitate regular implementing partners meetings (executive staff or their representatives) to ensure the advancement of the respective activities and ensure synergies and complementarities of the activities. Staff will be recruited in accordance with agreements between IFAD and GoT, with staff selected in the market with a record of interacting with farmers and private sector, to complement seconded civil servants. The team will be inclusive, respecting the following balance: 40% women (including 33% in management positions) and 30% youth. People with disabilities and autonomous peoples will be encouraged to apply and a coefficient will be assigned to them. The project will also benefit from the achievements of previous projects with regard to (i) programming and results-based management, (ii) implementation manuals, including the administrative and financial management manual.

327. The Project will rely on three main categories of implementing partners: (i) public institutions as TALIRI, ZALIRI and Sokoine University of Agriculture (SUA) for research, LITA/SUZA for training of technicians, Veterinary Services/SDLD for animal health and animal identification, he National Artificial Insemination Centre NAIC/SDLD for genetics, breeding and AI, Districts for extension (including L-FFS) and milk inspection, TVLA for disease surveillance, TDB will coordinate dairy standards and milk inspection, other implementing partners will include TADB for facilitating access to finances; NAIC for the implementation of improved quality and productivity of dairy breeds and NIC for mortality and accident insurance covers for the dairy breeds; (ii) National and International NGOs for community mobilization and group strengthening (including for POG and GALS), gender and nutrition awareness, support to cooperatives; (iii) international research in the scope of the “Maziwa Zaidi” project (more milk) but that is now dormant; and centers (ILRI, and the Alliance Diversity International, CIAT) for scientific support to national research institutions, and international institutions (such as FAO) for methodological backstopping (for L-FFS) and policy support on sustainable livestock systems. MoUs will be signed between MLD/MAINL and envisaged implementing partners (e.g. Government specialized agencies, NGOs), including potential domestic co-financier for the implementation of specific activities detailed in AWPBs. Performance contracts will be annually reviewed.

328. The project will create partnerships with the Local Government Authorities in each targeted District, building on the existing networks established through the on-going projects. All district level project implementation will adhere to the C-SDTP structures, which build on those established by a previous project, namely the ASDP II. The District Executive Director (DED) will hold overall responsibility for activities and funds used at local level, and will report to PCO and the Ministry. It will be supported by the District Facilitation Team (DFT) including the District Agricultural, Livestock and Fisheries Officer (DALFO), on issues related to targeting, livestock extension (mobilising one livestock extension worker (LEW) per ward/shehia included in the targeted area of intervention), nutrition, women empowerment, youth, climate change and environment.

[325] Due to the Union of Tanzania, it is practice to establish two coordination Units, one for of the two Union states, Tanganika and Zanzibar

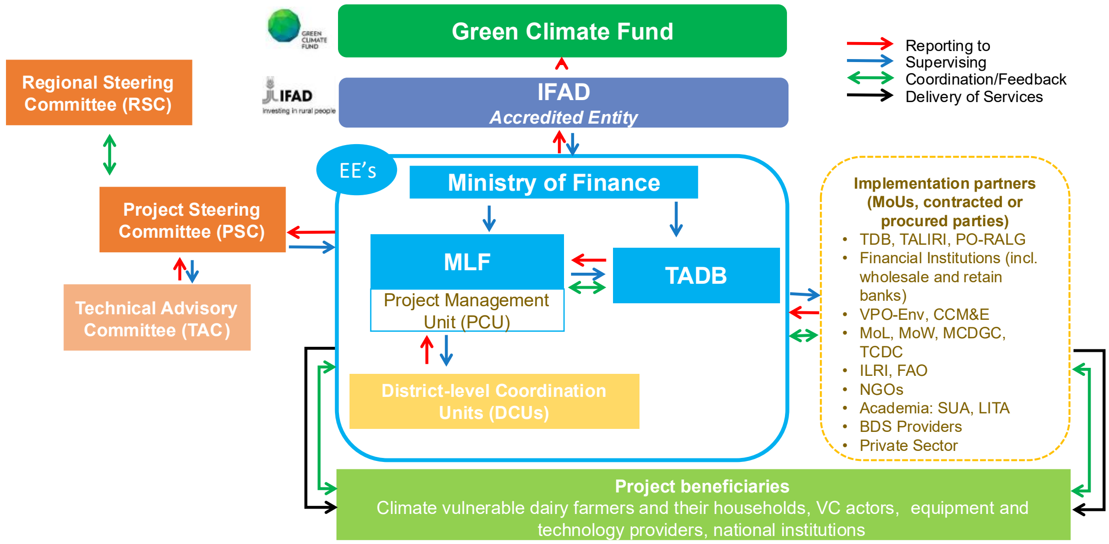


Figure 96: Programme implementation and coordination arrangements in Tanzania

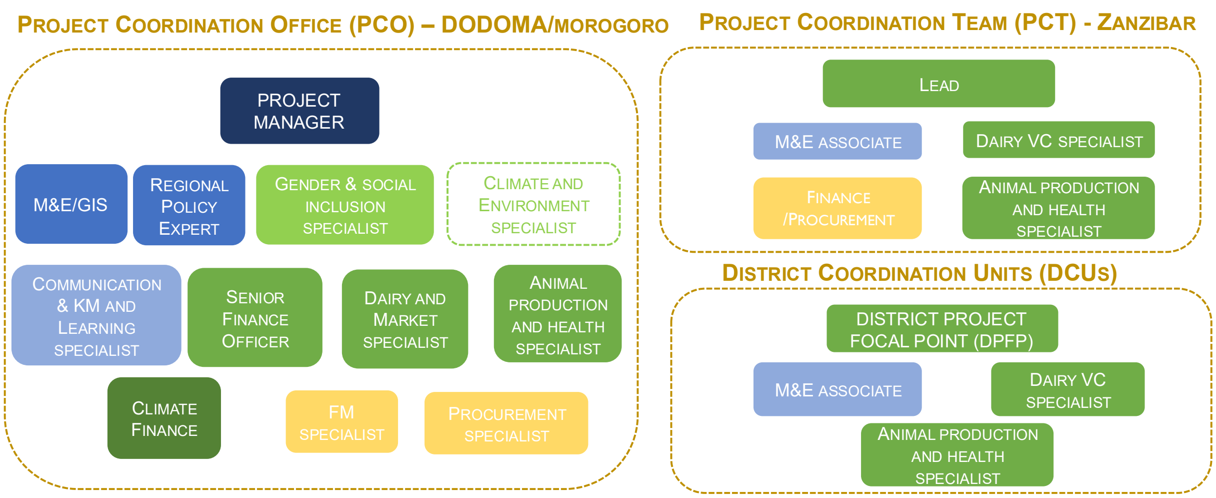


Figure 97: Programme organigram in Tanzania

7.5.3 Uganda

329. In **Uganda,** the ReLIV PMU will be established within MAAIF to act as a joint PMU for both ReLIV and DaIMA. If will consist of a qualified Programme manager, technical, procurement, and financial accounting staff to be competitively filled. At district level, a District Coordination and Implementation Unit (DCIU) will be formed and chaired by the Chief Administrative Officer (CAO), to coordinate implementation of activities at the District level. Members will include relevant Departments such as Production and Marketing, Veterinary, Environment, the Department responsible for gender, youth and social development, representatives of farmers' organization, the private sector and NGOs.

330. Implementation will be supported by the DDA, the National Animal Genetic Resources Centre and Data Bank (NAGRC&DB), NARO, Ministry of Local Government (MoLG), Universities (e.g. Makere University), local private sector and NGOs. MoUs will be entered into by the EEs with implementation partners. Each of these agencies will designate a focal person for the project. The PMU will ensure that these agencies conduct joint planning and review sessions, to ensure harmonisation across components. The project will collaborate with other entities as relevant, including private sector, NGOs, cooperatives and DLGs to deliver the Programme. These will be selected on a competitive basis or in accordance with their institutional mandate.

331. DLGs together with sub-county local governments at lower levels have the mandate of provision of extension services to farmers. Each district has a District Veterinary Officer (DV) and most of the sub-counties have Veterinary Officers. Districts will be part of the DaIMA implementation structure. District level coordination and implementation unit (DCU) will be formed and chaired by the CAO. Members will include relevant Departments such as Production and Marketing, Veterinary, Environment, the Department responsible for gender, youth and social development, representatives of farmers' organization, the private sector and NGOs. The roles of the DCU include; mobilization of beneficiaries, review DaIMA implementation progress against district targets, monitoring and reporting. Their tasks include mobilization of farmers and creating awareness, extension and advisory services, supporting organization of farmers groups, preparation of progress reports for submission to the PCU, coordinating extension services and M&E functions at the District level. DLGs will ensure that activities that are included within the District Development Plans (DDPs) and the DVO will be the focal officer for the Programme.

332. At the sub-county level, a sub-county Project Implementation Team comprising sub-county officers from relevant departments will be established to coordinate implementation of DaIMA activities at the sub-county. The planning process will start at the sub-county where each Sub-County Implementation team will develop a budget using indicative planning figures that will be provided before the Government annual budgeting process commences. The sub-county plans will be consolidated by the District level coordination and implementation unit which will ensure the sub-county plans are aligned to the project goals, objectives and targets. The District plans will then be submitted to the PCU in MAAIF which will quality check then and consolidate Project's AWPB.

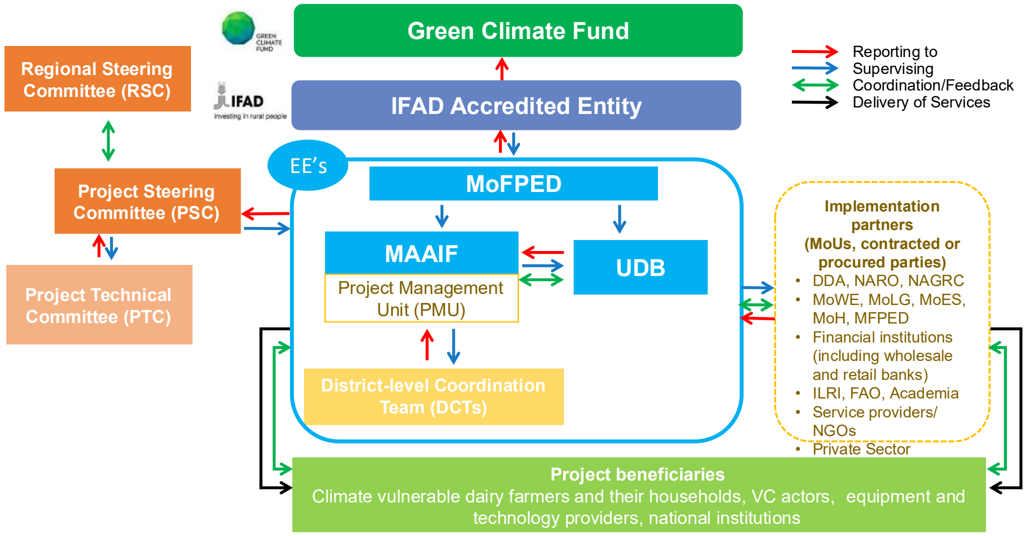


Figure 98: Programme implementation and coordination arrangements in Uganda

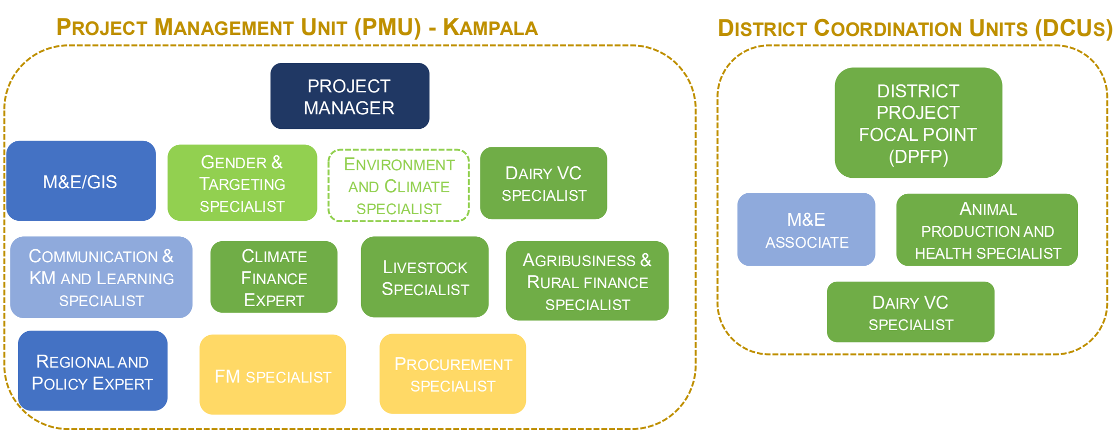


Figure 99: Programme Organigram in Uganda

7.5.4 Other partners and partnerships

333. At regional level, the proposed Programme will be complementary with the GCF-funded ARCAFIM for East Africa region (USD 200 million). At the national level, synergies will be developed with IFAD-funded initiatives, and key stakeholders will be involved in coordination and implementation.

334. ILRI has been identified as the knowledge partner with a comparative advantage especially in relation to data collection, protocols, GHC MRV measurement and implementation of best practices for soil management and has regional presence through its Mazingira Centre in Nairobi as well as research stations in each country. For this reason, ILRI will be proposed as a technical assistance partner for all four countries. Countries will receive implementation support from ILRI who will in turn build capacity of national institutions in the same areas. An overview of the activities related to GHG MRV is provided in the table below. ILRI will report to the EEs, through the PMU is each country. The Regional- Steering Committee will play a strong role in ensuring oversight and coherence between these activities.

Table 42: Activities to be supported by ILRI

Output /Activities	Sub-activities
Output 1.3 1.3.1: Develop capacity in the country on MRV system	Sub-activity 1.3.1.1 Capacity assessment in capturing, recording, tracking, and reporting data on dairy GHG emissions. *ILRI's Mazingira Centre will provide trainings to the four countries on data collection protocols adjusted to their needs to relevant stakeholders (technicians, university staff, staff of national research institutes and ministries, and other relevant actors). ILRI will provide dedicated digital data collection tools (e.g. ODK), data quality control, and calculation of GHG emissions for inventory reporting, following established protocols.* *DaIMA, in partnership with ILRI, will support the member countries in monitoring existing SOC stocks via targeted soil sampling campaigns, comparing different grassland management practices and degradation status along pedoclimatic gradients across the four countries. The Programme will inform on impacts of grassland management on soil carbon storage and sequestration The Programme will contribute to the development and validation of novel remote sensing approaches for rangeland monitoring via drones and satellites. This also includes application of modern techniques such as Eddy Covariance (EC) towers for landscape-scale monitoring of ecosystem carbon exchange to show if the ecosystem is a carbon sink or source, and how carbon uptake and release are affected by seasonality, climatic extremes, and management. ILRI has two EC towers set up in their Kapiti research station.*
Output 1.3 1.3.2. Improve GHG emission measurements	Sub-activity 1.3.2.1: Collect activity data on farm to calculate Tier 2 dairy emissions under various herd, feed, animal health and manure management situations. *This sub-activity will be performed annually with the support of ILRI, in direct partnership with national research institutions and academia of the four countries, to ensure sustainability and replication through the transfer of capacity (see output 1.4). This activity will inform the Programme's M&E system and provide data for baseline and "with-project" situation.*
	Sub-activity 1.3.2.2: Conduct experiments and run models to generate Tier2 emission factors (EF) for baseline and improved dairy, under various herd, feed, animal health and manure management situations. *ILRI will quantify the GHG mitigation potential of selected feed interventions using state-of-the-art cattle respiration chambers*[326] *to derive methane yields for enteric CH4, as well as manure incubation setups to derive CH4 and N2O emission factors for manure management.*
	Sub-activity 1.3.2.3: Training on the Global Livestock Environmental Assessment Model – interactive (GLEAM-i) and IPCC assessment tool to calculate GHG emissions biannually, and to inform the national MRV system and inventories.

[326] For more information, see https://mazingira.ilri.org/infrastructure/

	Throughout the whole process, ILRI will transfer capacity on Tier 2 EF, data collection and GHG emission calculation from the Programme.
1.4.1. Support to Regional Centers of Excellence for technology validation and for maintaining a regional database on practices, GHG emissions and adaptation indicators	Sub-activity 1.4.1.2: Develop and maintain a regional database/ repository on practices, GHG emissions per sources and systems, and climate change adaptation. *ILRI has a large repository of training materials on its open-access "CGSpace" platform, which will be leveraged, and made available to all actors in the Programme, with the support of the EAC.*
Output /Activities	Sub-activities
Activity 2.2.4 Promote climate-smart feeding practices to reduce enteric methane emissions.	Sub-activity 2.2.4.1 Develop production system-specific supplementation plans and feed packages. *This sub-activity will benefit from the Programme's partnership with ILRI, as well as its regional knowledge sharing platform.*
Activity 2.2.5 Increase sustainable nutrient recycling of manure and dairy waste to reduce emissions	Sub-activity 2.2.5.1 Manure management in intensive and semi-intensive dairy production systems. *The sub-activity will consist in providing trainings through L-FFS and demonstration farms, using existing manuals developed by NARO in Uganda, ILRI, etc. on scalable and already tested manure management practices (pit storage, manure ponds, manure covering with banana leaves, compaction, etc..) and manure use applications offering livelihoods opportunities.*

335. In addition, ILRI will support the countries on knowledge management activities (Output 1.4), as well as regional Monitoring and evaluation, particularly in the elaboration of

336. Supervision by IFAD IFAD will carry out supervision and implementation support missions every six month specifically related to DaIMA, but coordinated to the extent possible with supervision of the linked IFAD projects. One of the annual supervision missions will be country-focused, while the other will comprise of a joint team visiting all four countries and assessing progress towards overall Programme achievements. After the visits, the IFAD and national teams may meet in one country, to discuss findings and agree on recommendations. Such supervision reports will be presented both to the national and to the regional Steering Committees.

8 DETAILED PROGRAMME DESCRIPTION

337. Each of the three Outcomes will result in one Programme Component. Component 1 creates an enabling national and regional policy and regulatory environment as well as dairy value chain governance, improving public service delivery, amplifying GHG MRV capacities and ensuring regional knowledge management and exchange. Component 1 creates the enabling environment. This forms a robust foundation for sustainable practices enhancing lower emissions, climate resilience, and increased productivity for smallholders.

338. Concurrently, Component 1 informs Component 3 by improving visibility and strengthening countries' GHG measurement capability, a pivotal element for farmers' access to carbon certification and revenue streams from carbon markets. On the other hand, Component 2 enhances Component 3 by strengthening smallholder farm and pasture management capacity, elevating their creditworthiness, and fuelling their demand for alternative technologies and loans to acquire them. Lastly, Component 3 reciprocally reinforces Component 2 by broadening smallholders' access to finance through low-cost loans, providing revenue avenues in the carbon market, and rendering technical assistance to lower emissions and boost efficiency. Together, these intertwined components engender a holistic approach, addressing both environmental and economic facets. This contributes significantly to a sustainable and climate-resilient landscape in target countries.

8.1 COMPONENT 1: STRENGTHENED NATIONAL CAPACITIES AND ENHANCED ENABLING ENVIRONMENT FOR LOW EMISSIONS CLIMATE RESILIENT DAIRY SECTORS

339. This Component will support the desired paradigm shift towards a more productive, climate-resilient, and low-emission dairy sector, underpinned by sustainable practices and gender-inclusive growth. It will create an enabling institutional environment for smallholder dairy producers and value chain stakeholders to reduce methane (CH4) and other GHG emissions, while increasing resilience to climate-change. It will also address the institutional, planning and knowledge barriers identified in the ToC, and foster a conducive policy, institutional, and service delivery environment that facilitates the transformation of the East African dairy sector towards enhanced productivity, climate resilience, and low GHG emissions. This Component will contribute to the following GCF Results Areas: MRA4 “Forestry and Land Use”, ARA1 “Most vulnerable people and communities”, and ARA4 “Ecosystems and ecosystem services”.

340. The Component will deliver four Outputs namely (i) an enabling policy and regulatory environment, including improved consumer awareness and nutritional balance; (ii) improved public services delivery to the dairy sector, in particular specialized livestock extension and veterinary services; (iii) improved capacity to monitor GHG emissions and vulnerabilities; and (iv) enhanced regional cooperation and knowledge management. The activities under Component 1 will provide public service goods and will therefore be financed through grants.

341. **Activities under the Component are sustainable.** The Programme will carry out a set of activities to improve the enabling environment (policy, legal and regulatory) and long-term institutional capacity of key actors of the dairy sector, in order to provide effective services for more efficiency, climate resilience and reduced GHG emissions. These capacities will revolve around core public responsibilities of climate-smart policy preparation and implementation at national and regional levels; favourable trade policies across East Africa to unlock affordable climate smart solutions across the Region, GHG MRV, climate risk analysis, sector coordination with climate policies and to ensure that the dairy sector, fully contributes to the Nationally Determined Contributions (NDC) of the participating countries.

342. **Activities under the Component have scale-up and replication potential.** For example, innovative capacity support to countries on enhanced GHG monitoring, reporting and verification (MRV) in the livestock sector has been piloted through the intervention of the FAO or the International Livestock Research Institute (ILRI), but more action is needed to reach scale and replication in the Region. Data on GHG emissions from East African livestock systems remain scarce, and most estimates rely on indirect estimates and methodologies that were developed for systems from temperate zones in high-income countries and consequently do not represent East African livestock systems well[327]. Moreover, in the absence of specific regional dairy typology data, several inventories default to broad African averages[328]. This creates notable bias in national GHG inventories[329] and hampers African nations in their efforts to track mitigation progress in their livestock sectors. Furthermore, to ensure long-term feasibility and success of any implemented climate-smart agriculture (CSA) practice at scale, East African countries need the data and capacity to track progress and set up and maintain MRV systems. In addition, innovative support on climate risk analysis to extension services will strengthen the dissemination at scale of climate information services to last-mile users including women, youth dairy farmers through cooperatives and farmer organizations. Moreover, regional platforms and south-south cooperation will contribute to export the key structural elements, successes and lessons learnt of the Programme to other sectors, regions and countries.

8.1.1 Output 1.1: Climate-responsive policy and regulatory environment established.

8.1.1.1 Activity 1.1.1 Review and formulate Dairy Sector policies, strategies and regulations for climate-change adaptation and mitigation.

343. In the four countries, the Programme will support the Ministries, respective Departments and aligned institutions in charge of the dairy sector to review and formulate national policies, strategies, and regulations that are essential for a sustainable transformation of the dairy sector, in line with the NDCs and NAPs. This includes mainstreaming of climate change adaptation and mitigation, and adopting export and import regulations that favour sustainable development and private sector engagement and investment in the dairy value chain (taxation of imports of dairy produce, specialized equipment, inputs, such as germplasm, fodder seeds, feed additives, solar cooling, biodigesters, etc.). Resources will be provided to (i) mobilize national and international expertise for policy review and formulation; (ii) facilitate stakeholder consultations to ensure that the policy review and dialogue are inclusive; (iii) validation processes, and (iv) the preparation of policy notes/briefs and communication materials for popularization. This activity will be implemented by the relevant Executing Entities (see Section 8), i.e. ministries, as well as the representatives of dairy value chain stakeholders, including (i) SDLD and KDB, in Kenya; (ii) RAB, MINAGRI, and RNDP in Rwanda; (iii) MLF and TDB in Tanzania; and (iv) MAAIF and DDA, in Uganda. In addition, other relevant professional bodies would be involved in the process. The regional activities will involve the participation of EAC and the African Union Inter-African Bureau for Animal Resources (AU–IBAR).

344. Sub-activity 1.1.1.1 Support the review and preparation of national dairy policies, strategies, and regulations to mainstream climate-change adaptation and mitigation. Priorities will be the following: **In Kenya,** (i) a review of the Dairy Master Plan to guide the sustainable transition of the dairy sector; (ii) the finalization of the draft National Strategy and legal framework for Animal Feed and Fodder, incorporating land tenure, gender as well as climate change adaptation and mitigation; (iii) developing a National Strategy for Animal Breeding and breeding regulations; (iv) review and update the draft Dairy Industry Act (1958); (v) review the Kenya Agricultural Sector Extension Policy (KASEP); (v) the development of compost and bio-slurry standards and; (vi) milk and milk product standards on food safety and quality.

327 Graham MW, Butterbach-Bahl K, du Doit CJL, et al (2022) Research Progress on Greenhouse Gas Emissions from Livestock in Sub-Saharan Africa Falls Short of National Inventory Ambitions. Frontiers in Soil Science 2: https://doi.org/10.3389/fsoil.2022.927452

328 Intergovernmental Panel on Climate Change (IPCC), 2019

329 Korir D, Ndung'u PW, Onyango AA, et al (2023) IPCC Tier 1 methodology overestimates the carbon footprint of smallholder cattle production systems in Kenya. 10 July 2023, PREPRINT (Version 1) available at Research Square. https://doi.org/10.21203/rs.3.rs-3148140/v1

345. In **Rwanda**, the upcoming Strategic Plan for Agriculture Transformation 5 (PSTA5) provides a framework for a low-carbon and climate-resilient agriculture sector. Within this framework, the Programme will review: (i) the national climate and sectorial policies that are regulating the diary sector; a new agriculture and livestock policy for Rwanda is currently under development whereby, issues of climate resilient livestock production have been emphasized; (ii) the regulatory framework and standard operating procedures (SOP's) for dairy value chain operators in direct collaboration with Rwanda Food and Drugs Authority (FDA) as well as Rwanda Standards Board (RSB), for aspects of milk quality, standards and safety, feed formulation, energy efficiency, and CC; (iii) the 2016 Ministerial Order to address new dairy value chain realities, including the MCP-model and the need to regulate the raw milk market. Support will be given to the formulation of a national regulatory framework for the private veterinary practice including for CAHWs and L-FFS facilitators; finally, (iv) support will also be given to RNDP for the formulation and development of the dairy value chain regulatory law empowering the platform to conduct overall regulation of the Dairy value chain as it is in EAC member countries.

346. In **Tanzania**, The Programme will support the Ministry responsible for livestock to formulate and update national policies, strategies and regulations that are essential for the development and transformation of the dairy sector, and to provide a more conducive context for the Programme investments (e.g. privatization of veterinary services). The Programme will support finalizing the draft national Livestock Policy, as well as (i) review of the Veterinary Act (2003) to update aspects related to private practitioners; (ii) review the Dairy Act to update regulations on raw milk trade; (iii) the formulation of disease contingency and control plans; (iv) prepare the Tanzania Dairy Development Strategy and roadmap, (v) finalization of the Animal Breeding Act, (vi) review of the Animal Diseases Act (2003), (vii) review of the Animal Welfare Act (2008), (viii) review of the Grazing Land and Animal Feed Resources Act (2010), and (ix) finalization of a Strategy for Formalization of Dairy Industry When external expertise is required, and approved by the Ministry in charge, specialized service providers will be engaged. FAO has a clear comparative advantage in this domain and will be considered in priority. The activity will be co-financed with C-STDP.

347. In **Uganda,** a draft livestock Policy (2010) has been expected to guide the dairy sector. The Programme will support: (i) finalization of the National Livestock Development Policy, integrating CC priorities (breeding, feeding), enabling policies for private sector investments, research strategies on climate-resilient feed germplasm development to offset predicted yield declines, as well as rangeland ecology; (ii) the review of the Dairy Industry Act, the Animal Disease and Health Act and the Animal Breeding Act); (iii) drafting of regulations for animal identification, dairy cattle breeding, livestock insurance) to integrate climate change mitigation; and (iv) the review of land policies and regulation to mitigate land tenure insecurity for dairy farmers. The activity will be led by MAAIF.

348. Sub-activity 1.1.1.2 Support the regional policy dialogue to mainstream climate-change adaptation and mitigation in regional dairy policies, strategies and legislations. In coordination with regional and national dairy platforms and stakeholders, the Programme will support a region-level assessment and proposals for further regional alignment on dairy sector regulations. This includes the harmonization of milk and milk product standards on food safety and quality. This would include, for example, the compliance with EAC product standards for milk and dairy products 2005) to support valorisation and formalization of the dairy industry. The Market Study highlights that the EAC dairy industry stakeholders have recommended that "Standards for all dairy products being produced in the region need to be developed irrespective of whether one or only two countries are the only ones producing such products" and that "for commodities where quality standards are in place across the countries, there is need to harmonize them".

349. The regional-level assessment and proposal will also contribute to (i) develop compost and bio-slurry standards which are necessary to optimize the value of biodigester investments, (ii) export and import regulations and tariffs on renewable energy technologies (solar/ PV-powered appliances, milk cooling and resources-efficient technologies and spare-parts) to reduce to reduce the cost of investment and allow for widespread deployment of "green", low carbon, technologies across the region, and (iii) environmental regulations, in particular for bio-slurry handling.

350. For this to happen, recurrent regional policy dialogue events will be organised. Policy dialogue will be an interactive and inclusive consultation process that aims to develop and broaden the communication channels among the 4 participating governments, regional institutions and national stakeholders (including the private sector) for the purpose of informing and enhancing regional policies. Policy dialogue events will be organised bi-annually, on a rotational basis, in each of the 4 participating countries. The policy dialogue events will prepare and deliver a policy implementation plan. Senior national consultants, recruited and funded by each participating countries, will support the process, and be in charge of coordinating with their counterparts and organising the events on rotational basis, once every 2 years, as well as travel and participation to other regional meetings. These consultants will closely liaise with the Programme Regional Steering Committee (RSC).

351. *Sub-activity 1.1.1.3 National dairy value chain governance and awareness creation on climate-change*. The aim of this activity is to enhance dairy value chain governance and to mainstream the importance of climate-change in this process. At national level, the national dairy boards (KDB, DDA, TDB, RNDP) and other relevant professional bodies of private stakeholders, will be supported to participate in the dairy policy dialogue, to create awareness and education/capacity building on climate, feed and dairy policies and regulations.

352. *Sub-activity 1.1.1.4 District/regional/county level dairy value chain governance and planning*. Local-level multi-stakeholder platforms (MSPs) involving delegates from the various dairy value chain stakeholders will be formed to participate in the annual planning and review of Programme activities. These play a critical role in promoting better decision making by ensuring that the views of main actors concerned are heard and integrated at all stages through dialogue and consensus. The Programme will establish MSPs in selected districts or counties to bring together various stakeholders in the value chains. This will promote information collection on available opportunities and challenges, remove bottlenecks in the sub-sector due to increased chances to link producers with input suppliers, market, processors, traders, service providers, private and public actors. These platforms will be composed, amongst others, of dairy cooperative members, milk collectors, milk processors, service providers of AI and veterinary services, extension staff and local government authorities. The platforms also provide an important aspect of participatory AWPB development.

353. In **Rwanda**, until 2019, there was only a national level stakeholder platform (RNDP), that was facing some challenges of inclusivity with low representation of grassroots level sector actors. RDDP proposed to create District Platforms in 2019 and these were rolled out in the 14 RDDP Districts first, then in other Districts with the support of MINAGRI. The District Platforms allowed RNDP to involve dairy cooperatives, L-FFS groups in its activities, but also to discuss the organisation of the value chain and facilitate Business-to-Business (B2B) arrangements. It was agreed that the National Platform should focus its efforts on policy advocacy and lobbying, while the Districts Platforms should focus on this value chain facilitation role. RNDP will organize and convene district stakeholder dairy platforms in all RDDP-2 districts, which will form the basis for the MSPs under this Programme. The platforms will be composed of dairy cooperative members, milk collectors, milk processors, service providers for AI and veterinary services, extension staff and local government authorities. District stakeholder platforms will convene on a quarterly basis and will feed into a national platform. This activity will be co-financed with RDDP-2.

354. In **Tanzania,** the project will encourage and facilitate the emergence of local multistakeholder platforms (involving dairy producers' groups and coops, collectors, processors, local traders) to develop marketing opportunities at the level of one to three MCCs in average at the division/ward scale (in order to enable each platform to operate with very low operational cost). Collaboration with existing farmers organisations to facilitate such process will be sought, when possible, to build on existing dynamics. Each year several MSPs exchanges will be organized for to facilitate peer exchanges and eventually to develop common commercial strategies. The process will be facilitated by relevant implementing partners. Collaboration with existing farmer organizations will be sought when possible, to build on existing dynamics, following good experiences under the IFAD-financed project MIVARP with MVIWATA in Zanzibar (Binguni). This will be co-financed by C-STDP.

355. At the District level, under the chairmanship of the DED and the facilitation of the DALFO, District dairy multi-stakeholder platforms involving delegates from local MSPs and representatives of the various value chain actors (yearly meeting) and from the District authorities will be formed to ensure a broad participation of all the dairy stakeholders in the planning and review of the project activities. The project will encourage the emergence of 75 local multi-stakeholder platforms (MSP) to develop marketing opportunities at a cluster level that also comprise existing dairy hubs: clusters will be established at the level of one to three MCCs in average at the division/ward/shehia scale (in order to enable each platform to operate with very low operational cost). This meeting will be organized early enough for their contribution to be considered in the establishment of AWPB. Facilitation of cluster and districts platforms, as well as facilitation of the MSPs exchanges, will be entrusted to the same service provider as for support to cooperative and facilitation of productive alliance. The organization of the District MSP meeting will be organized by the DALFO in relation with the planning of the AWPB for their recommendations be transmitted in due time to the PCO for consolidation.

356. In **Uganda,** DDA facilitates dairy platforms at national and regional levels, which the Programme will build on.

8.1.1.2 Activity 1.1.2 Launch awareness campaigns on nutritional benefits of milk and food safety aspects.

357. Support to milk consumption and nutrition awareness, accompanied by nutrition education and social behaviour change, aims at improving nutritionally vulnerable group's consumption of milk, therefore enhancing their individual's health and climate resilience. The Programme will support milk consumption and nutrition awareness through increased availability, accessibility, affordability, and consumption of high-quality and safe dairy products, accompanied by nutrition education and social behaviour change and communication (SBCC) to improve their consumption amongst nutritionally vulnerable groups. The activity will be implemented by the various EEs, through (i) SDLD, KDB in Kenya;(ii) RNDP and SPIU/RAB in Rwanda; (iii) TDB and TFNC in Tanzania; (iv) DDA, together with the Ministry of Health (MoH), Ministry of Education and Sports (MoES) and recruited service providers, in Uganda.

Textbox 4: Aspects of a Social Behaviour Change Campaign (adapted from RDDP-2 Project Design Report, IFAD/Government of Rwanda)

Social and Behaviour Change Campaigns (SBCC) are a means to influence households and decision makers to change their behavior towards positive consumption patterns, targeting all audiences and thereby improving both access to and demand for targeted high quality and safety dairy products among smallholder farmer families, different value chain actors and businesses, including consumers (e.g., schools). A key message should be developed, which incorporates perspectives like: '*Caring for the members of your household starts with providing better nutrition to all*'; '*A healthy meal for all is possible if you use the resources that are at hand*' and '*Consuming more milk and dairy is good for all*', incorporating aspects of the importance of dietary diversity and the importance of safety and quality control during milk collection and transport; targeting all stakeholders across the value chain, including producers, processors and consumers. The campaign will seek to modify the current behaviors of the audience and promote the adoption of new behaviors while combining multiple SBCC approaches that resonate across the different audience segments with targeted messages. These approaches will include: i) interpersonal approaches: counselling, education, and support groups; ii) media: mass media, small print media, traditional media, social media, mobile technology and, iii) community mobilization campaigns. The campaign will also employ opportunities, approaches, and entry points to both identify and regularly reach small-holder farmers and households with messages, as well as to connect them with the identified access components of the Project. Entry points should use existing delivery structures with the government, existing service delivery models such as partnerships that have already organized farmers into farmers groups and are providing services. Finally, the campaign will aim to advocate and engage with small-medium dairy businesses to support increased demand and consumption of dairy in the country.

The following activities will be developed:

(1) Social behaviour communication change strategy: The Programme will develop a SBCC strategy and carry out a thorough analysis to better understand people's norms and values, what motivates and hinders them to change their dietary habits, the information to which they are receptive, and the skills needed to act on nutrition messages. This will be supported by a Nutrition Specialist (Nutrition education and SBCC). The Project will then identify and engage a service provider to implement a Social Behavioral change campaign.

(2) Nutrition Education and SBCC materials created. A range of mediums and instruments can be deployed to instigate behavior change such as pictures, info-graphics, audio and text messaging, small-scale dairy processing demonstrations, discussion groups, and/or video as well as participatory hands-on activities. The materials will be created based on SBCC strategy. Various existing materials will be reviewed and adapted for Project's context and needs. Additional materials will be developed using various communication tools that are suitable for different audiences (small-holder farmers, SMEs, processors and collectors, schools and general public). The materials will be disseminated through different channels and networks. Innovative ICT technologies (radio, mobile applications and etc.) will be utilized as much as possible to ensure cost effective outreach.

(3) Nutrition education and SBCC through agriculture extension services. In an effort to ensure that agricultural production and household income increases contribute to improved nutrition, activities will focus on raising awareness for dietary diversity and nutrition among farming communities, especially women of reproductive age, youth, and school children. To create demand and instill value for an overall balanced diet with special emphasis on dairy products and their nutritional value, the Programme will provide nutrition training to agriculture extension service staff, as well as a training of trainers module on nutrition. The Nutrition specialist will work closely with nutrition teams at various levels and is responsible to calibrate the extension messages with the training of village/field staff and of extension staff. Agriculture extension officers will be capacitated to conduct nutrition sessions for small-holder farmers using existing community platforms like L-FFS. Agricultural and health extension agents will work in teams to promote enhanced dairy production and nutrition knowledge to farmers. Nutrition sessions by extension officers needs to be focused on behavioural change towards better quality of dairy production and improved dietary intake of dairy as part of healthy diets. The extension sessions should not solely focus on transfer of knowledge, but also include ample attention for skills and attitudes. The trainings should include attention to extension methods and communication skills.

(4) Nutrition education and SBCC for value chain actors. The Programme will carry out nutrition trainings to MCCs/MCPs on importance of safe handling of dairy, quality assurance of dairy, nutritional, economic, and social benefits of dairy. The support will also focus on improving the capacity of food safety and value chain actors to adhere to standards and regulations on best practice. The trainings will be carried out by project field staff supported by agriculture extension agents. Simple training modules and messages will be created.

(5) Nutrition education and SBCC through GALS. As it is imperative to expose children at a young age to a varied diet so that their taste buds will not hamper them from trying new foods later on in life, complementary feeding practices and school meals can offer a good entry-point if complemented by appropriate nutrition education and SBCC interventions. Pregnant and lactating women are an important group to target (to consume larger quantities of nutrient-rich foods), young mothers to prepare complementary foods including locally available fruits and vegetables, and adolescent girls (encouraging the consumption of iron-rich foods, considering plant-based alternatives to animal products as many girls are said to be vegetarian). A module for delivering nutrition education and SBCC as part of GALS will be developed. The nutrition messages and information will be designed with culturally appropriate messages and images targeting the pregnant and lactating women with children under five years of age. Their key messages focus on: 1) the importance and benefits of animal-source foods and milk consumption; 2) the appropriate quantities of animal-source foods and cow's milk to be consumed by pregnant and lactating women and young children; 3) the appropriate time to introduce cow's milk and animal-source foods to young children; 4) recognizing cow's milk allergy or animal-source food intolerance symptoms and treatment; and 5) the importance of hygiene, food safety and storage of fresh milk. Key messages will be developed with a gender sensitive lens that promotes the inclusion of mothers, fathers and care-givers in the initiative and ensure that interhousehold food distribution, women time burden is also considered and discussed during nutrition sessions in GALS.

358. Sub-activity 1.1.2.1 Public awareness on the contribution of milk to nutrition and resilience, with focus on climate vulnerable population. The awareness raising will also use various community platforms such as agriculture extension, L-FFS, training of MCC to ensure that milk and dairy products are safe and of high nutritional quality. Topics will include the improved milk treatment and nutritional benefits of pasteurized and processed milk and dairy products. In **Rwanda,** awareness creation includes the participation in dairy fairs/expos under the auspices of RNDP at provincial level to showcase and promote climate-friendly and energy efficient local processing and consumption of milk and dairy products. In **Tanzania** and **Uganda**, the Programme will scale up school milk programs for improved nutrition of vulnerable children and promotion of dairy products.

359. *Sub-activity 1.1.2.2 Build capacity on dairy inspection to ensure milk quality and safety and reduce waste*. Dairy inspection is essential for overall (large scale) milk quality and safety increase, thus having impact on market development and on the reduction of milk rejection and waste (less GHG emission intensities). The Programme will provide technical training and equipment to strengthen their capacities to ensure development and enforcement of milk quality and safety standards. In **Tanzania**, milk inspection and control is undertaken by TDB and Tanzanian Bureau of Standards (TBS) and in Zanzibar, by the Zanzibar Bureau of Standards (ZBS) and SDLD/MAINL. The Livestock Training Agency (LITA) provides training at Diploma and Certificate levels for Animal Health and Production technicians but has no curriculum for dairy technologists. The Programme will support LITA to develop a new specialized curriculum, training of trainers, and roll out the training programme of dairy technologists. The Programme will also sponsor the first three cohorts of graduates, including students from Zanzibar, for them to gain appropriate qualifications. Milk quality and safety will be core to the curriculum. Graduates will play an important role in dairy market development and in the reduction of milk rejection and waste (less GHG emission intensities).

8.1.1.3 Activity 1.1.3 Improve land tenure security and management for sustainable dairy farming.

360. The Programme will adopt a fit-for-purpose approach to identify and mitigate tenure risks, which are key barriers to sustainability, and adoption of climate resilient and low carbon practices. In **Kenya, Tanzania and Uganda,** the main risk for intensive/zero-grazing is tenure insecurity, i.e. occupancy rights or land ownership. Activities to mitigate this risk will vary depending on the type of land and type of governance. For open-range, pastoral and agro-pastoral systems, the activities will focus on the identification and protection of rangelands and on supporting participatory planning and management. In **Rwanda,** the land is all registered and individually owned. The focus will be on optimizing land production and productivity through land consolidation and land use planning. Activities will include capacity building and support to participatory planning processes to create capacities at the local level. The activity will be implemented by (i) National Land Commission (NLC) and County Governments in Kenya; (ii) the Districts/land registration centers, and specialized service providers in Rwanda; (iii) MLF, LGAs and national land use planning commission in Tanzania; and (iv) MAAIF, DLGs and in consultation with the Ministry of Land, Housing and Urban Development in Uganda.

361. *Sub-activity 1.1.3.1 Mapping of local tenure risks and preparation of training materials*. The Programme will mobilize specialized technical assistance to: (a) implement a rapid tenure governance capacity assessment, including a tenure risk assessment for the Programme target areas; (b) develop training material to increase local authorities' capacity to secure tenure rights for dairy production and the public's capacity to identify and secure legitimate tenure rights in accordance with the law. Each dairy production system's tenure risks in terms of access, use and security of land are identified and assessed based on the national tenure context. Appropriate mitigating strategies, dependent on the national legal and policy framework for land, on how the dairy policies frame land access for livestock, the type of land, and the type of governance, are identified.

362. *Sub-activity 1.1.3.2 Developing capacity on land tenure at decentralized level*. The focus will be on capacity building local authorities' capacity and raising the public's awareness of available options to incrementally increase tenure security; training of local authorities in target areas to secure tenure rights; and support to the development of public campaigns to increase the public's awareness of tools available to secure tenure rights.

8.1.2 Output 1.2 Improved service delivery to the dairy sector.

8.1.2.1 Activity 1.2.1 Strengthen veterinary services for better animal health, higher milk yields and reduced losses.

363. One of the key barriers to reduce GHG emissions and sustainably increase the productivity of dairy animals is animal health and farm level husbandry and welfare. Healthier animals are more productive, with less milk to be discarded, leading to a reduction of “unproductive” GHG emissions and greater incomes, providing incentives for farmers to adopt animal health and welfare measures. Climate change exacerbates the emergence and re-emergence of diseases and infestation (ECF, helminths infestation etc.) Healthier animals are also more resilient to climate hazards. To expand the outreach and capacity of veterinary services, the Programme will invest at local level in animal health support, while diagnostic capacity of veterinary laboratories at national and veterinary posts at local level will be strengthened. The activity will be implemented by: (i) Kenya Veterinary Board and KALRO in Kenya; (ii) RAB, District (Local government) veterinary extension services, and the Rwanda Council of Veterinary Doctors (RCVD) in Rwanda; (iii) DVS and Tanzania Veterinary Laboratory Agency (TVLA) in Tanzania; (iv) MAAIF/DAR and NARO, in partnership with service providers in Uganda.

364. *Sub-activity 1.2.1.1 Support installation of both private and public veterinarians and veterinary paraprofessionals*. Having (para)vets visiting the farms of the rural poor is essential for early detection and response of communicable diseases and establishing a functional disease intelligence system. Women, working in last mile animal health services, go the extra mile and show ambition to improve their knowledge and skills to better serve the animal owners and remain with the community. The Programme will implement the animal health support and disease control system, based on the One Health approach. According to the national situation, the approach will have target three levels: (i) support private veterinarians and para-veterinarians, in particular young and women practitioners (at least 40% in each category); (ii) support livestock extension workers at local level; (iii) provide additional training to lead farmers from the L-FFS groups for coaching their peers and assist private para-veterinarians and livestock extension workers. In the Programme intervention area, these health workers will receive small start-up kits, as well as the required capacity building. Young animal health and welfare workers will receive support to install them as private practitioners.

365. In **Kenya**, the Programme will enhance veterinary education and training programs to both private and public veterinarians and veterinary paraprofessionals in the Programme area.

366. In **Rwanda,** the Project will support the training and installation of young veterinary doctors and veterinary technicians as private practitioners in order to create jobs and enhance accessibility of services under an economically sustainable model. 200 youths will be supported to establish private businesses, either individually or as a group. It is expected that veterinary technicians will also deliver AI services as it will increase their business volume and profitability. Priority will be given to the private veterinarians contracted by the Government in the scope of the Sanitary Mandate arrangement through which Public Veterinary Services will delegate implementation of some Veterinary Public Health (VPH) duties to contracted private vets to bridge the gap occasioned by low ratio of public veterinary officers to livestock population. The Project’s support will be provided through the Rwanda Council of Veterinary Doctors (RCVD) and will consist in training (in veterinary public health for beneficiaries of sanitary mandate, in clinical care and AI for all), and provision of start-up kits for both AI and surgery. To finance their additional initial needed investment (motorcycle, office installation, equipment), most of the veterinary practitioners may not be able to meet the collateral and other requirements set by financial service providers.

367. To reduce the financial burden on public services, and thus strengthen durability, two strategic directions will be explored (i) Supporting cost sharing mechanisms, mostly with producers, but also possibly by the private sector which could benefit from a direct return on investment if involved in subsidizing some services; and (ii) Delegating as much as possible services with a market potential (AI, veterinary care) to the private sector. private veterinary services can become sustainable if the following conditions are fulfilled: (i) the farmers are engaged in commercial value chain that allows them to get cash incomes to pay for the services; (ii) the regulatory framework is conducive to privatization of services, and is enforced to avoid for instance unfair competition from public service providers; and (iii) private service providers have access to sustainable financing mechanisms to finance their investments. The project will also provide additional training to lead farmers from the L-FFS groups for coaching their peers and assist private para-veterinarians to LEWs in analysing and advising management goas with farmers and support existing agri-businesses that provide farmers with veterinary services, inputs, and finance to scale their reach and strengthen their approaches. The approach on dairy farming is based on the FAO methodology tailored to the Rwandan context during RDDP. The activities will be co-financed by RDDP-2.

368. In **Tanzania**, the public services is understaffed and under-resourced and the private service very small. Extension and veterinary services for poor farmers is for the most part currently provided via public LEWs (diploma or certificate level), with a limited staff coverage (60 per cent), little mobility and limited proper equipment. Concepts for animal health services that have worked in other countries such as CAHW and agrovets (CAVE model), are not legal in Tanzania and Tanzania also is a country with large distances between farmers/villages, making it more difficult to economically sustain a private (para)vet. Only vets and paravets that are registered at the Veterinary Council can practice these professions and this has advantages for the public responsibilities for TADs, food safety and One Health. However, the public services would need to be too large to perform all public and private services. Enabling the establishment of private paravets can be encouraged. Private (para)vets will have to join in vaccination campaigns, surveillance data sharing, food safety inspections, and also extension and dairy management advise to avoid and prevent diseases. This is common practice in HICs with developed private services, but requires a policy review in Tanzania.

369. The privatisation of (para) vets will be supported under the Programme, in a phased way. In other LMICs such as Mali, Indonesia, Ethiopia and Paraguay, private entities are partnering with the public veterinary services. The World Organisation for Animal Health (WOAH) has developed guidelines for PPPs in the veterinary domain. In Tanzania, the NGO Land' O Lakes is implementing a Paraveterinary privatization project. Guided by lessons learned from other countries and the LoL project and based on an economic feasibility map, the project will first pilot and scale up the privatisation process.

370. For the privatization of animal health care, a policy review will be carried out. Combined or separate from this review, an animal health care privatization feasibility study will be undertaken by an international consultant, recruited by the PCO, in order to prepare the ground for the phased privatisation of (para) vets in the project area of intervention. In some selected areas a privatization programme will start. The project will recruit a local consultant /NGO to lead, coordinate and monitor the privatisation of paravets. In selected project areas, candidates are selected to be trained and subsidized to become private para-veterinarians. In groups of 15, ninety para-veterinarians per year for three years (270 in total) receive training in business and dairy management. The dairy management modules are the same ones LEWs receive via L-FFS. The business modules and candidates training providers are identified and proposed by the consultant performing the privatization feasibility study. The project will provide the paravets with a recognized business training (identified by the international consultant) and a second training on dairy management and coaching training, which is the same training as the public counterparts receive. The private paravets need to pass both training exams to become certified to benefit from a subsidized start and access to credit. The candidates will be equipped in the same way as the LEWs and additionally are provided with access to credit (see below). The private paravets will initially be subsidized by offering bundled services identified and proposed by the international consultant and dairy management extension provision. The subsidy will decline each year for four years. This phased privatisation programme will be closely monitored and guided by a local recruit (individual or NGO).

371. At mid-term the privatization process, coverage and quality of the animal health care services will be reviewed and options explored to further scale up the private component of the veterinary services domain. To make sure that animal health care also includes dairy management advice and coaching, both the LEWs and private paravets will work with L-FFS lead farmers that have been selected and trained to become dairy management coaches in collaboration with the ward LEW or private (para)vet. LEWs, paravets and lead farmer coaches. After being researched, a second scaling up will become part of the public/private livestock extension infrastructure. Coaching and training is considered a private activity paid by the farmer group or farmer coops/hub or aggregator, but initially the lead farmers will be subsidized. This sub activity will involve 500 LEWS/paravets and app. 2 500 lead farmers and at least 25 000 farmers will receive coaching, separately from those receiving extension services in Activity 1.2.2. below.

372. Strengthening the public outreach will also be supported. The GoT is responsible for the staffing of wards/shebia in the project areas with public LEWs. The project will provide the LEWs with the master training on L-FSS, working gear, extension kits (including a kit to perform California mastitis test for early detection of mastitis and a tablet to digitalise the disease surveillance system), pen side kits for surveillance and informed cow therapies, a motorbike and fuel coupons and a dairy management coaching training. In the first part of the project, the LEWs will provide animal health care to farmers (which is a private good thus recovering costs, but their salaries paid by the GoT) and perform public services (such as disease reporting, vaccination campaigns, etc.). They will also contribute to project services, such as providing L-FFS training. The animal health care role of some of the LEWs may alter during the project depending on the outcomes of a privatization feasibility study and policy review. To promote and support last mile animal health and extension services, private male and female (paravets) will be incentivized and facilitated e.g. through access to credit to offer bundled services in areas that can economically sustain private animal health care, including through the hub system. This innovative model will be documented and eventually scaled up.

373. In **Uganda**, the Programme will build capacity of veterinarians and para-veterinarian technicians (including private animal health workers), and CAHWs on One Health principles, disease diagnosis, emerging and re-emerging diseases because of climate change (anthrax, bovine tuberculosis, brucellosis, FMD, CBPP, lumpy skin disease, helminths infestations). District veterinarians (n=146) will receive a desktop and an IT and short epidemiology training. For this training, an international expert will be recruited by the PMU. All Subcounty (para)vets will receive a tablet with software and IT training. For logistical and efficiency purposes, a kit will be provided together with the IT equipment to the Sc (para)vets and the use of the kit trained in combination with the IT training. New recruits by the GoU will receive a refresher course. The combined training and refresher course will be developed and provided by MAAIF and NARO/University of Makerere.

374. Two arrangements for the sustainable delivery of private veterinary services will be supported by the project. Community-based animal health services (CAHWs model) will be facilitated, based on pilots carried out by international NGOs experienced with this model in the context of smallholder and (agro)pastoral production systems (e.g. VSFB and Heifer International), and followed by a scale up in relevant parts of the project area. Elsewhere, the project will support the privatisation of (para) veterinarians. Following a feasibility study, candidates will be selected to receive business development training and a postgraduate course in best practices (including in climate and environment and One Health), tailored to the services that the target groups will need. The CAHWs and private (para) veterinarians will be given access to finance to establish themselves in the project area. CAHWs, interested and selected in becoming paravets, will be supported.

375. One Health workshop and meetings will be organized between MAAIF/DAR, the Ministry of Health, and the PMU. Relevant experts in national institutes, other ministries and (inter) national experts will take part in the Workshops. The meetings will have One Health themes, One Health integration and action goals, targets, outcomes and progress evaluations. This is checked and monitored (and if necessary corrected) by the organizers and the PMU. From the meetings, thematic Task Forces can be formed that involve staff and experts across the agencies/ departments, etc..The results feed back into the WSs/meetings. Pulling political and policy weight (lobbying) and dissemination of the issues and outcomes is an important task of the One Health WSs/meetings.

376. *Sub-activity 1.2.1.2. Strengthening diagnostic capacity of veterinary laboratories and capacity to test quality of animal feed.* In each country, the Programme will: (i) enhance the capacity to undertake feed testing in the national research institutions (KALRO in Kenya, RAB and the University of Rwanda, Faculty of Veterinary Medicine and Animal Sciences (UR-CAVM) in Rwanda, TALIRI in Tanzania and NARO in Uganda,); this includes the necessary equipment, training of researchers, and inputs for testing feed samples; (ii) undertake on-farm feed sampling and laboratory quality testing (e.g., dry matter, carbohydrates, protein, fat, minerals, vitamins).

377. In **Kenya**, the Programme will improve disease control (surveillance and monitoring, contingency planning and treatment) of targeted diseases (ECF, Rift Valley fever, RVF, etc) including modern diagnostic equipment/technologies in regional centres (located in Nairobi i.e. Kabete and Embakasi, Nakuru, Kericho, Eldoret, Karatina, Garissa and Mariakani), testing kits, telemedicine. In Rwanda, the Programme will strengthen 4 satellite laboratories, and provide them with additional equipment in serology (ELISA) and molecular diagnosis (PCR) to enable rapid detection of infectious diseases, equip them for handling biological waste, and support the establishment of environmentally friendly practices. The Programme may also strengthen the national veterinary laboratory (NVL) to be able to handle advanced diagnostic capacity for viral diseases affecting livestock. Testing will be done in the national research organization, KALRO.

378. In **Tanzania**, the Tanzanian Veterinary Laboratories Agency (TVLA) is one of Tanzania's ten zonal veterinary laboratories and is not yet fully equipped. A high percentage of samples received by the laboratory in Iringa is even rejected due to poor sampling or conservation caused by poor transport and connectivity. In Zanzibar, the same situation prevails whereby the existing Central Veterinary Investigation Laboratories are not fully functioning. Coordinated under the national research organisation, TALIRI, the Programme will finance a feasibility study on laboratory infrastructure and capacity to determine whether additional zonal/regional laboratories will be strengthened/established. The Programme will (a) strengthen the laboratories; (b) establish district mobile laboratories that will serve the LEWs /or (para)vets at local level; (c) train laboratory technicians for each mobile laboratory. In Uganda, veterinary laboratories will be strengthened (equipment, reagents, consumables for sample collection and mobile laboratory facility) for detection of the diseases related to climate change. Re-establishment of the laboratory infrastructure will therefore follow a bottom-up approach, from Subcounty level (pensite kits and tablets) and re-establishing district veterinary investment laboratories to biosafety level 1. Existing regional laboratories will be upgraded from level 1 to level 2. More advanced laboratories, biosafety level 3 and beyond can be left to other projects (e.g. Fleming Fund, Pandemic Fund). It will also establish a national data management system on emerging and re-emerging diseases because of climate change (TAD and zoonosis).

379. **Uganda**. The PMU will hire a veterinary laboratory expert to do a feasibility study. District veterinary laboratories (41 in total) in the project area will be re-established to level one biosafety labs in the first two years of the project (two batches). The district veterinarians will receive a refresher course of 2.5 days, also in two batches (maximum number of trainees per course = 21). The course will include the importance of laboratory confirmation of clinical diagnoses, biosafety, how to perform the tests and prescribe suitable treatments. The course can be developed and provided by national experts. Three regional laboratories will be upgraded to level 2 biosafety labs in year two. Consumables for the district and regional labs are provided by the project. The regional laboratory veterinarians will be trained on site or together in one of the three upgraded laboratories by an (inter)national expert for two weeks. After the training a follow up on site is provided within three months. An electronic laboratory information system, a sample package and transport system, and a laboratory waste management system (including incineration) are developed. The feasibility study will provide plans for these and for the packaging and transport system of specimen. Fuel and sample package coupons will be provided by the project. This activity will be co-financed by the ReLIV Project.

380. In **Rwanda,** the programme will upgrade four satellite laboratories rehabilitated under RDDP which have good infrastructure and basic diagnosis capabilities, to (i) provide them with additional equipment in serology (ELISA) and molecular diagnosis (PCR) to enable rapid detection of infectious diseases, as illustrated during the recent RVF outbreak; (ii) equip them for handling biological waste; and (iii) support the establishment of environmentally friendly practices.

381. In **Tanzania**, the landscape is dispersed and samples for laboratories would be too few for local labs and too far for regional labs. Mobile laboratories at district level can bring the solution. Labs in converted buses or RVs are becoming more common. Tanzania is one of the six countries joining in the EU funded EAC Regional Network of Public Health Reference Laboratories for Communicable Diseases. Using mobile labs for detecting human pandemics (used for COVID-19). For the purpose of this Programme, the mobile labs need to perform several simple tests and store samples for more complex testing at the regional labs. Examples of simpler mobile labs could be the ones used for bringing education and science to remote schools in rural areas, e.g. Uganda has mobile teaching, operated by The African Science Truck Experience; or Labs in converted buses or RVs, which are becoming more common. An international expert on veterinary laboratory requirements and infrastructure will map the situation and recommend and further detail the lab infrastructure and capacity building plan for the project. Diagnostic capacity is made door-step as much as possible. The LEW/paravet will do pen side diagnostics if tests are available and affordable, esp. regarding production diseases such as mastitis and they take samples for further tests and deliver these samples to district mobile labs. On guidance of the study and depending on the size and farm and animal density of the district, project area districts will have a mobile lab for common uncomplicated testing. Implementation will be phased by 5 mobile labs per year in four years (last year 7 adding to the total of 22 project districts). Per mobile lab one trained lab technician will operate the mobile lab. A training is developed for certificate or diploma level candidates and the trainee lab technicians need to pass this training successfully. The lab technicians are public staff and in the beginning most testing will be subsidized to encourage this new way of further clinical diagnoses and guidance for AMR stewardship and AMR monitoring. The consultancy report will identify which parts of the services can become privatized and at what time in the project.

382. An international expert on veterinary laboratory requirements and infrastructure will map the situation and recommend and further detail the lab infrastructure and capacity building plan for the project. Pen side tests and sampling equipment, mobile labs, lab supplies and equipment, and lab construction will all be procured in open contest. For the training development and provision of lab technicians, an experienced consultant or company will be internationally recruited with some experience in Africa, concerning veterinary diagnostic labs. The main sustainability risk for breeding related activities is the inadequate maintenance of the LN plant, which may lead to closure of operations. Tanzania has several LN plants that were installed but not maintained properly and are now out of order. This is why a feasibility study will be required before installing a new machine (or repairing the existing one) in Zanzibar, as the volume of activity and available skills may not be sufficient to ensure this sustainability. For the AI sub-center and LN plant to be installed in Southern Highlands, it will be critical to ensure that it is placed under the management of NAIC which has the necessary capacities to ensure the maintenance, and not under Government Breeding Farms as it was the case before. The activity will be co-financed with the C-SDTP.

8.1.2.2 Activity 1.2.2 Strengthen extension services for low-carbon and climate resilient dairy sector.

383. To reach out to dairy farmers, raise their awareness and build their capacity in the field of CC mitigation and adaptation, the Programme will adopt innovative extension models and tools (including digital), and enhance the capacity of extension services. This activity will involve improving delivery of public and private extension services delivered at farm and cooperative/ aggregation level by decentralized (district/county) livestock officers who coordinate the community-based extension system. The Programme will use the L-FFS approach to provide proximity advisory services to dairy farmers, which is popular and has proven effective in East Africa.

Textbox 5: Livestock Farmer Field School model (adapted from ReLIV and C-STDP Project Implementation Manuals)

Poor adoption of livestock production technologies can have multiple economic, social, political, environmental and organizational factors. Uptake results can be limited by a lack of knowledge and inadequate support, but also by failing to target local needs and conditions and empower livestock keepers. Only identifying the bottlenecks will not increase uptake. Landscaping and coordination of overcoming constraints and adapting to e.g. existing production systems, to design a fitted ‘model’ of knowledge, skills, inputs, service and market linkage, is necessary.

To strengthen farmers’ technical skills and enable the dissemination of best practices and technologies in feed/fodder, herd management, breeding, animal health, manure management at farm level, and rangeland management community-based training and extension mechanisms will be supported with a strong focus on climate change adaptation and mitigation. This will. support farmer-to-farmer extension services on climate smart practices, through L-FFS in mixed crop-livestock systems and pastoral field schools (PFS) in grazing and pastoralist systems (trainings of master trainers and facilitators), demo farms and social networking groups. The purpose of the FFS is to improve the decision-making capacity of participants and their wider communities and to stimulate local innovation. To support the sustainability and scale-up of the interventions, existing L-FFS/ PFS master trainers and facilitators will be trained to teach climate resilient dairy production; where these groups are not existing they will be set up. L-FFS and PFS is where groups of farmers learn through observation and experimentation in their own context, based on methods of adult education. This allows dairy farmers to improve their management skills and become knowledge experts on their own resource use practices.

FFS are an established international best practice to facilitate practical learning amongst peers, and sustainable in that a network of master trainers, facilitators and lead farmers is established to continue capacity building efforts. The approach also encourages experimentation and innovation through testing of best practices on own or lead farmer fields, as well as documenting and discussing the findings. Livestock FFS, build on the FFS methodology targeting livestock farmers. L-FFS has proven to be highly effective in empowering farmers, sharing knowledge and promoting uptake of new technologies. In Rwanda, for example, the L-FFS approach combined with household methodologies (GALS) has played a pivotal role in terms of capacity building of farmers, organization of groups, introduction of technologies in particular fodder cultivation, gender transformation and even market access.

The project will build on successful experiences from other projects. Pastoral-FFS (PFS) are also a model practiced widely in Ethiopia, Kenya and selected other locations. In Tanzania, ASSP and ASDP-L projects were effective in empowering farmers, sharing knowledge and promoting uptake of new technologies.

In Rwanda, L-FFS approach combined with social mobilization approaches (Heifer VBHCD) and household methodologies (e.g. GALS) under RDDP have played a pivotal role in terms of capacity building of farmers, organization of groups, introduction of technologies in particular fodder cultivation, community organization and even market access. the L-FFS impact assessment showed that animal productivity has increased significantly (+33 per cent) for L-FFS members, and 86 per cent of L-FFS beneficiaries now cultivate improved fodder. 50 L-FFS groups now manage MCPs and some are also involved in processing. The L-FFS approach on dairy farming is based on the FAO methodology but has been tailored to the Rwandan context during RDDP. It follows a phasing approach that is implemented over a 5-year period on average but can vary depending on groups. The first phase consists of strengthening the “natural capital” of farmers, by building their technical capacities in animal husbandry, animal welfare, fodder management, which increases milk production and productivity (+33 per cent productivity increase under RDDP) and fodder production.

In Uganda, L-FFS is implemented by FAO in the Cattle Corridor, and has been effective in empowering farmers, sharing knowledge and promoting uptake of new technologies.

Sustainability of an L-FFS groups is greatly enhanced by collective activities that they implement in parallel to the learning by doing process, such as credit & saving, or those that have initiated income generating activities together managing MCPs, milk processing, fodder and fodder seeds production, and sometimes other non-livestock related income generating activities such as collective farming. The primary objective of L-FFS will be to improve farm management practices and increase production, productivity and resilience of systems.

<u>Key steps to following will include</u>:

- Development/adoption of existing curriculum on climate smart dairy production to incorporate climate smart technologies. The curriculum will be developed by hiring an international expert on practical high-quality training of the complex aspects of climate smart and dairy health management.
- STEP 1: Training of master trainers, who will be selected among existing master trainers already trained by FAO for crop FFS.
- STEP 2: raining of facilitators by Master Trainers. The first generation of facilitators will be District Livestock extensionists, and the second and following generations will be farmer facilitators selected among the first generation of trainees.
- STEP 3: Facilitation of FFS.
- STEP 4: Improving the “social and human capital” by empowering L-FFS groups to transform into self-help groups and later cooperatives, transforming gender relations, improving nutrition and increasing awareness on climate change adaptation and mitigation. The last graduation step targets strengthening the “economic and financial capital” and consists in supporting access to market and financial services, as well as income generating activities (such as processing, milk aggregation, fodder or seeds production).

The main topics for L-FFS will be fodder production and conservation to ensure that: (i) fodder and food crops are not in competition but rather complement each other through adequate intercropping and crop association between fodder (especially legumes, fodder trees, etc.) and food crops, and valorisation of crop residues for cattle feeding; and (ii) fodder varieties and practices contribute to climate resilience (utilisation of drought-resistant varieties, introduction of fodder conservation techniques, composting and manure management, etc.). The L-FFS will also put emphasis on milk quality and hygiene at farm level, including milking hygiene and control of mastitis, to improve productivity and food safety. Animal welfare is an important issue because of impact on productivity and health, market implications (need to comply with World Organization for Animal Health guidelines for international trade) and societal concerns. The zero-grazing system has some implications on animal welfare, and the L-FFS curriculum will include guidelines to improve living conditions of animals kept in zero grazing systems, including appropriate cowshed standards and good practices such as daily outdoor walk.

384. The support for farmer-to-farmer extension services on climate-smart practices, through L-FFS in mixed crop-livestock systems and pastoralist field schools (PFS) in grazing and pastoralist systems. This activity will be implemented through: (i) KALRO and SDLD in Kenya; (ii) by RDDP-2, RAB and REMA in Rwanda; (iii) by MLF and the LGAs in Tanzania; (iv) MAAIF (Directorate of Agriculture Extension Servi–e - DAES), NARO and MWE (UNMA), in partnership with service providers in Uganda. International technical assistance will be provided by ILRI and FAO.

385. *Sub-activity 1.2.2.1. Preparation of training modules for extension in climate mitigation and adaptation measures.* If required, specific topics that are part of the proposed pathways under Outputs 2.2 and 2.3 and related to climate change will be added to the modules of the L-FFS (or other extension approaches). The topics in the training modules related to climate-smart milk production and handling could include: fodder production, harvesting and conservation, use of conserved silage and urea-molasses multi-nutrient blocks (UMMB), supplementation (use of non-conventional feed resources e.g. sweet potato vines or tannin-rich plants reducing and inhibiting CH_4 production) reproductive management, health management including One-Health aspects and management of anti-microbials, biogas and manure management, use of drought-resistant fodder, application of crop residues, seed production (certification, traceability, quality control), improved diet formulation to reduce emission intensities (use of feed formulation software, such as the innovative SNV-developed Rumen8® tool), and animal welfare, including housing in zero-grazing practices. Guidelines will be prepared on improved fodder cultivar and climate-smart technologies, innovations and management practices (TIMPs) for pasture and fodder production, and agroforestry practices (such as establishment of leguminous fodder trees as standalone or line trees). Content must be gender-targeted, for example related to animal husbandry and hygiene, and basic disease identification and protocols. The L-FFS modules will be developed with the support of national or international technical assistance. Also, gender-inclusive training on the implementation of guidelines will be carried out.

386. In Rwanda, RDDP-2 will build on this methodology and will implement it in a differentiated manner in the RDDP areas and in the new districts. successful pilot RDDP conducted in Musanze with scaling-up. Village-based Livestock promoters will be trained, initially in the existing RDDP districts, in collaboration with RAB. RDDP will prepare a Policy Note that supports this scaling-up. At the end of the 5-year graduation process, L-FFS groups that managed to be transformed into cooperatives (whether involved in milk processing and/or marketing, or fodder production) will become autonomous, self-sufficient and independent that won't require any further support. Groups that will have not yet achieved this transformation will continue to be supported by the districts. The activity will be co-financed by RDDP-2.

387. In **Tanzania**, the project will first focus on the adoption of existing curriculum on climate smart dairy production, and training of master trainers, who will then train the facilitators. Furthermore, the project will review the existing curriculum to incorporate climate smart technologies in dairy sector, based on existing FSS curricula for crops already in use in the country, and building on the dairy L-FFS curriculum developed in Rwanda under RDDP, successfully tested and improved over the 6 years of implementation. The curriculum will be developed by hiring an international expert on practical high-quality training of the complex aspects of climate smart and dairy health management.

388. In **Uganda**, L-FFS and PFS will be implemented by District through their extension officers (preferably livestock specialists, but could be crop specialists in case of unavailability). They will be in charge of coordinating the process at local level, facilitate the first generation of L-FFS, and provide support to the second generation facilitated by farmer facilitators. FAO will be engaged to provide support for the development of the training curriculum, train the master trainers, coordinate the training of facilitators by master trainers, and provide continuous follow up and backstopping during implementation. An MoU with FAO will be entered into at the beginning of the project. L-FFS sustainability will be greatly enhanced by collective activities that groups will implement in parallel to the learning by doing processes, such as credit & saving, or income generating activities such as managing MCPs, milk processing, fodder and fodder seeds production, and sometimes other non-livestock related income generating activities such as collective farming. It is expected that some of the FFS/PFS groups graduate to a more formal and income oriented type of organization, and become economically sustainable through this transformation. The activity will be co-financed by ReLIV.

389. *Sub-activity 1.2.2.2 Training of master trainers (ToTs) and facilitators of extension systems in climate-change related topics*. The Programme will support the strengthening of existing L-FFS and the establishment of new L-FFS (aim at 40 percent women and 30 percent youth). To support the sustainability and scaling up of the L-FFS, existing L-FFS/ PFS master trainers and facilitators will be trained on the specific topics mentioned above and on inclusive approaches in extension service planning and provision, while paying attention to equitable distribution of profits within households. In **Rwanda,** the first generation of facilitators will be District Livestock extensionists, and the second and following generations will be farmer facilitators selected among the first generation of trainees. Facilitators will be recruited and trained to support these groups. New L-FFS facilitators will be trained in Y1 by the already existing master trainers. Each of them will take responsibility of 2 groups of 25 members in average. Facilitators will be incentivized (cash monthly allowances) by the Project for 5 years; after this period, the group should be autonomous. New L-FFS groups will also be provided with learning inputs including fodder seeds, planting material, and equipment for seeds processing and fodder conservation. The activity will be co-financed by RDDP-2.

390. In **Tanzania,** master trainers to be trained will be selected among existing master trainers already trained by FAO for crop FFS. Master trainers will then train the 1,160 facilitators. The first generation of facilitators will be District Livestock extensionists, and the second and following generations will be farmer facilitators selected among the first generation of trainees. this activity will be implemented by District through their extension officers (preferably livestock specialists, but could be crop specialists case of unavailability). They will be in charge of coordinating the process at the level of their ward, facilitate the first generation of L-FFS, and provide support to the second generation facilitated by farmer facilitators. FAO will be engaged to provide support for the development of the dairy curriculum, train the master trainers, coordinate the training of facilitators by master trainers, and provide continuous follow up and backstopping during implementation. An MoU with FAO will be entered into at the beginning of the project. The activity be co-financed by the C-STDP. In **Uganda** the project will be co-financed by ReLIV.

391. *Sub-activity 1.2.2.3 Promote innovative extension tools*. These innovative extension tools will include: (i) the use of participatory extension approaches, such as the Participatory Integrated Climate Services for Agriculture (PICSA) which has been piloted in Kenya, Rwanda and Tanzania, (ii) the use of e-extension tools by using bulk SMS and internet to reach more farmers, provide highly captivating and interactive packages, partner with other stakeholders in development of content and capacity and to improve ability to access and share knowledge and skills on farming technologies, (iii) use of, TV, radio and social media networks. In addition, other innovative extension tools could include: in **Kenya**, the use of the agro-weather platform namely Kenya Agricultural Observatory Platform (KAOP), a digital platform developed through a joint initiative between the KALRO and the KMD, designed to provide weather information to support decision-making in the agricultural sector in Kenya to develop capacity of extension officers and producers on climate change adaptability as per the newly redefined agro-ecological zones. In **Tanzania**, iCow app and or other innovative extension tool will be developed and promoted. In **Rwanda** digital agriculture solutions such as the *smart-nkunganire* system provides services (among other services) to farmers.

8.1.3 Output 1.3: Improved GHG MRV capacities & monitoring of climate vulnerabilities

392. To reliably track progress of the ambitious climate goals of the countries highlighted in their NDCs, state-of-the-art systems of Measurement, Reporting and Verification (MRV) of GHG emissions reductions are needed within the participating countries, along with enhancing the local capacity to implement such systems, more particularly in the livestock sector. This output will enable countries to report with accuracy on emissions in the dairy sub-sector in their national GHG inventories at Tier 2 level, and address the institutional, planning and knowledge barriers identified in the ToC. It will also unable countries to capture the impact of investments in dairy on GHG emissions in their Nationally Determined Contribution and therefore contribute to their climate commitments. Improved MRV systems will ensure that participating countries can sustainably conduct their own GHG calculations with cutting-edge methods, develop their own mitigation pathways and policies, and attract more public and private climate finance (including through carbon credits). In addition to GHG emissions reporting, this output will also address the issues related to the data for climate vulnerability assessment and national feed balances, all contributing to improved climate resilience. The National Research Centres and Government Institutions will receive implementation support from ILRI (Mazingira Centre, Nairobi) to execute the activities 1.3.1 and 1.3.2.

8.1.3.1 Activity 1.3.1: Develop capacity in the country on MRV system.

393. The programme will identify critical capacity needs at national and local levels to improve the operation of MRV systems. This will help developing consistent MRV systems for the dairy sub-sector that allows systematic updates, so that the impact of interventions of the Programme (and beyond) can be monitored over time, and progress can be assessed against an established baseline. Proposed sub-activities include:

394. Sub-activity 1.3.1.1 Capacity assessment and development of public and private sector in capturing, recording, tracking and reporting data on dairy GHG emissions. This sub-activity will carry out in depth capacity assessments of existing MRV tools and frameworks in the four countries, and the place of dairy in them. Based on the assessments, capacity development will be provided to design activity data questionnaires for Tier 2 and/or Tier 3 GHG emissions in dairy (e.g. animal numbers, weights, productivity, feed rations, animal health interventions, manure management and grassland management) and develop a data management system to ensure reliable flow of information between the various national and local agencies involved in the MRV system. Countries will receive capacity development on data collection protocols adjusted to their needs to relevant stakeholders (technicians, university staff, staff of national research organizations, and ministries, students, and other relevant actors). ILRI will provide dedicated digital data collection tools (e.g. ODK), data quality control, and calculation of GHG emissions for inventory reporting, following established protocols.

395. Sub-activity 1.3.1.2: Developing MRV systems and engage in policy dialogue to align with national MRV for the Livestock sub-sector. After assessment of national MRV systems, this intervention will include baseline, measurement of individual mitigation activities, impact assessment on absolute emissions and emission intensities and institutional arrangements. To ensure sustainability and impact at scale, the sub-activity will finance the update of national livestock census questionnaires to include activity data requirements for GHG inventories outlined by IPCC on other cattle and livestock needs. This will allow countries to track livestock productivity and to report on enteric CH_4 and manure CH_4 and N_2O emissions, as well as soil carbon storage, following international inventory guidelines, using IPCC Tier 2 methodology. In **Kenya**, an adaptation tracking tool for the Livestock sub-sector NDC will be developed. In **Rwanda,** and MRV system will be developed for the Livestock sub-sector to tract the NDC and measure emissions In **Tanzania,** a livestock MRV system is being developed with FAO support. The system will be strengthened with digital tools to collect on-farm activity data and practices to monitor methane emissions reductions at farm level. In **Uganda,** a study (Kiggundu et al 2029) on greenhouse gas emissions from Zebu weaner bulls showed that existing (Tier 2) models overestimate Uganda's emissions. Research will be undertaken to develop localized GHG parameters (such as methane emission coefficients) tailored to the national herd, including various livestock species, to enhance the accuracy of greenhouse gas (GHG) monitoring and reporting. By using collected activity data and Tier 2 EF generated, project results will inform the national MRV system.

Textbox 6: MRV of soil carbon storage under improved grassland management under DaIMA

Background. Grasslands cover most of the land of the four project member countries and are considered to be significant carbon sinks, capable of offsetting some of the livestock GHG emissions. However, considerable uncertainty remains about the actual carbon sequestration potential of East Africa's grasslands. Most estimates of SOC sequestration potential are based on models, and questions remain regarding model validity for tropical grasslands as well as the quality of the input data. Furthermore, most SOC models still rely on the old "humus paradigm", assuming that most organic carbon is stored long-term in the form of a substance called "humus", which was considered resistant to microbial breakdown (Schmidt et al. 2011). However, recent research has shown that SOC is stabilized by microbial processes and formation of organo-mineral complexes, which has led to a "scientific revolution" in soil science where the old models are no longer viewed as accurate, but we have yet to completely replace them (Popkin 2021). Finally, estimates of potential SOC sequestration rely on data from experiments and observations conducted in the past 20-50 years, but these experiments do not reflect the increasing severity and frequency of climatic extremes. For East Africa, grassland productivity and with that ecosystem carbon uptake will largely be restricted by recurring droughts, which will most likely reduce the potential for SOC sequestration. At best it is possible to prevent loss of additional SOC by preventing grassland degradation and ensuring long-term sustainability and drought resilience of management plans. However, there are scenarios where sequestration of additional carbon is possible, namely by restoring degraded grasslands and increasing SOC stocks. Whether this will be possible at large scale remains to be seen.

Action from DaIMA under activity 1.3.1. DaIMA, in partnership with ILRI, will support the member countries in monitoring existing SOC stocks via targeted soil sampling campaigns, comparing different grassland management practices and degradation status along pedoclimatic gradients across the four countries. The Programme will inform on impacts of grassland management on soil carbon storage and sequestration in line with *Activity 1.3.1*. Furthermore, DaIMA will contribute to the development and validation of new process-based SOC models to ensure their applicability in tropical climates. In addition, to be able to cover large areas of extensive grazing systems, the Programme will contribute to the development and validation of novel remote sensing approaches for rangeland monitoring via drones and satellites. This also includes application of modern techniques such as Eddy Covariance (EC) towers for landscape-scale monitoring of ecosystem carbon exchange to show if the ecosystem is a carbon sink or source, and how carbon uptake and release are affected by seasonality, climatic extremes, and management. ILRI has two EC towers set up in their Kapiti research station (Merbold et al. 2023) (see picture below), and the findings on carbon uptake and release from these towers are relevant for the extensive livestock systems that are a component of the IFAD/GCF project. The generated data and evidence will help to improve and support MRV of grassland soil carbon for carbon finance schemes by validating existing and novel tools for grassland monitoring and soil carbon modelling to ensure their applicability for grasslands in the four member countries. Furthermore, DaIMA will develop protocols for data collection that can be used by national governments and rangeland managers for monitoring of grassland soil carbon storage and soil health. The created evidence and developed tools will be made available to all project members, and we will build capacity of key stakeholders through protocols and workshops to equip them with the technical and scientific knowledge to continue monitoring beyond the project duration.

An Eddy Covariance, which is part of the research infrastructure at ILRI's Kapiti Research Station and conservancy is being used to measure ecosystem carbon exchange to determine whether the savanna ecosystem is a source or sink of carbon

8.1.3.2 Activity 1.3.2: Improve GHG emission measurements in dairy value chains.

396. On-farm activity data like animal live weights and milk yields are necessary to calculate Tier2 GHG emissions. Emission factors also need to be improved to reflect local conditions (e.g., animal metabolism, feed composition etc.). This activity will comprise the following sub-activities:

397. Sub-activity 1.3.2.1 Collect activity data on farm to calculate Tier 2 dairy emissions under various herd, feed, animal health and manure management situations. The Programme will finance the collection on-farm activity data for baseline and "with-project" situation, using digital tools (e.g. livestock Tier 2-specific ODK tool). This includes data on animal numbers, weights, productivity, feed rations and manure management system. This sub-activity will be performed annually with the support of ILRI, in direct partnership with national research institutions and academia of the 4 countries, in order to ensure sustainability and replication through the transfer of capacity (see output 1.4). This activity will inform the Programme's M&E system, and provide data for baseline and "with-project" situation.

398. Sub-activity 1.3.2.2 Conduct experiments and run models to generate Tier2 emission factors (EF) for baseline and improved dairy, under various herd, feed, animal health and manure management situations. Evidence shows that local feeding conditions and indigenous livestock breeds result in different emission factors for enteric methane[330] and manure CH_4 and N_2O emissions[331] than assumed by the IPCC. In this context, this sub-activity will develop local context-specific EF and inventory equations through lab experiments. Together with the 4 countries and research/academia, ILRI will quantify the GHG mitigation potential of selected feed interventions using state-of-the-art cattle respiration chambers[332] to derive methane yields for enteric CH_4, as well as manure incubation setups to derive CH_4 and N_2O emission factors for manure management.

[330] Goopy JP, Goopy JP, Korir D, et al (2020) Severe below-maintenance feed intake increases methane yield from enteric fermentation in cattle. British Journal of Nutrition 123:1239–1246. https://doi.org/10.1017/S0007114519003350; Korir D, Marquardt S, Eckard R, et al (2022b) Weight gain and enteric methane production of cattle fed on tropical grasses. Anim Prod Sci. https://doi.org/10.1071/AN21327

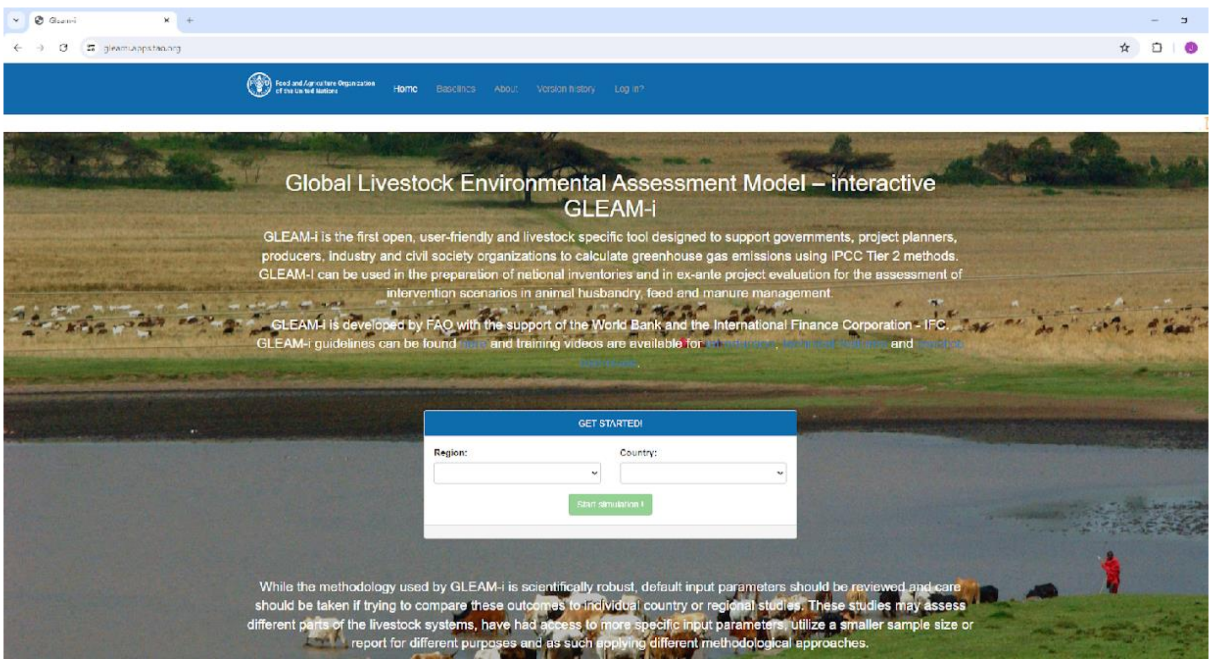
[331] Zhu Y, Merbold L, Pelster D, et al (2018) Effect of Dung Quantity and Quality on Greenhouse Gas Fluxes From Tropical Pastures in Kenya. Global Biogeochem Cycles 32:1589–1604. https://doi.org/10.1029/2018GB005949; Leitner S, Ring D, Wanyama GN, et al (2021) Effect of feeding practices and manure quality on CH4 and N2O emissions from uncovered cattle manure heaps in Kenya. Waste Management 126:209–220. https://doi.org/10.1016/j.wasman.2021.03.014

[332] For more information, see https://mazingira.ilri.org/infrastructure/

399. Sub-activity 1.3.2.3: Training on the Global Livestock Environmental Assessment Model – interactive (GLEAM-i) and IPCC assessment tool to calculate GHG emissions biannually, and to inform the national MRV system and inventories. By using collected activity data and Tier 2 EF generated, Programme results will inform the national MRV system, using tools like the Global Livestock Environmental Assessment Model – interactive (GLEAM-I, see Textbox 6)[333] developed by FAO to calculate emissions biannually. Throughout the whole process, ILRI will transfer capacity on Tier 2 EF, activity data collection and GHG emission calculation from the Programme. FAO, in particular the Animal Production and Genetics unit (AGAG), will be recruited to perform GLEAM-i assessments and provide training on carbon accounting. More specifically, the implementation structure will mainly comprise of the following actors: (i) FAO's global technical team to provide technical assistance and global oversight, (ii) IFAD's team and the SPIU to supervise the implementation of related activities, (iii) FAO and IFAD's country office teams to provide support as necessary, (iv) service providers for relevant technical deliverables as necessary, and (v) other key local UN, public and private stakeholders.

Textbox 7: FAO Global Livestock Environmental Assessment model (GLEAM-i)

GLEAM-i is a publicly available and free tool specific to estimating the greenhouse gas (GHG) emissions from different livestock species and production systems from all countries in the world. The livestock species covered in GLEAM-i are four ruminant species (cattle, buffalo, sheep and goat); and two monogastric species (chicken and pigs). The production systems embedded in the tool are grassland-based and mixed for ruminants; backyard, broiler and layers for chicken; and backyard, intermediate and industrial for pigs (FAO, 2017; MacLeod et al., 2017). For more details, see https://www.fao.org/3/cb2249en/cb2249en.pdf



400. The project will implement a low carbon certification and tracing system. A service provider will be identified and recruited to assist with the design and setting up of the low carbon certification system. The Project will also contact approved certification bodies, which will support throughout the entire process of certification, from product creation to final labelling, knowledge transfers and inspections.

333 See Feasibility Study for more details on the GLEAM-i tool.

8.1.3.3 Activity 1.3.3: Climate risk and vulnerability assessments.

401. Together with improvements to extension services described above under output 1.2, the Programme will seek to improve the accuracy and use of information (climate, feed availability) to last mile-users in the dairy sector. This will include building the capacity of devolved climate change units and decentralized meteorological offices to develop and disseminate climate information services, including (i) impacts of climate change on livestock/ dairy sector, and (ii) information about the availability of feed, through tools like national feed balance sheets. This activity will be implemented by the EEs, in cooperation with relevant livestock departments, together with national and decentralized meteorological departments. These include: (i) the State Department for Livestock Development (SDLD) in the MoALD and Climate Change Department (CCD) in Kenya,(ii) Rwanda Meteorology Agency. (iii) the National Carbon Monitoring Centre (NCMC) in Tanzania, and iv) Uganda,

402. *Sub-activity 1.3.3.1: Climate risk and vulnerability assessments, including impacts on the dairy sector, at local level*. It will consist of carrying out dairy sector climate risk and vulnerability assessments at local level, based on historical and projected climate data supported by impact-based models, analytical frameworks and machine learning. This will involve (i) the development of agro-climatic zone maps and Dairy Sector suitability maps based on the current and future climate, (ii) assessing the direct impacts of climate change on specific cattle breeds using the tropical humidity index (THI) and milk decline (MDEC), (iii) improved forecasting/projections of agricultural and pastureland drought through e.g. machine learning and artificial intelligence.

403. *Sub-activity 1.3.3.2: Review and enhancement of national feed balance mechanisms, and support to early warning systems*. The national feed balance mechanism and results will be reviewed and improved using the FAO guidelines, in order to produce a minimum of two balances per year, with dairy specific results. Improvements will focus on seasonality and quality of feed and fodder resources (metabolizable energy and crude protein content), in addition to quantity (in dry matter DM). In **Uganda,** existing early warning systems, including Scale-up PET and Land PKS will be strengthened and upscaled.

8.1.3.4 Activity 1.3.4 Facilitate low-carbon certification and reduce barriers to access carbon finance.

404. This activity will leverage MRV system developed under activities 1.3.1 and 1.3.2 to track GHG emission reduction from improved practices. The aim is to support selected dairy value chain stakeholders to receive premium prices for low-carbon and high-quality milk production, and engage on the voluntary carbon market. The Programme will pilot this initiative and raise awareness of processors and consumers of the environmental performance of dairy products.

405. *Sub-activity 1.3.4.1 Develop a carbon certification system for the dairy sector.* In order to reduce barriers to carbon finance, the Programme will mobilize technical assistance to: (i) review the alignment of national regulations for registration of carbon projects in East Africa (which facilitate foreign investments); (ii) develop/align monitoring and verification standards suitable for each national context (e.g. VERRA, Gold Standard) and specifically dairy sector projects – in cooperation with the Africa Carbon Market Initiative (ACMI) and research institutions; (iii) support the establishment of local/regional monitoring and verification companies – to reduce costs of certification/verification; (iv) undertake a policy dialogue and regional cooperation in strengthening the position of e.g. the Kenya Carbon Exchange. More particularly in Kenya, the Project will leverage INReMP's interventions to establish a Payment for Ecosystem Services (PES, see Textbox 7), and build on the MRV system developed under activities 1.3.1 and 1.3.2. These activities should be coordinated across the countries.

Textbox 8: Carbon credit scheme in INReMP

INReMP will establish a system for implementing and overseeing Payment for Ecosystem Services (PES) in line with the Kenya's Carbon Credit Trading and Benefit Sharing Bill, 2023 which is aimed at regulating carbon markets, driving the Country towards a greener, more sustainable future while combating climate change on a global scale. This strategic framework aims to ensure fair compensation for communities involved in conservation efforts, fostering sustained interest and participation in activities that safeguard natural resources. Inspired by the success of the Upper Tana's Rewards for Biomass and Soil Carbon (REDD) Mechanism under UTaNRMP, and in collaboration with The Nature Conservancy (TNC), INReMP will develop strategies for tax credit mechanisms as an advancement of the Water Fund into Water Fund+ aimed at implementing strategies for crowding in more private sector. These mechanisms will focus on protecting water catchments, forest cover, and water sources, rivers, and wetlands. Furthermore, INReMP will link these conservation incentives to climate finance, providing opportunities for tax credits and carbon credit rebates to engage the private sector actively. This will serve as a mechanism to encourage sustained private sector involvement in NRM activities, both during and beyond the Programme's duration. Under the Programme, the Geographic Information Systems (GIS) combined with remote sensing technologies and ground-truthing will be used to provide detailed spatial data on land cover, land use changes, and ecosystem services. This data will help in identifying areas with high potential for carbon sequestration or biodiversity conservation, guiding the implementation of PES and Carbon Credit schemes. Key actions under INReMP will include:

Establishing baseline assessments for carbon and biodiversity to measure and incentivize impactful conservation efforts – this would occur in two forms (i) pre-assessment of the Subcomponent 1.2 INReMP's Targeted Natural Resources-Specific Interventions and (ii) post-implementation of assessment of the Subcomponent 1.2 INReMP's Targeted Natural Resources-Specific Interventions, these assessments will serve as the foundation for quantifying the success of conservation activities and determining appropriate incentives. By establishing baseline data, the program can track progress over time and ensure that conservation efforts yield tangible results in terms of carbon sequestration and biodiversity conservation; (iii) engaging with local communities, including Indigenous Peoples forums, stakeholders, and relevant authorities to ensure participation and consensus in conservation efforts through solicitation of inputs, address concerns, inclusive decision-making, building trust/collaboration, and foster ownership of conservation initiatives; iv) ensuring robust MRV processes to link conservation activities with payment for ecosystem services by collecting reliable data (ground-truth provided by local community linked to GIS/remote sensing), the program can ensure transparency and accountability in the allocation of incentives and rewards; (v) developing transparent and equitable payment mechanisms to compensate communities for their conservation activities, taking into account factors like carbon sequestration, biodiversity conservation, and water resource protection; (vi) enforcing adherence to conservation agreements and standards; (vii) developing transparent measures and grading schemes to determine the level and value of rebates/benefits, as well as penalties for defaults or non-conformities; (viii) Providing training and capacity-building initiatives to empower local communities to effectively participate in and manage PES schemes; (ix) developing the policy support for the institutional capacity building and operationalising the carbon credit trading and benefit bill, as the development elements for the tax credit element and (x) exploring avenues for the private sector to adopt identified critical natural resource opportunities. The private sector can contribute by offering ecosystem payment services to cooperatives and communities responsible for managing these areas.

To deliver on PES elements, drawing insights from the water fund and GoK's national plan/strategy on tree planting, and aligning it with The Carbon Credit Trading and Benefit Sharing Bill, 2023, the programme aims to execute activities in Subcomponent 1.2, such as tree planting. This will follow an initial baseline survey and community engagement, setting specific targets for tree cover and its maintenance over a defined period. The programme will also establish MRV targets for the quality and quantity of tree cover through strategic engagement with the National Treasury and the provisions of The Carbon Credit Trading and Benefit Sharing Bill, 2023.

Transparent measures and grading schemes will be developed to determine the level and value of rebates/benefits, as well as penalties for defaults or non-conformities. These incentives will take the form of tax credits/rebates in corporation tax and/or business deductible expenditures for a specified tenure. The company awarded the credits/rebates will be responsible for maintaining the NRM asset (e.g., planted trees) by incentivizing and mobilizing the local communities most impacted by the process, as well as the GIS service provider and/or any government/non-government agency tasked with delivering the process. The unlocking of opportunities can only be valued through an independent verification process, with at least four verifications done per year to avoid greenwashing and related misuse of the process Harnessing carbon credits and benefits linked to the planted trees will be based on The Carbon Credit Trading and Benefit Sharing Bill, 2023 regulations. On Carbon Credits, INReMP's strategy leverages conservation efforts to mitigate climate change while promoting community engagement and private sector involvement and takes a similar approach as PES and Tax Credit (as above). Through advanced MRV techniques, the Programme will accurately quantify carbon sequestration and biodiversity conservation achievements that is linked to the National Strategy/Policy on Carbon Credits. This data will serve as the foundation for assessing and valuing carbon credits, providing tangible incentives for impactful conservation activities. The integration of carbon credit mechanisms with tax incentives and other financial instruments aims to establish a sustainable framework that incentivizes continued conservation efforts. Transparent grading systems will ensure equity and accountability, rewarding compliance while imposing penalties for non-compliance. Moreover, INReMP will actively engage the private sector in carbon credit schemes, fostering partnerships that drive innovation and investment in natural resource management. This collaborative approach not only enhances the efficacy of conservation initiatives but also unlocks new avenues for economic development and environmental sustainability. Through these initiatives, INReMP contributes to global efforts to combat climate change while promoting local community resilience and prosperity.

Additionally, the value of the Subcomponent 1.2 INReMP's Targeted Natural Resources-Specific Interventions e.g., a planted tree will create two opportunities for GoK; can be traded on the local and international carbon markets, and sustainable maintenance of the trees through a tax incentive/rebate programme. However, the benefiting companies of the carbon credits and tax credits/benefits do not have to be the same. It can be more than one company benefiting from two streams of opportunities presented by the planted trees. Thereby, providing more incentives for the crowding in of the private sector to participate in conservation efforts for the long-term sustainability of the INReMP programme and its domestication.

8.1.4 Output 1.4: Knowledge management and regional cooperation enhanced.

406. The Programme will facilitate transfer of knowledge through regional and south-south cooperation, with the objective to replicate the transformative practices for climate-resilient and low-carbon dairy adopted by the Programme. Activities will include (i) the support to Regional Centres of Excellence (RCoE) for technology validation and for maintaining a regional database on practices, GHG emissions and adaptation indicators and, (ii) the establishment of regional cooperation platforms and participation to regional/ global networks for knowledge exchange and policy dialogue. The AU-IBAR will contribute to the implementation, by facilitating regional platforms, sharing experiences, exporting best practices and spearheading policy dialogue. ILRI Mazingira Centre, as a state-of-the-Art environmental and regional research and education Centre, will also contribute. This output will address the institutional, planning and knowledge barriers identified in the ToC. Shared knowledge will enhance future low-carbon planning in the dairy sector, minimize climate risks and enable participating countries to take advantage of available climate smart opportunities within the region.

8.1.4.1 Activity 1.4.1. Support to Regional Centres of Excellence for technology validation and for maintaining a regional database on practices, GHG emissions and adaptation indicators.

407. To ensure sustainability and transfer of capacity to national institutions, the Programme will provide scientific support combined with capacity development to "regional centres of excellence" to export knowledge (regionally and globally) on climate change and GHG emissions for the dairy value-chain. Regional Centres of Excellence (or regional "knowledge hubs") will include national agricultural research institutions (e.g., KALRO in Kenya, RAB in Rwanda, TALIRI in Tanzania, and NARO in Uganda), local universities (e.g., Makerere and Busitema in Uganda; University of Nairobi, Eldoret or Maseno; University of Dar es Salaam or SUA in Tanzania) and relevant ministries. It will build on the legacy of the East Africa Agricultural Productivity Programme (EAAPP, World Bank-funded) which has built Regional Centre of Excellence (RCoE) in the dairy sector in Kenya.

408. *Sub-activity 1.4.1.1: Support to regional Centres of Excellence in technology validation and dissemination*. The Programme will assist the above-mentioned institutions with (i) technical trainings and protocols for GHG measurements (emission factors, soil carbon storage) and estimation methods to build their own capacity for research, MRV and technology validation linked to climate change mitigation, (ii) research capacity for conducting innovative research such as optimizing the biogas process for enhanced energy and nutrient recovery and building efficient biodigester technologies, (iii) vocational training and development of materials, standards, university-level educational curricula and guidelines, (iv) knowledge, information and visibility products, related to the four focus areas feeding, animal health, manure management and biogas, and grassland management and soil carbon sequestration.

409. Sub-activity 1.4.1.2: Develop and maintain a database/ repository on practices, GHG emissions per sources and systems, and climate change adaptation. This sub-activity will consist in developing, maintaining and promoting a regional database on best practices, and their impact on GHG emissions per sources and livestock production systems, and adaptation indicators. ILRI has a large repository of training materials on its open-access "CGSpace" platform, which will be leveraged, and made available to all actors in the Programme.

8.1.4.2 Activity 1.4.2: Establish regional cooperation platforms and participation to regional/ global networks for knowledge exchange and policy dialogue on climate-smart dairy sector transformation.

410. The regional collaboration platforms will include various public and private stakeholders, including the AU-IBAR, IFAD, FAO, ILRI, the East and Southern Africa Dairy Association (ESADA), local government partners (regional centres of excellence mentioned above), international organisations/NGOs, and involve private sector platforms and networks (e.g. One Health Research and Education Centre in Africa – OHRECA; Global Research Alliance Manure Management Network; Global Dairy Platform; Nutrient Circularity Network; National Biogas Stakeholders Network in Kenya, Africa Centre of Excellence for Sustainable Cooling and Cold Chain Systems - ACES). IGAD, through its ICPALD, will be engaged to share its experience in facilitating appropriate and applicable knowledge, research and technology development, including their domestication, adoption and transfer through regional platforms. Regional coordination experts within each country will be responsible for the coordination of these activities.

411. Sub-activity 1.4.2.1: Regional platform for knowledge sharing and policy dialogue to enhance low-emission, climate resilient dairy development. A regional platform – involving the above-mentioned entities - will be organised on a rotational basis in each of the participating countries to share experiences and scientific innovations and best practices implemented on farm. The regional platform will function as the knowledge management mechanism for the Programme and will capture and disseminate good practices and lessons learned from both public sector, private sector, networks and the research and academic community. This sub-activity will provide evidence – generated from the Programme M&E system - on the GHG efficiency gains (from breeding, artificial insemination/ herd management, feed, animal health), circularity (manure management, recycling) and carbon sequestration. Success stories for replication (e.g. Kenya for Tier 2 MRV), scientific innovations (animal nutrition / TIMPs, manure management for continuous improvement) will be documented. It will finance annual regional workshops, conferences, seminars, tours (exchange visits within the region), meetings and policy briefs.

412. *Sub-activity 1.4.2.2: Participation in regional and global climate policy mechanisms.* In practice, the sub-activity will consist of a joint participation of the 4 countries in global and regional events (global science and policy mechanisms on dairy and climate change) such as the Greenhouse Gas and Animal Agriculture Conference – GGAA 2025, the African Climate Summit, the African Dairy Conference, and the UNFCCC COP[334]). The objective will be to present the progress and results from the Programme for scale-up and replication, increase its visibility and engage with other countries in sharing experience and learning.

413. *Sub-activity 1.4.2.3: South-South and Triangular Cooperation (SSTC).* This sub-activity will finance the participation in knowledge-exchange programs, including through IFAD's "Learning Routes" with e.g. Argentina, Brazil (Embrapa), Costa Rica and Uruguay on Tier2 analysis and climate impact assessments in the dairy sector. Other initiatives for SS&T cooperation will be identified and assessed by the Regional Steering Committee. It will finance travels to dairy farms and cooperatives, private enterprises providing solutions for low carbon dairy, research and climate / meteorological centres, and participation of Country Delegations to workshops to share innovations and scalable practices generated by the Programme. This sub-activity will support the emergence of a global network of experience and expertise on reducing GHG emissions, especially methane, in dairy production and value chains, as well as financing solutions to support these reductions.

8.2 COMPONENT 2: ENABLING LOW EMISSION AND CLIMATE RESILIENT DAIRY VALUE CHAIN DEVELOPMENT

414. In line with the Programme paradigm shift, Component 2 aims putting smallholder dairy producers and private sector value-chain operators (dairy cooperatives, SMEs, farmers' associations, and other farmer-allied enterprises) on a transformative pathway towards low-emission and climate-resilient dairy sector. Climate mitigation and adaptation is critical on-farm, where 90 percent of sector emissions arise. This Component will contribute to GCF MRA4 "Forestry and Land Use", ARA1 "Most vulnerable people and communities" and ARA4 "Ecosystems and ecosystem services". Insufficient availability and adoption of climate-smart technologies and practices have are key barriers to low emissions and climate-resilient dairy value chains in East Africa. The selected technologies respond to the needs of smallholder dairy farmers as well as medium and large-scale commercial farmers, dairy cooperatives, milk collection centres (MCCs), milk collection point and other SMEs in the value chain.

415. This Component will contribute to the reduction of total GHG emissions and lower GHG emission intensity per kg of milk compared to a "business as usual" scenario, and increase climate resilience of dairy farmers through a three-pronged approach, i.e. (i) improvement in efficiencies in dairy production at farm and post-farm gate levels; (ii) enhanced nutrient circularity, more particularly through manure management and bioeconomy interventions, and (iii) carbon sequestration and removal through improved pastures and grassland management. This strategy will be implemented through three Outputs, namely: (i) smallholders' and cooperative capacity development; (ii) the adoption of pathway-specific integrated solutions for the dairy smallholder farm, including: animal breeding, animal health, feeds and feeding, manure management, and biogas use; and (iii) improved pasture management, including access to water to restore ecosystems' functions and increase soil carbon sequestration.

416. Beneficiaries of the component are smallholder dairy farmers, operating in zero-grazing/ intensive or semi-zero grazing/semi-intensive systems. According to the Market Study (presented in Appendix 1), these smallholder dairy farmers are the critical segment to scale, to grow the formal dairy sector and drive sustainable intensification while addressing climate change adaptation and mitigation. The support to the dairy value chain will also benefit medium and large-scale commercial farmers organised in dairy cooperatives and SMEs. Under Output 2.3, the Programme will also benefit pastoralists, agro-pastoralists, and medium and large-scale extensive farmers. Entry points to reach the dairy farmers include dairy cooperatives and MCCs, L-FFS/ PFS and community-based organisations.

[334] Several participants from the Programme preparation process in 2023 were present at COP 27 and will be attending or speaking at COP 28.

417. Given the main focus on climate-vulnerable smallholder dairy farmers, Component 2 will utilise grants (mechanisms depending on national practices and IFAD-funded projects co-financing DaIMA) to initiate the graduation of small-scale operators, and strengthen their capacities to adopt productivity enhancing and emission-reducing technologies. If appropriate, grants will also support dairy cooperatives and MCCs to finance solutions that drive increased awareness and understanding. Once this grant approach is successfully deployed to demonstrate the impact of smallholders' livelihoods, producers will be able to graduate and access finance through Component 3's instruments. Where private sector engagement is stronger, highly concessional loans (depending on the activity and the economic capacity of the recipient farmer) under Component 3 will be used.

418. **Activities under this Component are innovative, with scale-up and replication potential**. Transforming the dairy sector requires the comprehensive adoption of technologies and practices that sustainably increase production, reduce absolute emissions and lower emissions intensities. The proposed pathways, as identified in the Feasibility Study (see chapter on Scenarios and pathways for low-carbon and climate resilient dairy sector), includes a range of well-selected and proven technologies that have significant mitigation and adaptation impacts. These technologies will be promoted through the L-FFS, and adaptation studies be conducted to continuously monitor models for efficient advisory services. as all required modules will be updated with all aspects related to the pathways. In addition, digital apps will be promoted to improve herd management.

419. **Activities under the Component are sustainable**. The strengthening of dairy cooperatives and (Output 2.1) will significantly improve their operational and financial sustainability. This will be achieved through a combination of supports, including enhanced management capacity, business development services, expanding/upgrading the network of MCCs, investments in renewable energy to reduce the milk losses and energy expenditures, and building stable linkages with upstream and downstream dairy value chain stakeholders. The private sector will be expected to co-finance investments, which will be managed through the productive alliance model, described below.

8.2.1 Output 2.1: Smallholders' and cooperative capacity development strengthened.

420. The aim of Output 2.1 is to provide dairy farmers with consistent and stable access to market outlets for their milk, with fair prices and on-time payment. This will be achieved through the strengthening of dairy cooperatives and their network of milk collection centres (MCCs) and milk collection points (MCPs). Dairy cooperatives are an essential entry point to unlock the climate-smart milk production potential and driving adoption by dairy farmers of transformative climate-resilient practices, access to inputs, and technologies. Stable market access is a precondition for farmers to invest in market-oriented dairy and productivity-enhancing assets and technologies. Cooperatives not only provide a stable outlet for milk, but also (i) set the standards for milk; (ii) transmit technical knowledge and information on climate-smart practices to their members; (iii) structure the dairy value chain and engage in upstream and downstream supply-chain agreements; and (iii) facilitate access to markets, agri-inputs and services, and financial services. The cooperative-led MCC model has shown its relevance and efficiency in several contexts in the region (Kenya, Rwanda, Uganda) but requires a strong social cohesion in the community as well as management and leadership capacities. Aggregation around a nucleus farmer can be a valid alternative and a good mechanism for engagement of smallholders in the value chain when the socioeconomic context is not adequate for the cooperative model.

421. Investments under this component will be implemented through a cost sharing modality with beneficiaries, as presented in the text box below.

Textbox 9: Country-specific arrangements for cost-sharing

Support to upgrading, rehabilitating and establishing MCC/MCPs, including installation of cooling equipment (cooler vats or coolers for milk cans), renewable energy solutions etc., will be done on a cost-sharing basis with beneficiaries, through co-financing with the related IFAD-financed projects at country level. As a general rule, infrastructure for milk aggregation can be grant financed, processing equipment can be financed by private sector collaborations, through grants, or otherwise through blended financing involving grants and credit or private sector contribution, and transport (transport bicycles, possibly with electric support, motorbikes, motorized tricycles and small trucks) and solar energy solutions (photovoltaic panels, batteries and converters) will be largely financed Component 3 in the form of credit to the cooperatives and groups, either as loans to the farmers' organisations owning and operating the MCCs or MCPs, or as loans to individual farmers, with some differences between countries. For infrastructure development, the farmers' organisation needs to offer land with full title or a Voluntary Land Donation Agreement.

Kenya

In **Kenya,** a matching grant modality will be developed.

Rwanda

In **Rwanda,** For new MCPs/MCCs, investments will be financed through a blended arrangement involving community participation for land and premises in some cases, Project support for premises mostly and private sector participation for coolers and equipment, leased or placed by private processors. For existing facilities, extension and upscaling will be facilitated through technical assistance and business development support and financed through 100% grant for civil works and equipment of new MCPs and MCCs, and 70% grant for rehabilitation (remaining 30% can come from banks or PAs). Land remains beneficiary contribution (directly or through local governments). Solar energy for collection will be financed through grants, while for new processing units they will be loan-financed, under co-financing arrangement with RDDP-2.

Competitive tenders will be launched to acquire milk testing equipment and motorized bicycles and milk handling cans. For the construction of MCPs/MCCs, SPIU Farmer Organization Officer will assess producer groups' ability to mobilize enough milk for the capacity of the MCP or MCC. These producers' groups will also be members of L-FFS groups. The producers' groups must also offer land for the construction of the MCP/MCC. Competitive tenders will be launched for the construction of the MCPs/MCCs, rehabilitation of MCPs/MCCs and procurement and installation of milk processing equipment. The energy requirements of old and new MCPs/MCCs will be determined by a team of experts, including solar power requirements and other necessary adjustments to improve energy use and efficiency. Based on the recommendations of the consultants, a competitive tender will be launched for the supply and installation of solar energy solutions to MCPs/MCCs.

Productive alliances mean combining producer organizations, public extension and services providers and private companies to enhance service delivery at the MCC. These sets of activities will entail facilitating mutually beneficial contractual arrangements between producers' groups and organizations, milk collectors/aggregators, and financial institutions, building on the dairy hub concept. Establishment of dairy agro-vet inputs and services (veterinary medicines, stock feeds, artificial insemination services, etc.) will be facilitated at all MCCs. This will result in members accessing value offer of services from their MCC. A key productive alliance can be formed between financial institutions (FIs) and milk aggregators. Collectors sometimes face demands for on-the-spot payment for milk and are often hampered by lack of liquidity. By linking them to FIs, they can be provided with a credit facility to allow cash payments for milk. Another key alliance would be between the MCCs and large milk processors who can assist with services like milk collection, repairs of milk coolers, and leveraging acquisition of key inputs with milk delivered.

These set of activities will be undertaken by the Market Support Specialist under SPIU. There should be engagement of agrovet input suppliers of stock-feeds, veterinary medicines, and other dairy requirements and service providers such as AI technicians and extension staff through business to business (B2B) arrangements and facilitate contractual agreements with the MCC. Milk processors will be involved in guaranteeing payments for stock feeds and agrovets through milk deliveries and direct payment to suppliers.

Tanzania

In **Tanzania, t**he financing modalities for construction and rehabilitation of MCCs will involve private sector participation. The construction or rehabilitation of the premises will be financed entirely by the project, which will contract the construction firm directly. The producers' groups must contribute the land for the construction of new MCCs. All equipment except cooler and the solar panels to provide it with energy will also be provided and procured by the project. The cooler and the solar panels will have to be financed by the private sector. Several options that have been tested during the design mission and appear feasible could be considered: (i) financing by the aggregator, either as donation, as an in kind loan (paid back through milk sales), (ii) placement by the off taker (in this case the cooler remains the property of the off taker, but is put at the disposal of the cooperative), (iii) cooler purchased by the cooperative through a loan from a financing institution, guaranteed by the project/TADB, (iv) cooler leased by the equipment trader to the farmers' association. Three types of service providers will be involved in the implementation: (i) one or several consultancy firm(s) that will be in charge of designing the new MCCs, MCPs and assessing the needs for rehabilitation works for existing ones, and of supervising the construction works; (ii) private contractor(s) that will be in charge of the civil works; and (iii) suppliers of equipment (milk coolers, cans, etc…). All types of SPs will be contracted at the beginning of the project, starting by the consultancy company that will draft the Bills of Quantities for recruiting the two other categories. The contracts may be subdivided into lots by type of services/goods, and/or by geographical areas.

The Programme will also support "Productive Alliances" (PA) between organized small-holder farmers (usually cooperatives) and private off-takers/aggregators. This model is very compatible and complementary with the dairy hub. Through productive alliances, farmer groups/cooperatives are linked to a processor through a supply contract, which guarantees equitable benefits to both parties. In addition to milk purchase, the off-taker can provide services to the group, as per the dairy hub, but can also co-finance investments (e.g. milk coolers), directly or through tripartite agreements with financial institutions. This system is already existing in the project area and will be supported and upscaled. The activity will be contracted to a service provider, with good experience in the dairy value chain and good private sector orientation.

Uganda

In **Uganda,** both rehabilitation and construction will involve provision of equipment including milk coolers, milk cans, and various equipment for milk handling, quality control (including lactoscans), and MCC management, in addition to civil works. The producers' groups must contribute the land for the construction of new MCCs. Coolers will remain the property of the Dairy development Authority but will be leased to the cooperatives and groups, which is the usual practice in the country and appears as a satisfactory setup. This allows in particular withdrawing the cooler to place it in another location in case it is not used, which is currently the case for around 25% of MCCs in the Programme area. The construction and rehabilitation of MCCs and MCPs will be entirely under the responsibility of the Dairy Development Authority (DDA) which has a long experience in the domain and since this is entirely part of its mandate. DDA will be responsible for selection of sites and groups, feasibility studies, procurement of equipment, commissioning of civil works.

Solar energy and transport solutions will be financed under Component 3 in the form of credit to the farmers' organisations and individual farmers.

The Programme will also support the upgrading of the most mature MCCs into dairy hubs. The support will involve provision of equipment/infrastructure which will depend on the type of services provided by the hub. The Productive Alliance model, under which a farmer group/cooperative enters into a contractual arrangement with a private sector actor, often an aggregator, to strengthen its access to markets and services, will also be facilitated. This model is currently being implemented by some dairy processors and will be upscaled in the dairy sector, where aggregators are present and willing to enter into such arrangements. The same service provider engaged for supporting cooperatives will also provide support for facilitation of dairy hubs and productive alliances.

8.2.1.1 Activity 2.1.1 Strengthen dairy groups and cooperatives on organizational management and service delivery.

422. This activity aims to form and/or strengthen organizational and technical capacities of dairy groups and cooperatives, and raise their climate-change and gender awareness of their management team. Support will be provided to establish or enhance their network of MCCs and MCPs, and connect them with processors. Activities 2.1.1 and 2.1.2 will be coordinated and implemented by (i) SDLD and KDB in Kenya, (ii) the Rwanda National Dairy Platform (RNDP) in Rwanda; (iii) the Tanzania Dairy Board (TDB) and the Tanzania Cooperative Development Commission (TCDC); (iv) DDA in Uganda. Implementation will also rely on specialized service providers, such as farmers organisations (e.g. National Alliance of Agricultural Co-operatives in Uganda, NAAC), NGOs (e.g. Heifer International, SNV); national research institutions (KALRO, NARO, RAB and TALIRI) and agricultural technology providers.

423. *Sub-activity 2.1.1.1 Strengthen the governance and management structures of dairy cooperatives.* This sub-activity will include in the four countries: (i) the coaching of cooperatives by providers of business development service providers, (ii) training on cooperative governance and management practices for all management, supervisory and general committees of dairy cooperatives ensuring gender equity, (iii) where desirable, assistance for the registration as a formal dairy cooperative; (iv) the participation of these dairy cooperatives in events of their national and regional apex organizations as it is essential for dairy value chain governance issues; and (v) enhancing product development based on market research, for example predicting marketing trends, optimizing supply chains and ensuring efficient resource allocation.

424. **In Kenya,** the project will The Project will: (i) map and profile existing dairy cooperatives in selected counties, including women and youth representation, (ii) assist dairy cooperatives for formal registration, if appropriate, (iii) strengthen their operations to deliver or link them up with services, such as extension, information on herd management, dairy operations, food safety and quality, safe storage and transport of milk, (iv) strengthen institutional governance and management structures of dairy cooperatives, including women’s leadership in decision making bodies. Business development service providers will be recruited to undertake capacity building on leadership and governance, as well as coaching on business development and financial management. This sub-activity activity will be financed by GCF.

425. In **Rwanda,** on a demand driven basis, milk producer organizations will be reinforced in governance, advocacy and running the MCPs and MCCs as viable business enterprises through training and coaching by private Business Development Service Providers (BDS). Continuous coaching and mentoring will be provided through agri-business youths attached to MCPs/MCCs. The agribusiness youths will be identified and selected by the MCCs and trained and coached by a recruited service provider delivering BDS. They will train the producer organizations on (i) use of computers and other digital equipment, (ii) data capture and record keeping, (iii) data analysis, and (iv) preparation of business reports to the MCC committees. This will allow the MCC/MCP management committee to make financial and management decisions based on data and facts. For purposes of promoting women in leadership and decision-making positions and in line with the constitutional requirement, the Programme will target at least 30% women in decision making positions in farmer-based organizations. In other activities aimed at strengthening governance and leadership of Cooperatives/ MCCs/MCPs efforts will be made to ensure this quota is attained. BDS will be identified through a competitive bidding process and must be competent in mentoring and coaching, and not just training. Key topics for training and coaching MCC committees include: (i) leadership roles and responsibilities and gender equality, (ii) good leadership, (iii) how to achieve accountability, (iv) strategies for improving milk supply and (v) how to conduct business review meetings. Long-term coaching and mentoring will be provided by agribusiness youths whose purpose will be to ensure business records are properly captured whilst empowering the MCC/MCP. MCCs/MCPs in new RDDP-2 districts will be assisted to develop enterprise development plans (EDPs) as initiated under RDDP. Exchange trips to performing MCCs will be conducted for the MCC executive committees to see best practice in action. This sub-activity will be co-financed by RDDP-2.

426. In **Tanzania**, dairy cooperatives are key stakeholders for collection, building and selling milk from their members, as well as for provision of services to members. Establishing and strengthening farmer organizations (FOs) via cooperatives is a common practice in the dairy sector, however, some FOs are not yet formalized cooperatives in the milk sheds. The programme will support the organization of FOs, and, where desirable, support their registration into cooperatives. This also enables them to apply for loans as a group. The project will provide all farmer groups and cooperatives involved in milk collection and aggregation in the project area, with capacity building aimed at improving their business management, financial literacy, governance, and leadership. The target group will initially consist in the around 80 cooperatives existing in the project area and will during implementation increase to 100 additional with the creation of 100 new MCCs and cooperatives. The capacity building package will consist in an initial training (one week), a refresher training after 4-5 years (3 days) and continuous coaching services through the Programme implementation. The whole executive committee will attend the training that will take place in the field, to enable all executive members to participate. Coaching services will consist in a one-day visit every quarter, where the service provider will go through the records of the cooperative and analyse them together with the executive committee, to identify potential issues and possible solutions. The service provider will be required to regularly assess the management capacities of supported cooperatives and use a dedicated assessment grid for this purpose. Market relations between targeted farmer groups/cooperatives and off takers will be facilitated through the productive alliance mechanism mentioned below. “Creation and strengthening of dairy producers’ groups and cooperatives” will be entrusted to a qualified service provider (national, international NGO or consortium of National, and/or international NGOs), with proven experience in supporting farmers organizations in the dairy sector recruited on a competitive basis, who will work in partnership with Tanzania Dairy Board (TDB). All the logistics will be under the responsibility of the SP and TDB will provide additional trainers. This sub-activity will be co-financed by C-STDP.

427. In **Uganda,** the project will (i) map and profile existing fairy cooperatives nationally, including their extent of women and youth representation; (ii) assist dairy cooperatives in formal registration, in line with the 2011 National Cooperative Policy; (iii) define the role of the cooperatives in the development of post-production activities, including the provision of technical advisory support. The menu of trainings being offered include: Support to groups and cooperatives will entail capacity building in governance, business management, market access, and technical aspects such as milk handling and processing. Trainings will be completed by coaching of cooperatives, consisting of physical visits to will go through the records of the cooperative and analyse them together with the executive committee, to identify potential issues and possible solutions. The service provider will be required to regularly assess the management capacities of supported cooperatives and use a dedicated assessment grid for this purpose the 190 cooperatives will also receive regular coaching to ensure proper application of training content and support problem identification and solving. Each group will receive three visits per year. The coaches will work in teams of 2 to ensure that both management and technical issues are properly addressed. Exchange visits between regional and national produce groups will also be organized for the supported cooperatives. 50 visits will be organized in total. Each visit will benefit a group of around 12 people representing 4 cooperatives, accompanied by 1 or 2 facilitators. Transport will be by bus. The foreseen destinations include Southwestern Uganda, Kenya, and Rwanda, where farmers organizations are well structured and integrated into commercial value chains.

428. The training will also include sessions on gender awareness and relevance for youth inclusion. As such the project will promote active participation and representation of women (including in leadership positions) to ensure women have equal access to project services and decision-making offered to producer groups/cooperatives. The training will also take into account livelihood activities women are mostly involved in and technologies developed to respond to women’s needs. Initial capacity building will be provided to 205 cooperatives (155 existing, and 50 newly created) during the first 4 years of the project. Refresher training sessions will then be provided after 4 years so that each cooperative benefits from two sessions during the Programme. Participants to the training will be the executive members, as well as the staff (management and technical). Training sessions will gather 3 to 5 cooperatives, to promote exchange between peers, and will be organized on selected cooperative sites, to be as practical as possible, and enable participation of all members including women. These activities will be co-financed by ReLIV.

Textbox 10: Example training package to be provided to cooperatives (based on RDDP-2 approach)

The following capacity building activities are examples of what could be provided to cooperatives:

STEP 1: *Development of training modules and manuals*. Entrepreneurship and Business Management module covering the following topics: i. entrepreneurship orientation, culture, behavior, and characteristics; ii. introduction to principles of business management adapted to the various segments within the value chain (farmers, milk collectors/traders, MCCs, small-scale processors etc.); iii. business record keeping; iv. financial management (costing, budgeting, preparation of simple cash flow and financial statements); v. marketing; vi. contract management; vii. risk management skills and tools for dairy value chain enterprises. Financial Literacy module will cover: i. introduction to financial literacy; ii. money management; iii. basic knowledge of financial markets; iv. savings literacy; v. investment literacy; viii. Digital financial literacy. Preparation of business management and financial literacy manuals. Others including business management for farm-level dairy enterprises, business management skills for milk collectors/traders, business management skills for MCCs etc. as needed.

STEP 2: *Training of trainers*. Trainers will be drawn from the pool of L-FFS facilitators. They will be trained at two levels. First level training will aim at equipping them with knowledge of the financial literacy topics in the training manuals. The second level training will equip the trainers with financial literacy training skills –with emphasis on participatory and action centred training techniques.

STEP 3: *Preparation and implementation of training programme*. The activities include: (i) identifying training venues (preferable to hold training sessions at MCC premises, training for milk collectors will be scheduled immediately after the milk deliveries while training for farmers will be conducted during the weekly/bi-weekly savings group meetings, training for other groups (e.g., animal health technicians, veterinary doctors etc.) will be organised in consultation with the groups); (ii) implementing the training programme using best practice adult learning techniques with emphasis on participatory and action learning activities and, (iv) conducting regular follow up to assess practical application of financial literacy skills by value chain actors.

429. *Sub-activity 2.1.1.2 Strengthen capacity to reduce milk losses and ensure milk quality and safety*. At the aggregation stage, up to approximately 8 percent of the milk is lost via spillage and spoilage. Aiming at reducing "unproductive" GHG emissions due to milk loss or quality loss, this sub-activity is to assist dairy cooperatives, MCCs and MCPs in upgrading their technical capacity in milk quality control covering raw milk testing at milk collection, hygiene, and initial processing beyond the sale of raw milk, in line with national and regional food safety standards. The advisory interventions will lead to improving milk quality at farm gate level and thus reducing rejection and waste, important for both farmer profit and GHG emissions reductions. The support will consist in support to acquire: (i) basic equipment for milk collection (motorcycles, milk cans and can holders, testing equipment), (ii) insulated milk transport vehicles (demonstration purpose); (iii) training on milk quality, food safety and hygiene for milk transporters and managers/technical staff of cooperatives, MCCs and MCPs. **In Kenya,** this support will be co-financed by INReMP, in **Tanzania** by S-CDPT, **in Rwanda** by RDDP-2 and **in Uganda** by ReLIV.

Textbox 11: Construction and rehabilitation of MMCs and MCPs in Tanzania (C-STDP model)

3,000 liters MCC, which will be the most common type, comprise of: (i) a milk reception area (veranda), (ii) a cooler room, marge enough to accommodate a second cooler in case of increased capacity; (iii) a small laboratory; (iv) a dressing room; (v) a safe storage room for chemicals; (vi) toilets; (vii) a soak pit for management of effluents and washing water; and (vii) generator shed. The building will be made in hard material (stones, bricks), and the roof of corrugated iron with a ceiling. All soils and walls up to 1 meter high in reception area and cooler room will be tiled. The cooler compressors will be located outside the building for improved energy efficiency. Where piped water is available, the MCC will be equipped with a solar water heater and heat exchanger to use the energy generated by milk cooling for heating water. All new MCCs will be equipped with a milk cooler, a permanent source of power (generator or solar system plus grid connection when available), milk testing equipment (lactodensimetres, alcohol guns, lactoscans), and milk handing equipment (aluminium or stainless-steel cans, reception tank, pump). The milk cooler will have to be open (Vertical cylindrical tank with opening lid or Horizontal semi-cylindrical tank with opening lid) to enable proper washing even in the absence of tap water. The climate smart MCCs use renewable energy, reduce and recycle waste and waste water, reduce post-harvest losses of milk (also downstream) and are constructed of materials that are as climate and environment friendly as possible.

The project will not be prescriptive regarding the management model of the supported MCCs and will encourage all types of models as long as they are efficient and mutually beneficial. Based on lessons in the region and in the country, several models can be envisaged: (i) MCC owned and entirely managed by the cooperative – this is only possible when the cooperative has enough experience, managerial and financial capacities; (ii) MCC owned by the cooperative but entirely managed by the off-taker through a management delegation agreement – this model is adequate with nascent cooperatives; (iii) MCC owned by cooperative, or co-owned by the cooperative and the off-taker (equipment), but management partially delegated to the off taker – this can be the case for the management of the cooler in particular, especially if it belongs to the aggregator, or for the management of payments that can be done directly to the farmers by the off taker, instead of through the cooperative. All the farmers groups in charge of these MCCs will also benefit from the capacity building activities.

The financing modalities for construction and rehabilitation of MCCs will involve private sector participation. The construction or rehabilitation of the premises will be financed entirely by the project, which will contract the construction firm directly. All equipment except cooler will also be provided and procured by the project. The cooler will have to be financed by the private sector. Several options that have been tested during the design mission and appear feasible could be considered: (i) financing by the aggregator, either as donation, as an in kind loan (paid back through milk sales), (ii) placement by the off taker (in this case the cooler remains the property of the off taker, but is put at the disposal of the cooperative), (iii) cooler purchased by the cooperative through a loan from a financing institution, guaranteed by the project/TADB, (iv) cooler leased by the equipment trader. The facilitation of these co-financing mechanisms are described below in the activity supporting productive alliances.

Construction and rehabilitation of MCPs

MCPs will be instrumental to enable farmers located in remote areas to access more easily to milk aggregation networks and allow MCCs to collect more milk and operate at higher capacity. In average, it is estimated that 5 MCPs of 800 litres capacity will be needed for each MCC (assuming that 1/3 of the milk will be supplied directly to MCCs, and 2/3 through MCPs).

Each MCP will consist in a simple tiled and roofed slab (possibly with one-meterhigh walls), equipped with milk handling (cans) and testing equipment, rainwater harvesting system and simple can washing system. It is not envisaged to equip MCPs with cooling equipment as most of them will be located in off grid areas and at the same time close enough from MCCs. MCPs will be managed by the cooperative managing the MCC they are connected to, and will be placed under the oversight of local farmer groups belonging to the cooperative.

Pictures from field visits (October 2023). Milk collection point - MCP (left), and milk collection centre – MCP (right)

430. *Sub-activity 2.1.1.3 Expand the outreach and capacity of cooperatives, MCCs and MCPs*. The expansion of market-oriented dairy operations and higher productivity of dairy cows, which leads to lower emission intensity of milk produced and sold, requires the nearby availability of milk collection capacity. Therefore, the Programme will support investments in MCCs and MCPs, as well as small processing equipment for cooperatives that are not linked / out of reasonable reach from existing formal market processors and have sufficient scale to viably engage in processing. Both rehabilitation and construction will involve provision of equipment including milk coolers, milk cans, and various equipment for milk handling, quality control (including lactoscans), and MCC management. Milk collectors will be facilitated to collect safe milk (at farm gate) and to deliver the collected milk to the storage facilities in place (MCCs & MCPs). MCPs are simple premises without cooling facilities, equipped with cans and simple milk quality control equipment, where milk is collected from neighbouring farmers and then ferried to the MCC (see also Textbox 12). This setup is particularly indicated in areas with a loose network of MCCs and that the electricity grid does not reach. MCPs will be managed by farmers' groups that can originally be L-FFS groups having graduated to more business-oriented organizations, without having necessarily reached the level of a cooperative. It usually takes several years for an MCP or MCC to reach its optimal volume of operations. This can be exacerbated by mistrust of producers, which can be addressed through awareness campaigns and training that can improve their ownership, participation and commitment. But the main risk resides in the competition from the raw milk sector/traditional milk traders, who sometimes offer better conditions (higher prices, upfront payment) since they have lower transaction costs (no taxes, no chilling costs). This risk can be mitigated by reinforcing controls on the raw milk sector, to ensure that it complies with regulations, which is often not the case. Attractivity of MCCs can also be provision of essential services such as AI, inputs, as well as payment facilitation through the system of off-checks (payment in kind through deduction on milk sales).

431. In **Rwanda,** previous projects resulted in increased supply of milk to the formal value chain, from 47% to 75% of households, from the rehabilitation and construction of MCCs and MCPs. However, an MCC assessment indicates that 19 per cent of MCCs (14 out of 73), some or all of the cooling equipment are not working and as a result these MCCs are not operating at full capacity. This is mainly due to poor management as illustrated by a recent MCC performance assessment which showed that the majority (67 per cent) of MCCs could be considered as not yet sustainable and requiring substantial external support. Under this Programme, non-functional MCCs may be rehabilitated or new ones constructed. An initial assessment will be made for the capacity of the MCP/MCC to consistently procure milk, with a cooler of the corresponding capacity installed. For new MCPs/MCCs, investments will be financed through a blended arrangement involving community participation for land and premises in some cases, with the Programme contributing to premises. Private sector will be supported for coolers and equipment within their premises, through the technical assistance and business development support and financed through existing financing mechanisms and private sector through productive alliance arrangements (see below); SPIU/RAB will train milk collectors in milk handling and testing, and to obtain additional expertise from RICA whose mandate is to enforce the Ministerial Order of 2016 that pertains to milk quality and licensing of milk handling and processing premises. Competitive tenders will be launched to acquire milk testing equipment and motorized bicycles and milk handling cans. For the construction of MCPs/MCCs, SPIU Farmer Organization Officer (see Section 7: Implementation arrangements, above) will assess producer groups' ability to mobilize enough milk for the capacity of the MCP or MCC. These producers' groups will also be members of L-FFS groups. The producers' groups must also offer land for the construction of the MCP/MCC. Competitive tenders will be launched for the construction of the MCPs/MCCs, rehabilitation of MCPs/MCCs and procurement and installation of milk processing equipment. The energy requirements of old and new MCPs/MCCs will be assessed by a team of experts to determine solar power requirements and other necessary adjustments to improve energy use and efficiency. Based on the recommendations of the consultants, a competitive tender will be launched for the supply and installation of solar energy solutions to MCPs/MCCs. This sub-activity will be co-financed by RDDP-2.

432. In **Tanzania**, the project will capacitate the TDB to centralize milk data collection. New MCCs will be established through cost-sharing modalities between beneficiaries and the programme. New MCCs will have a capacity of 3,000 litres, ranging from 2 to 5,000 litres initially. 50% will be concentrated in the Southern highlands. The programme will also rehabilitate existing MCCs in the Project area, to improve their efficiency (including energetic), as well as sanitary conditions and hygiene. This will be done by three types of service providers: (i) one or several consultancy firm(s) that will be in charge of designing the new MCCs, MCPs and assessing the needs for rehabilitation works for existing ones, and of supervising the construction works; (ii) private contractor(s) that will be in charge of the civil works; and (iii) suppliers of equipment (milk coolers, cans, etc.). Service Providers (SPs) will be contracted at the beginning of the project, starting by the consultancy company that will draft the Bills of Quantities for recruiting the two other categories. The contracts may be subdivided into lots by type of services/goods, and/or by geographical areas. This sub-activity will be co-financed by C-STDP.

433. In **Uganda,** the project will also provide new milk coolers to 66 existing MCCs to replace existing ones or increase their capacities. In total, the project will supply 110 coolers with capacities ranging from 1,000 to 5,000 liters. Coolers will remain the property of DDA, but will be leased to the cooperatives and groups, which is the usual practice in the country and appears as a satisfactory setup. This allows in particular withdrawing the cooler to place it in another location in case it is not used, which is currently the case for around 25% of MCCs in the project area. The project will also support the creation of MCPs. The construction and rehabilitation of MCCs and MCPs will be entirely under the responsibility of DDA which has a long experience in the domain and since this is entirely part of its mandate. DDA will be responsible for selection of sites and groups, feasibility studies, procurement of equipment, commissioning of civil works. Equipment and construction will be financed on a cost sharing basis between beneficiaries and the Programme. This sub-activity will be co-financed by ReLIV.

434. *Sub-activity 2.1.1.4 Create gender awareness among households of dairy farmers.* Gender awareness activities have been mainstreamed in the Programme. The Enhanced Gender Action Learning System (GALS+) methodology will be used to address power relations and inequalities especially at household level, thereby enhancing behavioural change for purposes of increasing gender equality and women's empowerment, as well as climate resilience. As men and women have diverse ways of coping and adapting to the adverse impacts of climate change, GALS+ includes (i) an integrated climate component to strengthen the mitigation measures and adaptive capacities of households and communities to climate change; (ii) nutrition and food safety aspects. Support will be given to: (i) gender awareness and targeting workshops for staff of implementation units and contractors; (ii) training of GALS lead farmers and cooperative management; (iii) rolling out of GALS in L-FFS households; and (iv) national gender sensitization and training workshops for the management of dairy cooperatives. **In Kenya,** this sub-activity will be co-financed by INReMP. In **Tanzania,** the GALS+ methodology will be implemented and intertwined with L-FFS groups to address power relations and inequalities, especially at households level, co-financed by S-CDPT. In **Rwanda,** the activity will be implemented integrally by a hired consulting firm. SPIU will competitively hire a firm to implement GALS in the new project area. GALS will be introduced to L-FFS groups, and GALS champions and L-FFS lead farmers will be trained and equipped to roll out GALS to household level, co-financed by RDDP-2. In **Uganda** the activity will be co-financed by ReLIV.

Textbox 12: Gender Action Learning System household methodology (adapted from RDDP-2 Project Design Report)

GALS is a structured and phased intervention which can be successfully implemented between 18-24 months. The recruited firm will begin by introducing GALS to the District project staff members and identification of potential L-FFS to benefit from GALS. This will be followed by identification and training of GALS champions, L-FFS master trainers and L-FFS –Lead farmers through a series of workshops including the change catalyst, participatory gender review and the GALS community tools workshops. The trained team will then roll out individual life planning and community action learning in L-FFS groups and households.

The sustainability of GALS outcomes is hinged in the mindset change reflected in the behavioural change of beneficiaries which is often shared through participatory reflection meetings at group and household levels. The individual or household plans and community transformation plan often generated in a participatory manner remain change trigger tools to the beneficiaries. The community-based GALS champions remain a community asset to regularly consult. The changed beneficiaries remain reference points in the communities for a long time.

8.2.1.2 Activity 2.1.2 Build and enhance Productive Alliances along the dairy value chain

435. The Programme will facilitate the establishment of productive alliances between farmer cooperatives and enterprises with farmer-allied engagement models, particularly processors, and scaling-up of dairy clusters, that enable farmers to access to affordable, high-quality inputs and services. The Programme will encourage and support the development and signing of milk supply contracts between farmers and MCCs, MCPs/MCCs and milk aggregators, MCCs and processors or other off-takers. Contracts will define milk quality, milk handling procedures, time of delivery and payment terms. Penalties for breach of contract will be clearly defined and understood by all parties. This follows the Productive Alliance model, as described in Textbox 12. The Programme will support cooperatives to develop business plans, and their financial management and extent of digitalization as steps to make them more attractive and equitable partners for off-takers. The Programme will also support creation of linkages amongst value chain players, In cases where financing beyond what the Programme can provide is needed (upgrade of MCCs and MCPs), in particular to individuals, the Programme will assist in establishing linkages to other initiatives, for example ARCAFIM. Larger investments may be eligible under Component 3 of the Programme.

Textbox 13: Productive Alliance Model

The productive alliance model is now promoted under most of IFAD funded value chain projects, establishing contractual arrangements and mutual accountability and services/sales between all players from the farm to the processors, in this case specifically involving producers; cooperatives, MCCs/MCPs, and private companies; and marketing outlets. The model is well adapted to the dairy value chain as it allows farmers to get guaranteed access to services and market, and aggregators to have a certain control on quality and quantity of commodities. It, however, can only be implemented where large scale aggregators (processors) are active. The project will not finance investments needed for productive alliances except through the climate financing facility in some cases, but through credit in this case. The PA model should be self-financing as the cost of services provided by the lead enterprise to the participating farmers should generate a return on investment, and on the other hand, participation of farmers in the PA should also increase their incomes. If it is not the case, a PA would not be sustainable and should not be supported.

The Programme will work directly with the dairy cooperatives and the other enterprises to build out and establish (typically via contracts) the components of these productive alliances. Components will be in response to farmer needs and differentially focus on enabling the production and productivity growth of improved family dairies to become small commercial dairy farms with 5+ cows. Nascent anchor farms will be supported to serve as both sources of greater milk production and small dairy farmer support and milk aggregation, particularly for farmer cooperatives that are not connected to market. Alliances may include co-finance investments (as milk coolers), directly or through tripartite agreements with financial institutions. Parallel to producer alliances, is creating linkages to public procurement (e.g. schools or hospital procurement) for better milk prices guaranteed by contract (e.g. quality payment system).

Productive alliances between farmer cooperatives and enterprises with farmer-allied engagement models, particularly processors, and scaling up of dairy hubs that enable farmers to access to affordable, high-quality inputs and services. These services cost is generally deducted from the milk sales, sometimes on credit. Extension is sometimes offered free of charge. Different models will be promoted as services can be provided by the cooperative itself, by an input or service provider (including the supported paravets that can benefit from guaranteed business through this arrangement) contracted by the cooperative, or by the aggregator (such as the processors or anchor farm). The Programme will not be prescriptive and support all types of arrangements as long as farmers access services in an equitable manner. The Programme will aim to build upon existing models in the region, which are predominately through cooperative partnership with processors (and linked agri-input businesses).

Women and youth entrepreneurs in rural and peri-urban areas involved in processing and marketing milk products in milk zones/kiosks/shops/bars will be organised into groups and capacitated in milk testing, small-scale milk processing and value addition to dairy products, and business management skills. The youth entrepreneurs will be assisted to acquire refrigerators and milk warmers to enhance their businesses through a credit facility. The Project will support training and equipping youth technicians in cold chain operations and maintenance. They will be responsible for maintaining cooling tanks and facilities in their locality. The Project will work with MCCs to strengthen their capacity to access school feeding procurement systems as a market outlet, focusing on building local, safe, and high quality of dairy supply chains for home-grown school feeding. There should be engagement of agrovet input suppliers of stock-feeds, veterinary medicines, and other dairy requirements and service providers such as AI technicians and extension staff through business to business (B2B) arrangements and facilitate contractual agreements with the MCC. Milk processors will be involved in guaranteeing payments for stock feeds and agrovets through milk deliveries and direct payment to suppliers.

Two of the major dairies in Tanzania have put in place productive alliances through which farmers not only access a guaranteed milk market, but also essential services such as extension, inputs, and even credit through tripartite agreements between the off-taker, a financial institution and cooperatives. This type of arrangement provides significant opportunities for sustainable development of the value chain in the country. This mechanism therefore appears to adequate and can be upscaled in the project areas.

436. *Sub-activity 2.1.2.1 Strengthen cooperatives' capacity in business and financial management*. The aim is to ensure that dairy cooperatives and their milk collection centres (MCCs) are run as viable and sustainable business enterprises. In particular, the Programme will support cooperatives in building out business plans and partnerships for expanding and enhancing the services they offer member farmers (e.g., facilitated feed and AI service purchases checked-off against milk sales) – serving as "dairy hubs". For implementation, providers of BDS will be mobilized. In addition, the members of cooperatives and MCCs will receive: (i) financial literacy and including financial management software and computers for dairy sector stakeholders, with particular focus on women and youth needs; (ii) gender-sensitive and inclusive business management and business plan development training (using participatory tools such as RuralInvest, developed by FAO[335]).

437. In **Kenya,** the activity will be co-financed by INReMP. In each county, in conjunction with physical upgrade of MCCs, their management and members will be trained in marketing and business plan development.

438. **In Rwanda,** co-financed with RDDP.2, stakeholders will be trained on the dairy hub concept and to develop business plans specifically targeted the productive alliance model.

439. In **Tanzania,** a service provider will be contracted with good experience in the dairy value chain and good private sector. MCCs and local processors will be supported to acquire energy-efficient pasteurizing and small-scale processing and packaging equipment, plus innovative proximity milk marketing systems. Gender awareness will be included in these trainings. These set of activities will be undertaken by the Market Support Specialist and co-financed by C-STDP.

440. **In Uganda**, co-financed with ReLIV, value chain actors will be provided with business development services from a specialised provider to develop bankable proposals. They will receive financial management training as well as enterprise viability mentorship and coaching.

441. *Sub-activity 2.1.2.2 Build linkages along the dairy value chain*. The suppliers of BDS will also provide technical support in building capacity for negotiation of offtake agreements between farmers/cooperatives and private off-takers (productive alliance model), as well as public procurement (e.g. school or hospital procurement) for better milk prices guaranteed by contract. The aim is to support other businesses the value chain in forming Productive Alliances with cooperatives and in designing, enhancing, and scaling key components of their farmer engagement models, such as quality-based or volume-based price incentive terms offered by processors, extension provision, and direct or facilitated provision of inputs and services. Attention will also be given to marketing and product development. For implementation, providers of BDS will be mobilized and NGOs. Through this support, a pre-investment pipeline will be developed, and related financing needs identified.

442. In **Kenya,** a specialised business development service provider, will undertake a study to identify strong cooperatives with potential for good off-taker arrangements in the area. Selected, stronger MCCs will be selected to enter into productive alliances with partners through dialogue, drafting of contracts and updating of business plans. and in **Rwanda,** co-financed by RDDP-2, B2B workshops will be organised to scope potential partnerships and draft contractual arrangements between producer groups and off-takers. A specialised service provider will support the process and continue to backstop the productive alliances as they form. In **Tanzania,** a specialized service provider will facilitate holding of district platforms as B2B events to identify opportunities and interests to form productive alliances. For selected, stronger cooperatives, a productive alliance business plan will be developed and partners actively be supported to formalize a contract. These activities will be co-financed by C-STDP. In **Uganda**, a national consultant will undertake a study to identify possible productive alliances, based on which district platforms will be held. Potential partnerships will further be strengthened with finetuning of business plans, development of draft contractual arrangements and engagement with identified off-takers. This activity will be co-financed by ReLIV.

Textbox 14: Digitalization of value chains for productive alliances

[335] https://www.fao.org/in-action/ruralinvest/about/en/

A key enabler to these productive alliances is improving the digitization of the value chain and enhance monitoring and information systems (MIS) for the processors and other farmer-allied enterprise. This is important for targeting solution and record keeping. The Programme will support digital enablement of these enterprises supporting farmers.

This MIS system will support the MCP/MCC to keep track of the farmers, production levels, animal health and quality of milk. The system will also be connected to the mobile money aggregators and FIs to enable mobile money payments to the farmers and facilitate access to credit. Connecting the MCP/MCC MIS to mobile payments and banks, will enable faster payments between the MCP/MCC and the Milk processors/Off-takers whilst ensuring that milk producers are paid also accurately and on time increasing the transparency and governance of the MCC. For instance, data on milk production and sales can be used to calculate payments, which can be processed electronically to reduce the risk of errors and delays. In this regard Milk collectors will be equipped with tools to support data collection at farm level. Some of the data to be collected will be: - details of the farmer and animal, quality of milk, and time stamp. This data will be validated at MCC level and entered into the MCC MIS for milk that has been accepted. The MCC MIS will support the MCC to produce forecasts to plan their operations and ensure that they have adequate storage and processing capacity. For example, historical milk production data can be used to identify seasonal variations in production and adjust collection schedules with milk collectors and processors. The system will also support the MCC in Quality control by tracking and tracing to ensure that milk meets quality standards. For instance, data will be collected on milk temperature, acidity, and other parameters, which can help identify any quality issues. The system will integrate notifications to the farmer through SMS on milk delivery or quality issues. This will support the MCC connect to Agri-Vets and L-FFS providing advisory services to support farmers produce high quality milk and follow up any cases in case of milk rejection. Training on digital literacy for MCCs is critical to ensure consistent follow-up and monitoring of adoption and use of the digital systems.

A good example of Value chain digitalisation exists **in Tanzania**, piloted by ASA Dairies has enabled better data management in the dairy value chain, allowing stakeholders to collect and analyse data more efficiently, understand the supply and demand of dairy and support the value chain to track the quality of dairy products more effectively, which has led to improved quality control. The project can scale lessons from the mobile application by ASAS which has enabled value chain integration from farmers to the off taker. The project will also leverage data from tracking on advisory for farm management to enable sector level reporting and decision making. The project will thus enable comprehensive data collection to support delivery of services and sector level reporting.

Another example of agritech/fintech **in Uganda** is Emata. Emata (https://www.emata.ug) brings digital and affordable financial products to dairy farmers and cooperatives (MCPs/MCCs) based on digitisation of records (digital MIS system) and the creation of a reliable performance and risk assessment (credit worthiness analysis) on which to base affordable lending.

443. *Sub-activity 2.1.2.3 Improve the digitalization and traceability of dairy operations*. The Programme will ensure digitalization and traceability to ensure quality and entry into formal supply arrangements that come with services, and improved accounting (money and stock) for access to credit. Use of transformative end-to-end (E2) digital solutions is limited. Digitalized systems for monitoring on-farm activities, milk production disaggregated by farm (gender of farmer), aggregation, transportation, and marketing will play a significant role in increasing the efficiency and transparency in the dairy value chain and cold chain. It will support off-takers and cooperatives managing MCCs to improve timely payments to farmers, traceability of the quality of milk and linkage to advisory services where farmers might need advisory interventions and access to finance. In each of the four countries, the Programme will enhance the capacity of milk aggregators/cooperatives to improve their record-keeping and management through a digital cooperative and MCC management information system (MIS) that will: (a) record the production of farmers, (b) track milk flow/volumes and quality, (c) manage records of farmer payments allowing the development of digital profiles and credit scores. Digital solutions developed by local agri-techs and agri-fintechs (e.g. Emata in Uganda; and eCow and DigiCos and other technologies by agritechs in Kenya) or FAO (Collect Mobile App) to enable business operations management and credit-scoring for better access to finance will be scaled-up.

444. **In Kenya,** this activity will financed by INReMP. In **Rwanda**, this activity will be co-financed by RDDP-2, supporting the implementation of MCP/MCC Management Information system (MIS) alongside modules that will be linked to Farm and Animal Management System under RAB. In **Tanzania**, milk aggregators/cooperatives will be strengthened to improve their record-keeping and management through a digital MCC management information system (MIS). The project will build a few pilot MCCs capacity to use MIS in coordination with producers/off-takers to facilitate quality-based payments. Digitalization of value chain will be first piloted in Southern Highlands because of the presence and strong interest of the local off-taker; Digitalization of value chain will be facilitated by a technical working group that will include, TADB Mobile Network Operators, FAO, ILRI and other key stakeholders to ensure that the upgraded system takes into consideration other services that will be interlinked such as Milk Collection Centre information system, Feed Assessment tool and digital payments. The project will also capacitate the Tanzania Dairy Board (TDB) to centralise milk data collection. The activities will be co-financed by C-STDP. **In Uganda,** this activity will be co-financed by ReLIV.

8.2.1.3 Activity 2.1.3 Promote renewable energy (RE) and waste management technologies.

445. Efficient and renewable energy for milk cooling and processing for decarbonization of the dairy value chain will be promoted. The Programme will focus on resource use efficiency and the substitution of fossil fuels and firewood by green energy sources such as solar or less wood-intensive energy sources for milk cooling and processing. Insulated vehicles and solar energy supply are typically more suitable solutions for larger MCCs (>3m^3 Litres capacity). At the processing stage, cold-chain and quality preservation solutions (e.g., cooling tanks, insulated / refrigerated trucks) are considered fundamental to business operations, and contribute to reduced milk losses (and less unproductive GHG emissions), yet not always used by small-scale processors. Solar is the key mitigation solution and most applicable to relatively larger processors in the short-term given high upfront costs. Also the management of waste and wastewater will be upgraded. There is limited adoption of waste management solutions along the value chain today. Processors only re-use waste (e.g., by-product whey as feed) selectively and recycling is not a priority. Beneficiaries of the support would be MCCs and SMEs. Activity 2.1.3 will be implemented by (i) the KDB and specialized service provider in Kenya, (ii) the SPIU and Rwanda Energy Group (REG) in Rwanda; (iii) the MLF and TDB in Tanzania and (iv) the DDA, Ministry of Energy and Mineral Development with service providers, in Uganda.

446. *Sub-activity 2.1.3.1 Assess the need and economic viability of renewable energy and waste management solutions*. The aim will be to assess the clean energy needs within dairy cooperatives and propose RE solutions (Photovoltaics Milk Refrigeration Technology - PMRT). PMRT adopts a modified off-the shelf direct-drive photovoltaic refrigerator (PVR), coupled with innovative cooling and energy storage approaches to chill evening milk on the farm for later transport the next morning to dairy collection centres, biogas systems, etc.), equipment that is low in energy use, as well as solid and water waste management solutions. This intervention can be particularly adaptable for on-farm solar milk refrigeration for off-grid dairy farmers, as well as for MCCs and MCPs. The battery-free PVR unit is designed to work optimally in locations with at least 4 average peak sun-hours per day. The system can be used as low as 30 litre milk-can, therefore on-bike milk transporters can utilize this technology. The assessment will look at scale and viability of such investments not just needs and potential tech solutions. Guidelines will also be developed for energy audits and energy efficient measures and create a catalogue of suitable renewable energy technologies and equipment (to be potentially financed under Component 3). Specialized service providers will be mobilized in each country to undertake the assessment.

447. The upfront costs associated with purchasing and installing PV systems can be a significant barrier for farmers and business owners, especially those with limited capital. However, providing upfront capital through grants can reduce this financial barrier and enable farmers to purchase and install essential equipment. This approach also gives them the time to familiarise themselves with the technology and ensure its long-term maintenance. Dairy farmers, in particular, may face challenges in operating and maintaining the equipment. Therefore, capacity building initiatives and technical assistance will be provided to enhance their skills and ensure the sustainability of the infrastructure. Another potential challenge is the intermittency of power supply due to weather conditions. To mitigate this, the integration of energy storage solutions, such as batteries, will be essential. These solutions ensure a consistent power supply to production processes by matching power supply to demand periods.

448. A significant risk associated with the installation of solar systems is inadequate system design, which could lead to insufficient power supply, resulting in milk spoilage and potentially discouraging stakeholders from adopting the technology. A key mitigation measure is to allocate a sufficient proportion of the investment to the technical design of the solar systems. To ensure cost-effectiveness, PV systems should have the capacity to meet the peak demand of the primary consumer. In cases where the consumer expands its production capacity, the PV capacity must be increased and factored into the expansion cost estimate.

449. In **Tanzania**, the sub-activity will be co-financed by C-STDP. It will also include research and development, capacity building and technical assistance to local actors, through implementing partners (SNV, TAREA) to be identified.

450. *Sub-activity 2.1.3.2 Support the acquisition of renewable energy and waste management solutions*. This would include the upgrading or equipping existing and new cooperatives with suitable RE, PV-powered technology for milk coolers for milk aggregation, milk transfer tanks, solar water heaters, water recycling systems, heat exchangers, milk pasteurizers, butter churners and cheese makers. The solar energy will complement the existing electricity from national grid or generated by standby generators to cool down milk to 4 degrees centigrade.

451. In **Rwanda**, the Programme will prioritize MCCs and SMEs in areas with no and unstable access to electricity, as well as small MCCs/MCPs to get access to solar systems. The solar panel directly or hybring will be provided as a grant to MCCs and MCPs to maintain collect chain system for milk delivered from farmers. The solar energy will complement the existing electricity from the national grid of generated by standby generators to cool milk down to 4 degrees centigrade. The Programme could support (i) an assessment of the need and economic viability to support adoption of renewable energy solutions for target dairy cooperatives, MCCs and MCPs; (ii) acquisition of various sizes of solar panels for at least 50 well operating MCCs and 150 MCPs; (ii) access to chargers for electric bicycles at MCCs/MCPs equipped with PV systems; (iii) organization of capacity building in energy efficiency and energy management for the management of dairy cooperatives and MCCs. In Uganda, the project will assess the clean energy needs within DDA-supported dairy cooperatives and propose fit-for-purpose solutions and provide these to the cooperatives. Now cooperatives with suitable RE technologies may be established.

452. In **Tanzania**, Insulated vehicles and solar energy supply are typically more suitable solutions for larger MCCs (>3K l capacity). In addition, at the aggregation stage, up to ~8% milk is lost via spillage and spoilage due to lack of basic inputs (e.g., milk cans), equipment (e.g., cold-chain transportation) and practices (e.g., testing), making collection of sufficient quality milk challenging for aggregators within Tanzania. At the processing stage, cold-chain and quality preservation solutions (e.g., cooling tanks, insulated / refrigerated trucks) are considered fundamental to business operations, yet not always used by small-scale processors. Solar is the key mitigation solution and most applicable to relatively larger processors in the short-term given high upfront costs. There is limited adoption of waste management solutions along the value chain today. Processors only re-use waste (e.g., by-product whey as feed) selectively and recycling is not a priority. solar energy will be launched in Tanga, Morogoro and Zanzibar first, because of the more suitable climatic conditions.

453. *Sub-activity 2.1.3.3 Organize capacity building in energy efficiency and waste management*. This training will focus on the management of the RE solutions the management of dairy cooperatives, small dairy processors and MCCs, as well as technicians of dairy boards. Trainers will be specialized service providers. In **Uganda,** waste management units will be established within existing cooperatives.

8.2.2 Output 2.2: Breeding, animal health, feed and fodder, manure management improved.

454. The pathways to reduce farm-level GHG emissions from dairy cattle are based on the following building blocks[336]: (i) promotion of dairy breeds that are productive, resistant to heat stress and better adapted to climate change; (ii) improving animal welfare, animal health and disease prevention to increase productivity of dairy cattle and reduce mortality, and herd management to optimize the size of the dairy herd; (iii) affordable quality forage and fodder, including high starch forage and access to water harvesting at farm level; (iv) climate-smart feeding practices including the optimization of diet formulation and use of highly digestive feed materials (including those with methane inhibition properties) to reduce enteric methane emissions; (v) manure management and use to contribute to sustainable nutrient recycling and to reduce GHG emissions; and (vi) biogas digesters at farm level to treat manure, recover methane for household energy use, thus reducing on-farm emissions.

8.2.2.1 Activity 2.2.1 Promote the adoption of climate dairy breeds adapted to climate change

455. Breeding and genetic improvement will aim at improving productivity and heat resistance of dairy cattle while preserving resilience of livestock keeping systems by crossing carefully selected indigenous and exotic breeds through AI. Exotic breeds, such as Friesian Holstein or Jersey, are more vulnerable to high temperatures, and consequently to climate change, but present a higher productive potential. Indigenous breeds, despite their lower productive potential and small size, are a reservoir for resilience traits such as hardiness, mobility, rendering them more adaptable to extreme climatic conditions and to certain diseases. Different generations of crossbreeds (exotic x native breeds) would contribute to maintaining the resilience traits of indigenous breeds, while also adding productive traits to the gene pool, increasing the offspring's productivity in milk production, therefore contributing to reducing GHG emission intensity. Available studies shows that improved dairy animals have a significantly lower GHG emission intensity per kg of milk due to their higher production when compared to indigenous breeds. It is important to identify existing local genetic resources with climate smart attributes from which candidates can be selected for cross breeding with exotic ones. Currently, there is dearth of data on level of climate-smartness of the local breeds which warrants research. This activity will be implemented by (i) KALRO and KAGRC in Kenya; (ii) RAB and private sector in Rwanda; (iii) MLF, SUA, TALIRI, NAIC, in Tanzania; and (iv) MAAIF with support from tNARO, the National Animal Genetic Resources Centre (NAGRC&DB), DDA) and private sector in Uganda. Support will be given to scale-up the national breeding strategies with specific focus on productivity and climate resilience of dairy cows.

456. Sub-activity 2.2.1.1 Make good quality semen for climate-smart breeds available, adaptable to extreme climatic conditions and to diseases. In the four countries, the Programme will enhance availability and accessibility of germplasm of exotic that will be crossed with local[337]. This will be achieved through (i) the identification of potential climate-smart cattle breeds to be adopted as well as characterization of existing local genetic resources with desired attributes, appropriate to the agroecological zone; (ii) the import of sexed semen and/or embryos, if needed. Local breeds may be included for IVF and AI if highly desired properties are identified; (iii) the procurement of high genetic merit bulls to produce sexed semen or no-sexed semen for national and regional use; (iii) the production and conservation of climate-smart breeds' germplasm, using laboratory techniques like in-vitro fertilization, or simply AI to multiply the germplasm; and (iv) capacity development of laboratory personnel to produce sexed semen to increase production of dairy heifers. A system for data collection will be used to trace and evaluate the performance of climate-smart animals may be developed as needed, as well as the development of climate-smart breeding standards and AI breeding protocols.

[336] 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
[337] Sahiwal, an indigenous breed that is a relatively high producing breed and resilient and has been adopted in Kenian pastoral communities as a means to improve milk production.

457. *Sub-activity 2.2.1.2 Invest in breeding and AI centres*. To solve bottlenecks in AI and embryo transfer, the Programme will support scaling up capacities for production and distribution of liquid nitrogen, semen, and embryos. This includes the availability of liquid nitrogen, storage and quality control equipment, dry ice pilots for conservation of semen, and other specialized equipment. In addition, the following investment will be supported. In Kenya, the programme will involve the Kenya Livestock Breeders Association, which is specialised in extension and training, breed inspection and registration, performance recording and reporting and feedback. In Rwanda, the Programme will support establishment of semen and liquid nitrogen storage and distribution centers. In addition, the existing bull centre in Songa Station will be supported to acquire micro-manipulators to produce sexed semen and embryos to enhance semen production operations. Moreover, RAB will be strengthened in record keeping and continuous updates of the Studbook to identify resilient and high productive crossbreeds.

458. In **Rwanda,** the new National Artificial Insemination Centre built and equipped under RDDP will be completed with an In Vitro Fecundation (IVF) laboratory that will allow local production of large quantities of high-quality embryos which will be a cost-effective local alternative to importation of pedigree bulls and cows. However, in order to increase semen production capacities of the centre in the short term, 10 elite bulls will be imported to complement the 10 existing ones provided under RDDP which cannot fully meet the semen needs. Access road rehabilitation to the centre will also be supported to ensure a better connection to the public road network. A third Liquid Nitrogen (LN) RAB-managed production unit will be established in Eastern Province to address the increasing need of LN for AI and ECF vaccines conservation. Local LN and semen storage, distribution facilities, and semen quality control equipment, will be installed in some Districts, under the management of cooperatives of private veterinarians, and will be placed either in veterinary posts, in MCCs, or in the offices of the private vets cooperatives. this set of activity including training, support to installation, and support to saving and loan mechanism will be implemented through a MoU with an implementation partner. The experience of RDDP has shown that SPIU or RAB do not have comparative advantage to support this privatization process mostly because of their institutional position. Implementation could happen through service providers, for example the Rwanda Council of Veterinary Doctors which was in charge of similar activities under RDDP, although experienced some challenges related to implementation effectiveness; or an international partner could be selected, for example, *Vétérinaires Sans Frontières* – Belgium which has a good reputation and experience in the country and beyond.

459. In **Tanzania**, The NAIC, based in Arusha, will be capacitated to produce sexed semen and to establish a sub-center in Southern Highlands. A PPP arrangement could be developed for its management, in the absence of capacity and financial autonomy of NAIC. The conservation of semen in carbacid (dry ice) will be piloted in Zanzibar, and the feasibility of establishing an LN unit there assessed, enabling the conservation of semen and vaccines for 10 days without efficiency loss, and requires only a small investment. In areas where AI technicians have not been trained, they will be, and equipped with start-up kits. The training will be delivered by NAIC, and the startup kit procured and delivered by the project based on ANIC specifications. NAIC will be in charge of managing the new AI sub centre and LN plant and training the new AI technicians; feasibility studies (for new LN plants and carbacid pilot) will be undertaken by private consultants selected on a competitive basis. The sub-activity will be co-financed by C-SDTP.

460. In **Uganda,** there are two operational liquid nitrogen plants, one in Western Uganda, one in Entebbe, which is not enough to cater for the needs of the whole country, and Eastern and Northern Uganda being from production points are the least well served regions. 4 regional AI sub-centers will be established, in order to improve distribution and availability of LN and semen. These centers will be composed of a simple but secured building, equipped with LN and semen storage and transport tanks. AI technicians will be able to LN and semen from these centers, instead of Entebbe as it is currently the case. The activities will be co-financed by ReLIV. This investment will strengthen the National Animal Genetic Resources and Data Bank to improve the production and access to high-quality semen in small and medium size farms. NAGRC owns several breeding ranches including three in the project area. In these ranches, breeding stock of exotic and local breeds is raised for conservation, genetic improvement and dissemination. The project will provide support to the 3 ranches to improve their infrastructures (fencing to prevent intrusion of animals from neighbouring communities, rehabilitation of buildings), and purchase elite parental breeding stock (mostly bulls, e.g. boran bulls from Kenya). The sub-activity will be co-financed by ReLIV.

461. *Sub-activity 2.2.1.3 Scale up the insemination of dairy cattle to make the herd more productive and climate resilient*. The Programme will (i) train AI technicians, who can be private inseminators, para-veterinarians, lead farmers of L-FFS and District livestock officers (at least 30 percent youth and 40 percent women); (ii) scale up the insemination of dairy cattle in the Programme intervention area; (iii) include aspects of the interaction between dairy cattle husbandry and climate change in the L-FFS curriculum. In **Kenya,** the Programme will support the National Breeding Strategy and Action Plan, in collaboration with the Kenya Livestock Breeders Association. Public and private partnerships (PPP) will be promoted to have AI services accessible to the farmers. In **Rwanda,** the breeding programme of RAB will be scaled up including the training of more private AI technicians. In **Tanzania,** 110 additional technicians will be trained and equipped with start-up kits. In addition, bull centers will be established in regions where AI is not available. **In Uganda,** more AI technicians will be trained by the National Animal Genetic Resources and Data Bank and will be equipped with AI kits focusing on the regions where AI services are still poorly developed. Digital solutions (e.g. Dairycow Africa, My Fugo, or iCOW) will be promoted for farmers access to AI and herd management/record keeping services.

462. *Sub-activity 2.2.1.4 Organize awareness campaigns and support breeders' organizations*. The campaigns will target members of dairy cooperatives and L-FFS groups to create awareness on the use of sexed-semen, thus impacting the herd's sex ratio, and further reduce absolute GHG emissions and the emission intensity per kg of milk produced mainly by replacing a large number of low-productive local cows with a few adapted and high performant crossbreeds, thus reducing the herd size. In the four countries, support will be given to create or strengthen breeders' associations and societies for animal involving registration and maintenance of breeding standards.

8.2.2.2 Activity 2.2.2 Provide support for better animal care, herd management and disease prevention.

463. In East Africa, infectious diseases and parasites rank among the primary causes of livestock productivity and production loss. Production losses through reduced performance (growth rates, milk yield) or animal loss through morbidity, mortality, and abortion results in cows with relatively high GHG emission intensities. These losses affect people's resilience to climate change, livelihoods and nutrition security and can affect human health through zoonotic disease transmission. In addition, the growing importance of zero-grazing systems has implications for animal welfare, thus farmers will be encouraged to consider animal well-being aspects. This activity will be implemented by veterinary services and (i) KALRO and County Governments in Kenya; (ii) RAB, RCVD and the LGAs in Rwanda; (iii) MLF and LGAs in Tanzania; and (iv) MAAIF/DAR , DLGs and the private sector in Uganda.

464. Sub-activity 2.2.2.1 Organise trainings on animal husbandry, with a specific focus on animal health, animal welfare, herd management and disease prevention. Updated modules of the L-FFS training on animal health and welfare, and herd and reproduction management will be implemented. Dairy farmers will receive training to better care for the animals and to adopt biosecurity measures to prevent common diseases and pests that impact the production or suitability of the milk for human consumption. They will also receive support to better manage their herds, reproduction calendar, and animal nutrition to reduce animal mortality, heat stress and increase productivity, thus further reducing absolute CH_4 emissions and the emission intensity per unit of milk produced.

465. *Sub-activity 2.2.2.2 Scale up the use of digital apps to monitor animal health and herd performance.* Digital record keeping on-farm (e.g., with the use of iCow, DigiCow Africa, My Fugo, i-EDSR, AMIS) will be scaled up to monitor the productive and health performances of the herd (e.g., records of calf mortality and causes, number of lame animals), to plan artificial insemination, guide herd management, and rapid disease identification diagnostic tools. The use of the app will be promoted through the L-FFS in interested groups. The support includes: (i) training of L-FFS lead farmers on the use of the apps; (ii) guiding L-FFS farmers in the use of the technology; (iii) equip the farmers in the pilot with digital tools. To implement the sub-activity, the Programme will work with agritech companies and start-up to develop digital solutions that will enhance transparency in farm data and operations, monitoring of CH4 emissions reduction and traceability of milk products. In Tanzania, technical advisors of the TDB will be trained on the use of digital apps to facilitate herd performances record keeping, for example using iCow. Trained advisors will support and guide farmers in the use of the technology.

466. *Sub-activity 2.2.2.3 Scale-up vaccination campaigns to mitigate the impact of climate change on the spread of diseases.* The Programme will scale up and extend the vaccination campaigns to target in priority the dairy farmers in the Programme area, who are members of various cooperatives and L-FFS. The vaccination campaign will focus on: (i) the spread of ECF, CBPP and Heartwater disease to new production areas through an extended vaccination campaign, in Kenya, targeting dairy farmers who are members of various cooperatives as well as milk cooling plants and satellite milk coolers owned by larger processors; (ii) ECF, RVF and FMD (among others) in Rwanda; (iii) ECF, FMD, RVF, LSD and CBPP in Tanzania, in areas where the diseases are prevalent and timed with cow placements.; (iv) trans boundary animal diseases (TADs) e.g., ECF, FMD, CBPP, and LSD in Uganda. Attention will also be given to finalization of nationally developed vaccines currently under development for FMD and tick.

8.2.2.3 Activity 2.2.3 Promote climate-smart forage production and conservation, and water harvesting.

467. The adoption of climate resilient forage varieties and conservation technologies is essential to reduce enteric methane emissions intensities in the dairy value chain, while increasing milk yields of dairy cattle[338,339,340]. The benefits are multiple and encompass climate change adaptation through adoption of a resilient forage variety (*Lablab purpureus, Brachiaria sp., Cenchrus purpureus* (Napier grass)*, Leucaena, Calliandra, Panicum maximum* (Giant Panicum)), improvements in soil fertility and increased capacity of farmers to meet forage production needs during dry periods and to respond to climate-induced pests and diseases. This activity will be implemented by (i) KALRO and private seed multiplicators in Kenya; (ii) RAB and LGAs in Rwanda; (iii) MLF, Tanzania Official Seed Certification Institute (TOSCI), Vikuge and Pasture seed farms and LGAs in Tanzania; and (iv) MAAIF / NARO and private sector or service providers in Uganda.

468. *Sub-activity 2.2.3.1 Make certified forage seed available to private and community multipliers*. In the four countries, this sub-activity will (i) support the multiplication of breeder and foundation seeds for climate-smart, emission-reducing fodder by the national mandated public services; (ii) facilitate a seed certification scheme and sensitize the private sector to produce certified forage and fodder seeds, and (iii) facilitate the establishment of a functional pasture seed system clearly delineating the different players and their roles. it is expected that demonstrations on fodder production conducted through L-FFS will create a sufficient demand for fodder seeds, and that this demand will be sufficient to make the seed production business profitable and sustainable, once the project will stop buying seeds for subsidized distribution. Lessons from Rwanda using a similar approach indicate that fodder seeds production has become a profitable business, sometimes even more than dairy production.

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[338] FAO & New Zealand Agricultural Greenhouse Gas Research Centre. 2017. Supporting low emissions development in the Ethiopian dairy cattle sector – reducing enteric methane for food security and livelihoods. Rome. 34 pp.

[339] 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. https://www.fao.org/3/ca3375en/ca3375en.pdf

[340] 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. https://www.fao.org/3/ca3215en/CA3215EN.pdf

469. In **Kenya**, priority will be given to production and conservation (seed production, grass seed banks) for e.g. Cenchrus ciliaris, Chloris gavana, Eragrostis superba.

470. In **Rwanda**, fodder seeds producers in all 27 targeted districts will be supported with technical and business management training, seeds production and processing equipment and vegetative propagation materials. The Programme will collaborate with other initiatives such as USAID Feed the Future Programme to leverage on diet formulation app such as MODRAFT (in Kinyarwanda) developed by University of Florida, IESC, United States Development Assocuation and Market-Oriented Dairy or ILRI's on-farm feed advisor. The sub-activity will be co-financed by RDDP-2.

471. In **Tanzania**, 5 resilient fodder seed producers will be targeted per district (110 in total), with technical and business management training, seeds production, and processing equipment. During the first years, the Programme will distribute the seeds through the L-FFS and cooperatives. In Zanzibar, the centre of seeds production and multiplication unit provides fodder seeds to the dairy farmers and will be supported. The fodder seeds certification scheme by the Tanzania Seed Certification Institute (TOSCI) will be supported. A study on possible role of Government Farms in provision of seeds and fodder will also be commissioned. The activities will be implemented by the Districts. The sub-activity will be co-financed with C-SDTP.

472. In **Uganda,** support will be provided to support on-farm, climate resilient forage production though mapping stakeholders and their needs as well as awareness creation. Start-up kids will be provided to L-FFS to introduce intensive or semi-intensive practices such as precision feeding and the use of agroforestry leguminous fodder seeds and providing fodder choppers/cutters. The sub-activity will be co-financed by ReLIV.

473. *Sub-activity 2.2.3.2 Support multiplication of climate-resilient seed for fodder crops and pastures.* This sub-activity will include contracting community and private seed multipliers (including the youth and women) for multiplication, conservation and certification of forage and pasture seeds. **In each of the four countries,** the standard approaches will be used to multiply seeds and make available for the L-FFS, PFS, cooperative members other groups involved in the Programme.

474. Sub-activity 2.2.3.3 Build capacity of dairy farmers on forage production and conservation on intensive and semi-intensive dairy farms. The L-FFS will be the knowledge-sharing vehicle to promote improved forage production and conservation. The L-FFS will focus on (i) training on good forage management practices (e.g., grass and legume intercropping, agroforestry, weed management, use of biochar), (ii) training and demonstration on small-scale irrigation to produce forage crops; (iii) training and demonstrations of mechanization of forage production with fodder choppers/cutters and conservation equipment; (iv) training and demonstrations on forage conservation practices, to respond to seasonal feed availability and quality (e.g., protein content, digestibility etc.) variations. Youth groups will be supported to venture into commercial hydroponic forage production. In **Kenya,** in the ASALs (Marsabit and Samburu), the Project will promote fodder production in county farms to act as supplementation to grazing animals as well as fodder reserves for the drought seasons. The ongoing initiatives for 'fodder gardens' and legume intercropping to support adaptation approaches for traditional systems, based on improved feeding and focused on small scale farmers or pastoralists, would be scaled up through regional collaboration programmes, with spillover effects in terms of reduced emissions. The programme would also assess the development of feed and fodder production, including low-methane yield feed and concentrates that can be locally produced to substitute imports. In **Rwanda**, The Uruhimbi Kageyo Cooperative is a successful example in promoting innovative pasture production. Youth will be facilitated to venture into commercial hydroponic forage production. In Uganda, the Government agencies operate feed production hubs. Their capacities will be assessed, and infrastructure be provided. Theu will also be used to demonstrate business viability to the private sector. In intensive and semi-intensive dairy farms, implementation of destocking and restocking will be promoted. This entails sale of animals during the dry season and restocking during the high feed availability seasons to reduce pasture pressure.

475. *Sub-activity 2.2.3.4 Access to water for animals and forage production in intensive and semi-intensive dairy systems.* In **Kenya and Uganda,** the Programme will provide small-scale equipment for rainwater harvesting and recycling (e.g. individual dam sheets, 3m^3 rooftop water tanks and water distribution kit) at household level; as well as construction and rehabilitation of charco dams in semi-grazing system areas. The Programme will provide the liner and the beneficiaries will prepare the site. Feasibility studies will be conducted before the start of the work to assess sustainability. Water infrastructure design will follow the local government authorities guidelines. In **Rwanda,** low-cost small-scale water harvesting systems in zero grazing will be constructed, and co-financed with the IFAD-funded RDDP-2. **In Tanzania,** at household level, the Project will facilitate the construction of small-scale water harvesting systems in zero grazing systems, and of individual dam sheets. Solar-powered boreholes and charco dams will also be installed and/or rehabilitated in semi-grazing system areas. The sub-activity will be co-financed with the IFAD-funded C-SDTP.

8.2.2.4 Activity 2.2.4 Promote climate-smart feeding practices to reduce enteric methane emissions.

476. Appropriate diet formulation, based on the available resources, is a key requirement to improve dairy cattle productivity, improve welfare, while reducing methane (CH4) emissions. Balanced diets (more energy-dense or more digestible) decrease retention time in the rumen, leading to a reduction in ruminal fermentation and methane yield (kg CH4/kg dry matter intake). Better nutrient utilization (e.g., avoiding deficiencies or surpluses) can also contribute to reducing the environmental impact of livestock. The Programme will support the feed packages and plans, build national capacity of appropriate feed formulation, and promote these technologies through L-FFS and others. Also the capacity of feed testing in each of the countries will be strengthened. This activity will be implemented by: (i) KALRO, SDLD in Kenya; (ii) RAB and UR-CAVM and LGAs in Rwanda; (iii) MLF, SUA, TALIRI and LGAs in Tanzania; (iv) the MAAIF (NARO), in collaboration with NGOs and private service providers in Uganda.

477. *Sub-activity 2.2.4.1 Develop production system-specific supplementation plans and feed packages*, based on available feed resources (energy or protein depending on the limiting nutrient, e.g. Urea Molasses Mineral Blocks[341]). **In the four countries,** the national research institutions will develop feed plans and packages for the main national dairy production systems. Biochar as an edible feed supplement will be promoted. Feed formulation will be included in the curriculum of the L-FFS. This sub-activity will benefit from the Programme's partnership with ILRI, as well as its regional knowledge sharing platform.

478. *Sub-activity 2.2.4.2 Build capacity on appropriate feed formulation*. In each of the four countries, the Programme will support the capacity development of technical advisors, cooperative management, small-scale dairy feed processing plants and L-FFS lead farmers on sustainable animal feed formulations such as total mixed rations (TMR) to enhance productive efficiency and to mitigate GHG emissions. In **Kenya,** the project will (i) develop capacity for and carry out biennial national feed inventories and feed balance sheets based on FAO Guidelines[342] and tools to inform feed planning and budgeting, (ii) train cooperatives, model farmers, KALRO, SDLD, and County Extension Officers on use of existing diet formulation digital tools such as the SNV-developed Rumen8 or Feed assessment tool (FEAST) and later disseminate this information using L-FFS, (iii) Support the National Livestock Farms in the targeted counties (Oyani, Marimba and KALRO Dairy Research Institute Farm) to establish large-scale demonstrations on highly digestible forage and fodder with emission-inhibiting properties (adaptable forage species such as desmodium, lucerne, mulberry trees for mixed systems, and Leucaena and Calliandra fodder trees for pastoral systems), fodder banking and seedling production and multiplication. Another sub-activity will replicate (iii) at county level. In **Tanzania,** the capacity of TDB technical advisors will be built on sustainable feed formulations, to provide farmers with specialized consultancy services. TALRI will be the main target of capacity enhancement of research institutions.

[341] FAO. Feed Supplementation Blocks. FAO Animal Production and Health Division. Paper 164. 2007
[342] https://www.fao.org/publications/card/fr/c/CA9111FR/

479. *Sub-activity 2.2.4.3 Promote appropriate diet formulation that reduce enteric methane emissions*. In the four countries, the L-FFS and the dairy cooperatives will be the vehicle to reach out to dairy farmers and promote appropriate feeding of dairy cattle. The Programme will: (i) provide start-up kits for L-FFS to monitor diet formulation to reduce methane yield (e.g., Rumen8 tool by SNV); (ii) run L-FFS of feed formulation, including on the use of agroforestry leguminous fodder trees with methane inhibiting properties such as *Calliandra Sp.* for improved feed supplementation and carbon sequestration; and (iii) pilot studies to establish regional/country-specific CH4 emission factors for region/country-specific models to enhance the precision of greenhouse gas emission estimations. The programme will also pilot and leverage on the existing innovative enteric methane inhibitors used as mixtures in feed to be adopted in zero-grazing and commercial/intensive systems.[343]

8.2.2.5 Activity 2.2.5 Increase sustainable nutrient recycling from manure and dairy waste to reduce emissions.

480. Livestock manure is a source of methane (CH_4) and nitrous oxide (N_2O) emissions as well as of pollutants such as ammonia (NH3) and nitrate (NO3-). At the same time, manure contains essential nutrients and is often the primary source of crop fertilization on smallholder dairy farms because mineral fertilizer is either too expensive or not available.[344] Moreover, its costs have further increased due to recent political events (COVID-19 pandemic, Ukraine war.[345] Many smallholder farms are nutrient limited, which restricts crop yields[346,347]. The circular management of farm nutrients via livestock manure is the best scalable option to overcome these limitations, improve soil health, and improve on-farm productivity. This positively affects livestock productivity because better manure management also improves the nutrient availability for feeds and forages, which increases their growth, biomass yield and nutritional quality and ultimately improves dairy production. In addition, manure application reduces soil nutrient mining and soil degradation and prevents additional CO_2 emissions from loss of soil organic carbon. This activity will be implemented by (i) SDLD, KALRO, KBP in Kenya; (ii) RAB and LGAs in Rwanda; (iii) MLF, TDB, LGAs in Tanzania; and (iv) MAAIF (NARO), ZARDI, and implementing partners (e.g. SNV, Heifer) in Uganda. Training materials have been developed by ILRI and NARO (Uganda).

481. *Sub-activity 2.2.5.1 Manure management in intensive and semi-intensive dairy production systems*. The Programme will create awareness and build capacity on manure management and compositing for soil health and soil microbiome improvement. Farmers will be reached through L-FFS (e.g., manuals developed by ILRI) to promote different low-cost manure management practices (e.g., use of biochar, covering with polythene or banana leaves, manure ponds, compaction). The activity will consist in providing trainings through L-FFS and demonstration farms, using existing manuals developed by NARO in Uganda, ILRI, etc.) on scalable and already tested manure management practices (pit storage/ manure ponds, manure covering with banana leaves, compaction) and manure use applications offering livelihoods opportunities.

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[343] FAO. 2023. Methane emissions in livestock and rice systems – Sources, quantification, mitigation and metrics. Rome. https://doi.org/10.4060/cc7607en

[344] Sheahan, M., & Barrett, C. B. 2017. Ten striking facts about agricultural input use in Sub-Saharan Africa. Food policy, 67, 12-25. https://doi.org/10.1016/j.foodpol.2016.09.010

[345] Alexander P, Arneth A, Henry R, et al (2022) High energy and fertilizer prices are more damaging than food export curtailment from Ukraine and Russia for food prices, health and the environment. Nature Food 2022 4:1 4:84–95. https://doi.org/10.1038/s43016-022-00659-9

[346] Leitner S, Pelster D. E., Werner C, et al. 2020. Closing maize yield gaps in sub-Saharan Africa will boost soil N_2O emissions. Curr Opin Environ Sustain 47:. https://doi.org/10.1016/j.cosust.2020.08.018

[347] Mueller ND, Gerber JS, Johnston M, et al. 2012. Closing yield gaps through nutrient and water management. Nature 490:254–257. https://doi.org/10.1038/nature11420

482. In **Kenya,** the Programme will (i) implement trainings for technical staff in target Counties on biogas valorisation - Zero waste technology, (ii) handle gender-inclusive capacity building of farmers and processors on manure and nutrient-rich bio-slurry and dairy effluent management and (iii) provide business development support for dairy single or mixed gender cooperatives and farmers who want to produce bio-slurry for their operations or commercial purposes. As a result, participating producers will enhance the recycling of nutrients (nitrogen, phosphorous, micro-nutrients) from animal manure (or digesta) to arable and grassland to increase soil fertility. Capacity building on compositing will be given attention to efficiently use both waste from the farms, manure and kitchen waste and proper application of the compost to the fodder plots demonstrated.

483. In **Rwanda**, the Programme will create awareness on manure management and composting for soil health and soil microbiome improvement.

484. In **Uganda**, extensive systems (pastoral and agro-pastoral) will establish L-FFS to promote manure collection from communal kraals for income generation and establish manure sheds at community level. Selecting knowledgeable local partners is critical, as they can facilitate adoption, provide training, and offer ongoing support to ensure successful implementation. Furthermore, investment in applied research addresses technical challenges, improves technology efficiency, and contributes to the continuous improvement of biogas systems. In addition, thorough training equips smallholders with the knowledge and skills needed to properly operate and maintain biodigesters, ensuring long-term functionality. Engaging the local community and raising awareness promotes acceptance and ownership and involves community members in planning and decision-making processes. Finally, establishing a comprehensive M&E system is essential to track progress and identify challenges early on, providing evidence for timely adjustments to the implementation strategy. Specialised service providers will be mobilized to carry out adoption and feasibility assessments. Solar energy and waste management solutions at MCCs and at MCPs will be implemented by tDDA, the Ministry of Energy and Mineral Development (MEMD), and MWE. A consulting firm will be engaged to provide technical assistance for design and implementation. Other partners, such as Heifer International and SNV, will be consulted for potential synergies. This activity will be implemented in partnership with ReLIV.

485. For interventions related to biochar promotion in the four countries, the Programme will explore partnerships with IITA, in agreement with the Programme Coordination Units in the four countries.

486. *Sub-activity 2.2.5.2 Promote adapted animal housing*. The Programme will promote adapted animal housing for manure management with the possibility of separating solid and liquid manure. There is already good example of animal housing promoted by Heifer International that can be scaled up.

487. *Sub-activity 2.2.5.3 Manure management in extensive systems (pastoral and agro-pastoral dairying regions)*. The Programme will: (i) run L-FFS/PFS for promoting manure collection from communal kraals for use, sale/ income generation at community level; and (ii) establish community manure sheds to promote manure collection, storage and covering for better manure management and reduce emissions.

8.2.2.6 Activity 2.2.6 Build capacity for on-farm use of biodigesters and biogas.

488. Biogas digesters utilize microorganisms to decompose organic materials such as livestock manure or other organic waste, during which biogas and a nutrient-rich co-product called digestate or bioslurry are produced. This technology offers a clean energy source, potentially serving 2.3 billion people worldwide who lack access to clean cooking fuels[348]. Furthermore, it creates a biofertilizer, reduces manure methane emissions (up to 70-90percent compared to liquid manure storage)(Steinfeld et al. 2006)[349], and emissions of ammonia and nitrous oxide (Mohankumar Sajeev et al. 2018)[350]. In addition, biodigesters can avoid 4 million deaths annually related to household air pollution[351], reduce deforestation, and empower women by decreasing their time spent collecting firewood[352]. Manure management using biogas digesters is particularly attractive for intensive and semi-intensive dairy systems. As part of the low-carbon pathways, the Programme will promote on-farm adoption of biodigesters for intensive and semi-intensive dairy farms. Bio-digesters will contribute to produce energy for cooking and electricity generation for use on the farm, and to generate a biologically safe, nutrient-rich slurry for use as organic fertiliser on nearby fields. The activity will be implemented by (i) SDLD, Ministry of Energy and Petroleum (MoEP) (State Department for Energy) in Kenya; (ii) RAB and REG in Rwanda; (iii) MLU, the Centre for Agricultural Mechanisation and Rural Technology (CAMARTEC), MoE in Tanzania; (iv) the MAAIF (NARO), Ministry of Energy and Mineral Development, private sector service providers to support installation and other specialized implementation partners in Uganda.

489. *Sub-activity 2.2.6.1 Support capacity building in biodigester construction and management*. The Programme will support trainings and accreditation of biodigester technicians, particularly with the focus on women and youth, in target districts, scaling up results achieved by the Tanzania Domestic Biogas Programme, part of the overarching Africa Biogas Partnership Programme, implemented by GDIS, Hivos and SNV. In addition to aspects related to the installation of biogas valorisation and quality management, including safe working standards. In Rwanda, biogas has not taken off, due to high capital and maintenance costs, limited financial mechanisms, lack of quality control measures, limited institutional coordination and collaborate. Capitalizing on lessons from the National Domestic Biograd Programme, starting in 2007, the Programme will serve as a platform to identify and eventually correct the shortcomings that hinder the development of biogas in Rwanda, through feasibility studies and analysis of in-country experiences, as well as the promotion of the newest technologies that are available. Once studies confirm the viability of biogas in Rwanda, the Programme will identify private companies and financial institutions to support the development and of a comprehensive product including provision of equipment, technical support and financing, based on the model existing in other countries in the Region. The Programme could also promote the installation of biogas facility at targeted household building on the lessons learnt from the recent project on home biogas implemented by UNDP.

[348] International Energy Agency (IEA). 2020. The Energy Progress Report, 2020. Paris. https://www.iea.org/reports/tracking-sdg7-the-energy-progress-report-2020

[349] Steinfeld H, Gerber P, Wassenaar T, et al. 2006. Livestock's Long Shadow: Environmental Issues and Options. FAO ftp://ftp.fao.org/docrep/fao/010/A0701E/A0701E00.pdf 1–377. https://doi.org/10.1007/s10666-008-9149-3

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[351] International Energy Agency (IEA). 2020. The Energy Progress Report, 2020. Paris. https://www.iea.org/reports/tracking-sdg7-the-energy-progress-report-2020

[352] Clemens H, Bailis R, Nyambane A, Ndung'u V. 2018. Africa Biogas Partnership Program: A review of clean cooking implementation through market development in East Africa. Energy for Sustainable Development 46:23–31

490. *Sub-activity 2.2.6.2 Support the investments in biodigesters at the household level*[353]*.* The Programme will support investments in biodigesters for dairy farms in the Programme intervention area. In **Tanzania,** Biogas construction enterprises, constructed under CAMARTEC will be responsible for the construction of biodigesters. in addition to investments in Mainland, a pilot phase in Southern Highlands and Zanzibar will be scaled up, through the engagement of local partners and the private sector (MFIs). Biogas digesters will be installed at the household level, scaling up the results achieved by the Tanzania Domestic Biogas Programme part of the overarching Africa Biogas Partnership Programme, implemented by DGIS, Hivos and SNV. Biogas construction enterprises, organized under the CAMARTEC, will be engaged throughout the country and will be responsible for the construction of bio-digesters. There will be a preference for fixed-dome modified CAMARTEC designs (MCD) or fixed-dome solid state digesters (SSD) which are better adapted to dry areas as less water demanding (1:0:25 dung to water/urine ratio). There will be a pilot phase in Southern Highlands and in Zanzibar, followed by a scaling up phase in other places, based on feasibility mapping, through engagement of local partners and the private sector (MFIs/SACCOs). Activities will also include research and development, capacity building and technical assistance to local actors, through implementing partners (SNV, TAREA) to be identified, with the objective of developing a commercially viable and market-oriented biogas sector. Operation and maintenance, quality management, extension on the application of bio-slurry (and linkages with kitchen gardens for improved nutrition), institutional support and digitalized M&E will also be necessary activities to ensure the investments are successful. The poor and near-poor smallholder farmers with 1-2 and 3-5 dairy cows respectively will be targeted. Other activities will include research and development, capacity building and technical assistance to local actors, through implementing partners (SNV, TAREA) to be identified.

8.2.3 Output 2.3: Pasture and grasslands management improved.

491. Many dairy producers rely on pastures and grasslands as main feed resource, which are constrained by limited water availability and follow seasonal rainfall patterns. Well-managed and restored pastures and rangelands increases climate resilience through healthier ecosystems, improved water retention in soils, biodiversity conservation, and mitigate environmental risks – such as land degradation. In addition, to reduce emissions from dairy production systems, the Programme considers soil carbon sequestration as an important pathway of GHG emission removals to offset livestock and manure emissions. Well-managed rangelands not only improve the carbon balance of the livestock production systems, but they are also more productive (increased biomass yield) and improve the animal diet and reduce enteric CH4 emissions.

492. The success of implemented grassland management and restoration practices will be closely monitored. This activity will be done through the MRV system established output 1.3 (see activity 1.3.1.1), with the support of ILRI.

Textbox 15: Interventions for rangeland management, lessons from Research projects implemented by ILRI

In the intervention area, grasslands can be roughly classified into two main systems, based on water availability. These include: (i) arid and semi-arid grasslands/rangelands in Kenya and Tanzania, and (ii) humid and semi-humid grasslands/ rangelands in Uganda and Rwanda.

Humid and semi-humid grasslands in Uganda and Rwanda: in these systems, planted pastures are common, and many livestock keepers are using or willing to use improved forage grasses such as Napier (*Pennisetum purpureum*), Brachiaria sp., Rhodes grass (*Chloris gayana*), amongst others. Potential management practices include paddocking, rotational grazing, strip grazing, and cut-and-carry. Fertilization of grasslands is key to ensure high productivity and nutritional quality as well as long-term soil health, but is not common since mineral fertilizers are expensive, and livestock keepers don't have the equipment to use manure as fertilizer at a large scale. Livestock grazing on pastures can partly compensate for nutrient removal via manure deposition. In case of moderate to severe grassland degradation, several restoration practices can be considered for humid and semi-humid grasslands. As part of the Restoring Degraded African Landscapes (ReDEAL) project, ILRI found that superficial tillage to break the soil crust, manure application, and mixing with topsoil to reintroduce beneficial soil microorganisms show promise

[353] Scaling up the results achieved by the Tanzania Domestic Biogas Programme part of the overarching Africa Biogas Partnership Programme, implemented by DGIS, Hivos and SNV

to enhance grassland productivity, biodiversity, and improve ecosystem functioning and soil health. In case of severe topsoil loss and loss of the indigenous seedbank, reseeding can also be considered.

Arid and semi-arid grasslands in Kenya and Tanzania: in these systems, rainfall is much more limiting, and drought tolerance of grassland species is key. Here, grasslands are usually dominated by indigenous natural vegetation. Options for management and restoration practices include seasonal resting, packed grazing followed by resting, and enclosures. To avoid feed scarcity during droughts, dedicated dry season grazing reserves and feed preservation are key. Also, planted irrigated forage plots along rivers can help to improve feed availability. In case of shrub encroachment, shrub clearing and controlled burning might be necessary. Reseeding is often not feasible because land areas are too big and germination progress is limited by rainfall. As long as topsoil is not lost and the seedbank is viable, restoration practices should aim to work with dormant seeds that are present. Only in cases of severe topsoil loss and/or changes in vegetation composition due to invasives, reseeding will be necessary.

Cattle resting area. Photos from field visits, Uganda, October 2023.

Research from ILRI has shown that cattle enclosure and cattle resting areas are significant hotspots of GHG emissions and nutrient losses. *See **Butterbach-Bahl K**, Gettel G, Kiese R, Fuchs K, Werner C, Rahimi J, Barthel M and **Merbold L** (2020) Livestock enclosures in drylands of Sub-Saharan Africa are overlooked hotspots of N2O emissions.* Nature Communications *11*, https://doi.org/10.1038/s41467-020-18359-y

8.2.3.1 Activity 2.3.1 Strengthen rangeland governing structures for communal grazing areas.

493. The sub-activity will be mainly implemented **in Kenya** (by SDLD, KALRO, County Governments and NLC) **and Uganda** (by MAAIF, with DDA and NARO, as well as DLGs). This activity will finance interventions to improve rangeland management (including access to water). Engagement and awareness raising among local stakeholders involved in landscape management is essential for locally-led adaptation and people-centred planning. Involving communities in the planning, implementation and maintenance of rangelands fosters a sense of ownership and encourages responsible use of ecosystems. In addition, the integration of traditional knowledge with science-based techniques contributes to the longevity of interventions. The sub-activity will be mainly implemented in Kenya (by SDLD, KALRO, County Governments and NLC) and Uganda (by MAAIF, with DDA and NARO, as well as DLGs) where. In each country, facilitators specialised in participatory rangeland management will be mobilized if needed. Other partners – such as ILRI – will be involved.

494. *Sub-activity 2.3.1.1 Participatory rangeland management planning*. In a selected number of districts/counties, the Programme will (i) map and carry out a capacity assessment of the existing community governance structures (including gender aspects), formal (e.g., village land committees, environment committees, water use committees, local government, district) and informal (grazing committees, traditional committees, clan heads/ opinion leaders) entities; (ii) carry out participatory planning for rangeland management to produce pasture and rangeland management plans, including land tenure to secure tenure rights, and (iii) support the development, reviving and strengthening laws and by-laws governing the communal resource-use (pasture and water).

495. More particularly in **Kenya,** the project will (i) carry out an assessment of rangeland governance systems, (ii) promote gender-sensitive participatory rangeland mapping (using for e.g. FAO's sustainable rangeland management guidelines) to identify and prioritise degraded rangelands, and articulate investment priorities (including water access, as well as markets to increase animal offtake and decrease stocking rates) for the protection/ rehabilitation of key grazing resources and seasonal access, (iii) enhance local-level governance, by supporting development of appropriate by-laws, recognition of local institutions and capacity building in by-law formulation and facilitation, together with the County Government, (iv) support communities in incrementally securing tenure rights, with particular focus on women's rights. It is expected that these activities will deter/reduce incidences of conflicts which are exacerbated by climate change. More particularly in **Uganda**, the project will produce pasture and rangeland management plans. The PMU will hire experts /NGOs to engage with the communities, and establish participatory work securing land use rights and making communal grazing, seeding, planting and water use plans. The PMU will hire experts/researchers that monitor and provide feedback to the project on the progress that is made. Last, the PMU will hire experts for external audits of the governing entities and if not covered by the facilitating NGO/experts, cultural norms change / GALS specialists. The sub-activity to be co-financed by the IFAD-funded ReLIV.

Textbox 16: Principles for sustainable rangeland restoration and pasture management

Sustainable rangeland restoration and pasture management will start with land use planning (which land is for crops or rangeland), followed by securing land tenure (customary rights/title deeds). Communities and land will be selected, that align with the targeting strategy and number of hectares required, in contiguous lands preferably forming large stretches of land under restoration and best practices. Experts /NGOs will be hired to engage with the communities, and establish participatory work securing land use rights and making communal grazing, seeding, planting and water use plans. For implementation of the plans, capacity building with the pastoralist and formation and maintenance of governing platforms/institutions for participatory rangeland management, and technical support will be required. The restoration will also require grazing tools, establishment of water use and maintenance, removal and introduction of plants including resilient fodder seeds and (fodder) trees, that are a hybrid of technical and local knowledge for creating a sustainable rangeland system with ground cover and also include plant species that are palatable and favoured. The communities will implement with assistance of multi-disciplinary technical expertise. Assessment and monitoring of restoration will also comprise a combination of methods, namely GIS monitoring, surveys measuring in the pastures and soil and measuring people's perceptions. Communal plans and actions can benefit some community members more than others and power disparities can corrupt governing entities. Gender, youth and wealth sensitivity is especially important in the (continuous) participatory planning, but also in the governing entities. A good representation of the less wealthy and empowered and their interests is essential for the whole exercise to succeed and sustain. Governing entities (local government, chiefs, grazing and water user groups), if biased towards the interests of the most powerful, will hamper the outcome and sustainability. Regular external audits – also including participatory meetings and focus group interviews with the less empowered – of the governing entities that influence water access, grazing plans, implementation and enforcement, need to take place for prevention and correction of ill governance. (Agro) pastoralists may be inclined to keep more cattle if the grasslands produce more grass and fodder. The grazing plans need to include selling animals for beef production as a condition and address wealth distribution. The community members will need to agree on certain poor households being allowed to increase the herd size in a controlled way for livelihood resilience, even at the expense of their own numbers. These poor HHs can be FHHs or youth. This will require a transformation of some cultural norms for the benefit of sustaining pastoral livelihoods in the communities during the participatory sessions (comparing to and possibly including GALS).

8.2.3.2 Activity 2.3.2. Restoration of degraded rangelands, including access to water.

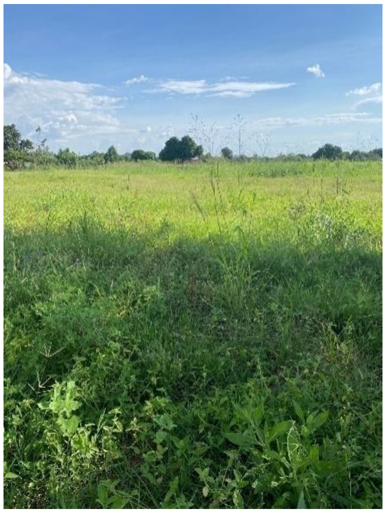
496. This activity will finance interventions to restore rangelands. The sub-activity will be implemented by (i) the SDLD, KALRO, County Governments and the NLC in Kenya; (ii) RAB and REMA in Rwanda (iii) MLF and LGAs in Tanzania; (iv) MAAIF (DDA, NARO) with DLGs in Uganda. In each country, service providers specialised in rangelands restoration will be mobilized, if necessary. The technical expertise from ILRI – more particularly at the level of innovations such as biochar production - will also be leveraged.

497. *Sub-activity 2.3.2.1 Training on rangeland management*. **In all four countries,** the Programme will facilitate L-FFS/PFS (25-30 people per L-FFS). L-FFS will be run by the facilitators trained under output 1.2 (see above). L-FFS will aim at (i) training pastoralists and agro-pastoralists on rangeland restoration and management; (ii) guiding and engaging farmers (in particular women who have in-depth knowledge of rangeland ecology) towards improving the management of communal grazing points, develop the capacity of community on grazing management (e.g., destocking and restocking, traditional rotation grazing, sell of animals during the dry season and restock during the high feed availability seasons to reduce pasture pressure, managing stocking rates on the grazing areas and promoting non-conventional/traditional rotational grazing[354], use of biochar in bomas/ overnight enclosure, see Textbox 16), (iii) promoting practices for the removal of invasive woody species such as *Prosopis juliflora*, followed by conversion of the waste biomass into biochar (through e.g partnerships with the IITA-led PlantVillage Project), reseeding of pasture with adapted plant species (e.g. Cenchrus ciliaris) plus use of biochar-fortified manure to improve pasture soil fertility, and (iv) scale-up integration of sylvo-pastoral and trees on communal lands for increased carbon sequestration and reduced exposure of livestock to heat stress conditions, by providing shade for animals. The potential for peer-to-peer learning among dairy farmers exists by highlighting good practices and promoting cross-site visits and other learning opportunities for successful herder-led sequestration initiatives. The Programme will support the dairy stakeholders for paying visits to various parts of the country where land degradation and depletion of nutrients due to harsh environmental conditions could be obviously seen. Women stakeholders will constitute at least 40 percent, and youth 30 percent. This sub-activity will be financed by GCF in the 4 countries.

Textbox 17: Examples of rangeland management interventions promoted through L-FFS

	*Enclosure.* Area of rangeland which is enclosed by a fence with branches of native thorny Acacia trees as well as traditional rules to protect vegetation from grazing and/or browsing with the exception of calves and sick animals. Enclosure aims to conserve standing pasture for dry season. *Left: Enclosure. Picture from the field, October 2023, Uganda*

[354] Feasibility Study 6 for details on the various strategies to be promoted.

	*Rotational grazing*, is defined as where a paddock is not stocked continuously but grazed and rested regularly either on a set calendar schedule or intermittently as needed.. *Left: Picture from the field, October 2023, Uganda*
	*Improve agroforestry system* (component 2, output 2.3). Integrated systems combine livestock, gardening, and fodder production. Integration of multipurpose leguminous trees and shrubs such as *Acacia anguistissima, Cajanus cajan, Gliricidia sepium, Leucaena collinsii, Sesbania sesban, Tephrosia candida and Tephrosia vogelii* and fruit trees. *Left: Agroforestry system, Kenya*
	*Improved pasture management*. Combination of improved practices such as rotations and use of manure and fertilizers, as well as use of suitable pasture species increases biomass yields and feed availability for livestock. *Left: Improved pasture management. Picture from the field, October 2023, Uganda*
	*Management of grazing intensity and timing*. Rangeland occupied by agro-pastoralists. Paddocks established for rotational grazing. *Left: Management of grazing intensity. Picture from the field, October 2023, Uganda*

498. *Sub-activity 2.3.2.2 Rangelands restoration.* This sub-activity will include (i) reseeding and integration of drought-resistant and low-emission feed-crop legumes with grasses in natural pastures (case of Rwanda), (ii) integration of multipurpose leguminous trees and shrubs (improved agro-forestry systems in Kenya, Uganda and Tanzania), (iii) removal of invasive woody species such as *Prosopis juliflora*, followed by conversion of the waste biomass into biochar, reseeding of pasture with adapted plant species (e.g. Cenchrus ciliaris) plus use of biochar-fortified manure to improve pasture soil fertility (in Kenya, Uganda and Tanzania). For this DaIMA will leverage existing efforts for remote sensing of *Prosopis* (e.g. through the ILRI-implemented ESSA project[355]) to support countries in mapping spread of this invasive plant species and demarcate areas with great potential for shrub clearing and pasture restoration in conjunction with biochar production from *Prosopis*. This sub-activity will also include (iii) implementation of soil and water conservation practices. This sub-activity will be financed by GCF in Kenya, Rwanda and Tanzania, and IFAD (GEF8) in Uganda.

499. *Sub-activity 2.3.2.3 Water availability*. Depending on the country, to enhance access to water for dairy cattle, the Programme will invest in water harvesting systems such as micro-dams, damsheets, small-scale valley-dams, construction/ rehabilitation of charco dams and rock-catchments schemes. In each country, feasibility studies will be carried out before the start of the work to assess sustainability. The Programme will also enhance the capacity of the community-based water supply organizations (COWSOs) to better manage and operate all water harvesting and storage infrastructures. The design of water infrastructure will follow the guidelines of the local government authorities.

500. In **Kenya**, the Programme will invest in (i) sub-surface dams and rock catchments, more particularly in Samburu, Marsabit and West-Pokot, and (ii) water storage and desilting of small dams in the Lake Victoria and Rift Valley drainage basins, that would benefit dairy farmers downstream in targeted counties, with better quality and quantity of water. This will be done through the mobilisation and awareness raising through the integrated natural resource management approach, by establishing and strengthening key community structures managing access to water. This sub-activity will be co-financed by IFAD, through the INReMP Project.

501. In **Rwanda,** communal valley dams face management and maintenance issues, due to inadequate community organization and management systems, and low availability of service providers for maintenance. At community levels, in grazing system areas (Eastern Province, Gishwati basin), the Project will invest in individual dam-sheets (dam sheets are water harvesting systems, made of an impluvium and a storage reservoir dug in a natural terrain and covered with a plastic liner). For these, the Project will provide the liner and the producers will contribute through the preparation of the site, as it is the case under RDDP. This sub-activity will contribute to climate change adaptation, through enhancing access to water, and to soil conservation, by decreasing soil erosion caused when livestock move to and from the lowlands to fetch water. Rehabilitation of valley dams will only be undertaken after the feasibility study and if it confirms that management issues can be sorted out. The sub-activity will be co-financed by RDDP-2.

502. In **Tanzania**, the Programme will (i) in communal charco-dams, and (ii) build capacity of COWSOs to better manage all the water harvesting and storage infrastructures implemented by the Programme. The sub-activity will be financed by the GCF grant.

503. In **Uganda,** in the context of climate change, rainwater harvesting and small dams play a key role in capturing and storing rainwater, particularly in areas prone to erratic rainfall patterns. These infrastructures will be financed by the GCF grant.

[355] Earth observation and environmental sensing for climate-smart sustainable agropastoral ecosystem transformation in East Africa.

504. **In all four countries,** ensuring the sustainability of these facilities requires a multi-faceted approach. First and foremost, community involvement and local capacity building are critical components. Involving communities in the planning, implementation and maintenance of water harvesting structures (see activity 2.3.1) fosters a sense of ownership and encourages responsible use and maintenance. In addition, the integration of traditional knowledge with modern techniques contributes to the longevity of these facilities. Regular maintenance, coupled with training in repair and maintenance, ensures the continued functionality of water harvesting infrastructure. Incorporating climate-resilient designs, using durable materials, and aligning water harvesting efforts with broader water resource management plans are also important aspects of ensuring long-term sustainability. In addition, partnerships with government agencies, NGOs and local organisations can provide ongoing support, technical expertise and financial resources to sustain water harvesting initiatives. A key risk is vulnerability to climate variability, as changing weather patterns can affect rainfall and therefore the amount of water collected. In addition, poor maintenance and limited community involvement pose challenges to municipal water infrastructure.

505. To address this, community-based management models and the involvement of COWSOs, coupled with regular training and awareness programmes, can empower local people to take ownership of the facilities and ensure their continued functionality. A holistic approach that includes climate-resilient infrastructure, community engagement and rigorous quality control measures will be implemented to ensure the sustainable success of water harvesting facilities. District officials, guided by local government authorities, will lead the design – together with other identified partners (e.g. Heifer International), and implementation of water infrastructure, while COWSOs will oversee operation and maintenance. In addition, partnerships with government agencies, NGOs and local organisations will provide ongoing support, technical expertise and financial resources to sustain water harvesting initiatives. Regular maintenance, coupled with training to COWSOs in repair and maintenance, ensures the continued functionality of water harvesting infrastructure.

8.3 COMPONENT 3: GREEN DAIRY FINANCING FACILITY (GDFF)

506. **Justification of GDFF Investment and GDFF Response Structure.** As noted in the Market Study (see above), the adoption of low-carbon and climate-resilient solutions and practices by dairy SMEs is constrained by challenges in access to finance paired with technical barriers. Dairy value chain actors are typically cash constrained that makes them reliant on debt capital to invest in climate-smart technologies. The Market Study finds there is a lack of affordable debt within the market with high collateral needs that smaller businesses cannot fulfil. Alongside this, cash-constrained businesses are more likely to prioritise investments that in the short term improve productivity over climate mitigation or adaptation projects.

507. GDFF is designed to overcome these challenges through green dairy loans from private banks to small and medium agro businesses, using capital from DaIMA/GDFF credit lines targeted for green dairy investments. The loans will be provided at favourable interest rate and with option for adequately long loan and grace periods. A central offering that is critical to the delivery of the GDFF's impact is lending in local currency to dairy SMEs. The currency issue is a significant challenge faced by enterprises in the sector, and it poses risks to SME viability and sustainability.

508. Furthermore, as lack of knowledge of bankable green dairy investment options among both financial institutions and dairy sector companies is identified in the DaIMA target countries as a key constraint for investing in green dairy projects. GDFF will proactively use the TA facility of Sub-Component 3.2 to (a) build the capacities of the participating banks to understand and finance green dairy sector projects, and (b) maximise both the impact and returns of the financed investments by enhancing the capacity of borrowers to implement effective strategies, improve their operational efficiencies, and achieve sustainable growth. In doing so, the TA facility will address non-financial barriers currently preventing greater climate-smart dairy financing in the GDFF target countries. Combining lending capital injections provided from the GDFF credit lines with appropriate TA provision, Component 3 of DaIMA is a justified intervention in the programme area to support the sustainable growth and greening of the dairy sectors in East Africa.

509. To support the achievement of the programme objectives and impact, DaIMA will under Component 3 establish a Green Dairy Financing Facility (GDFF) that will operate in the four targeted countries. GDFF aims to enhance access to finance for the target group and support the implementation of climate-smart technologies and practices, thereby facilitating the transition to climate-resilient, sustainable, and low-carbon dairy value chains. This component will specifically address the financial and technological barriers identified in the ToC as key obstacles in greening the sector's operations. Under Component 3, medium-sized farmer-allied dairy value chain actors, including aggregators and processors, agro-input and technology providers, and farmers' cooperatives, will be eligible to access DaIMA-supported financing. Businesses identified by Component 2 as suitable for GDFF financing will be proactively encouraged to apply for support under Component 3.

510. To achieve its development objectives, Component 3 activities are structured into two mutually reinforcing sub-components: (a) Sub-component 3.1: Effective Green Financing for Dairy Value Chains; and (b) Sub-Component 3.2: Capacity Building for Green Dairy Investments. Both sub-components will increase climate resilience across the dairy value chains in East Africa and contribute to the reduction of total GHG emissions and of the GHG intensity per kg of milk produced.

1.3.2 Output 3.1: Effective Green Financing for Dairy Value Chains

511. **Activity 3.1.1. GDFF Operationalized.** In each of the four participating countries, a GDFF line of credit will be established to channel green funding to eligible dairy sector borrowers. This line of credit will be managed by a local Public Development Bank (PDB), which will act as a Wholesale Bank for the GDFF intervention. The Wholesale Banks will at national level manage the financial DaIMA services to the programme target group based on eligibility criteria and other terms and conditions, agreed upon in the programme design and included in the financing agreements between IFAD, the Governments, and the Wholesale Banks. Based on IFAD's rural finance experience in East-Africa and reviews of financial markets in the targeted countries as well as interviews with several candidate banks, the following PDBs were selected as candidates for the Wholesale Banks for GDFF: Agricultural Finance Corporation (AFC) for Kenya, Uganda Development Bank (UDB) for Uganda, RDB Bank for Rwanda, and Tanzania Agricultural Development Bank (TADB) for Tanzania.

512. The criteria for Wholesale Bank identification included:

513. Status of a leading PDB in the targeted countries;

514. Solid institutional and financial condition;

515. Strong interest in agriculture and rural finance operations;

516. Corporate objective to develop and scale-up the bank's climate finance portfolio;

517. Corporate mandate and operational capacity to provide wholesale financing products;

518. Strong expressed interest to manage the DaIMA wholesale financing operations in the dairy sector.

519. The Wholesale Banks will provide bulk loans for on-lending to the eligible Retail Banks, which can be commercial banks or such microfinance banks and commercial development banks that are prudentially supervised. Financial resources provided as bulk loans by the Wholesale Banks to Retail Banks will be exclusively on-lent to eligible climate-smart projects of the dairy sector SMEs. Operating with the targeting guidelines and other conditions of the wholesale loan agreements between the Wholesale Banks and Retails Banks, the actual lending methods used for retail loans under GDFF financing will follow each Retail Bank's operational structure and network, rural and agriculture finance strategy, and their digital tools development approach.

520. Retail Banks for each country will be selected after programme effectiveness as a joint activity between the Wholesale Banks and DaIMA/IFAD. Key criteria in the selection of Retail Banks will include:

521. Prudentially supervised institutions with solid institutional and financial conditions;

522. Strong interest in financing operations of rural small and medium size businesses;

523. Corporate objective and documented strategy to develop and scale-up the bank's climate finance operations;

524. An appropriate network to provide services in the DaIMA programme area in the target country;

525. A strong expressed interest to partner with DaIMA in the planned dairy sector financing operation and co-finance 25% of each investment.

526. During the period leading to DaIMA effectiveness, the DaIMA PMU and the Wholesale Banks will closely co-operate to ensure a smooth take-off of the programme activities. To support and co-ordinate the start-up phase, experienced Climate Finance Specialists will be recruited and hosted by each Wholesale Bank (financed by the TA Sub-component 3.2). At the same time IFAD and the Host Banks would finalise the preparations for the selection and training of appropriate Retail Banks to take part in the GDFF lending and develop the framework and action plans for capacity building at both the Retail Bank and the borrowing SME level. Each Retail Bank selection will also go through the IFAD no-objection process.

527. **GDFF financial resources.** DaIMA will provide catalytic international financial resources of at least US$ 35 million, including US$ 17.5m from the GCF and minimum US$ 17.5m from IFAD and other partners, to be shared between the selected four Wholesale Banks for on-lending through the Retail Banks to the programme target group. The target in later negotiations with the participating Retail Banks is to raise an additional investment capital injection of US$ 8.75 million (25% of retail loans) from the Retail Banks' local private sector resources. In addition, substantial grant financing is included under Component 3 to support the GDFF lending and dairy sector development operations through a US$ 10 million technical assistance facility. (see more below).

528. The GDFF credit capital from DaIMA resources will be lent by the four Governments to the Wholesale Banks in local currencies, and all the lending operations to the end borrowers will be conducted in local currencies. The credit capital provided by the international financiers will revolve in the GDFF operation during the DaIMA loans period and will be paid back by the Wholesale Banks to the Government according to the repayment schedule of the IFAD DaIMA loans.

529. **Targeted borrowers and key lending products.** As indicated, the GDFF lending operations under Component 3 target medium-sized farmer-allied dairy value chain actors, including aggregators and processors, agro-input and technology providers, and mature dairy farmers' cooperatives. In all four targeted countries, various projects supported by donors including IFAD have special lending windows for individual dairy farmers operating in these dairy value chains. The proposed large Africa Rural Climate Adaptation Finance Mechanism (ARCAFIM) covers the same countries as DaIMA and targets smallholder farmers with CC adaptation finance services including the dairy sector. The GDFF financing support to dairy value chain companies will be planned and operated in close co-operation with these other green financing interventions in the four target countries.

530. Based on the market and demand surveys conducted during the DaIMA design (see attachments to this Funding Proposal), the following two types of lending approaches/products can be included in GDFF lending, depending on the scale and maturity of the dairy value chain operations of the borrower:

531. **Green dairy investment partnership loan product.** These are longer-term partnerships between mature, well-organised dairy businesses and the GDFF Retail Banks. The GDFF will offer tailored lending packages to dairy companies at favourable interest rates, with substantial TA to develop the companies. The financed greening opportunities could include - but are not limited to - to proactive expansion and modernising of the smallholder outgrower networks of the companies, supporting smallholder farmers to access more productive cows or energy-efficient fodder, solarising cooling or processing equipment, and developing the milk transport networks. These investments would require long-term debt finance, supported by working capital injections. While the exact loan conditions will depend on the identified needs and objectives of the businesses, the GDFF loans are expected to range between US$ 250,000 and US$ 550,000 with investment loan tenors of between 5 and 9 years, with the average loan size at US$ 400,000. Eligible businesses will need to exhibit clear ambitions to invest, develop or distribute climate-smart technologies and productivity-enhancing technologies, and have a track record and solid plans for intensifying their smallholder partnerships. Based on the market surveys, it is anticipated that businesses in this borrowing category will be with annual turnover above US$ 800,000, and investment decisions will be based on a thorough credit assessment by the Retail Banks using lending criteria agreed for the GDFF operations.

532. **Green dairy loan product.** These are shorter-term, smaller-sized working capital or capital expenditure loans that seek to meet a specific financing need of businesses of smaller SMEs and well-organised dairy cooperatives. The Retail Banks in GDFF will provide standardised Green Dairy Loan Products with the maximum loan size at US$ 250,000, an estimated average ticket size of US$ 50,000, and loan tenor of up to three years. Similarly to the Green Dairy Investment Partnerships loans, eligible businesses will need to exhibit clear ambitions to invest, develop or distribute climate-smart technologies, productivity-enhancing technologies and have a track record and clear plans of strong smallholder partnerships. However, recognising that the majority of the dairy sector SMEs will not be operating at a significant scale, these Green Dairy Loan Products will target smaller businesses, likely with an annual turnover of less than US$ 800,000. Investees will be eligible to receive pre-investment TA to translate investment needs into investment requests, and they can be connected to other DaIMA components to access post-investment TA support as required.

533. *Table 43* provides lists of initial criteria for the screening of potential borrower companies for each of the above described GDFF loan product.

Table 43: Initial SME screening criteria for loan categories in GDFF lending

Investment/Loan Type	Screening criteria
Green Dairy Investment Partnership	534. Registered dairy value chain SMEs with annual revenues >US$ 800,000 located in the GDFF's target geographical areas. 535. Ambitions to invest, develop or distribute climate-smart technologies, productivity-enhancing technologies, or SHF extension services 536. Established business model and revenue stream 537. Strong leadership and management skills with governance bodies in place 538. Strong characteristics and track record of smallholder dairy farmer partnership (likely to be working with over 200 dairy farmers) 539. Investment intended to fund technology or loan purposes included in the Green Dairy Taxonomy agreed for GDFF-supported projects 540. Potential impact of adoption of new technology (both financial and environmental) 541. Willingness to commit to achieving key agreed outcomes.
Green Dairy Loan Product	542. Registered dairy value chain SMEs with annual revenues <US$ 800,000 located in the GDFF's target geographical areas. 543. Ambitions to invest, develop or distribute climate-smart technologies, productivity-enhancing technologies, or SHF extension services 544. Established business model and revenue stream 545. Strong leadership and management skills with governance bodies in place 546. Strong characteristics and track record of dairy smallholder partnership (likely to be working with less than 200 dairy farmers) 547. Investment intended to fund technology or loan purpose included in the Green Dairy Taxonomy agreed for GDFF-supported projects.

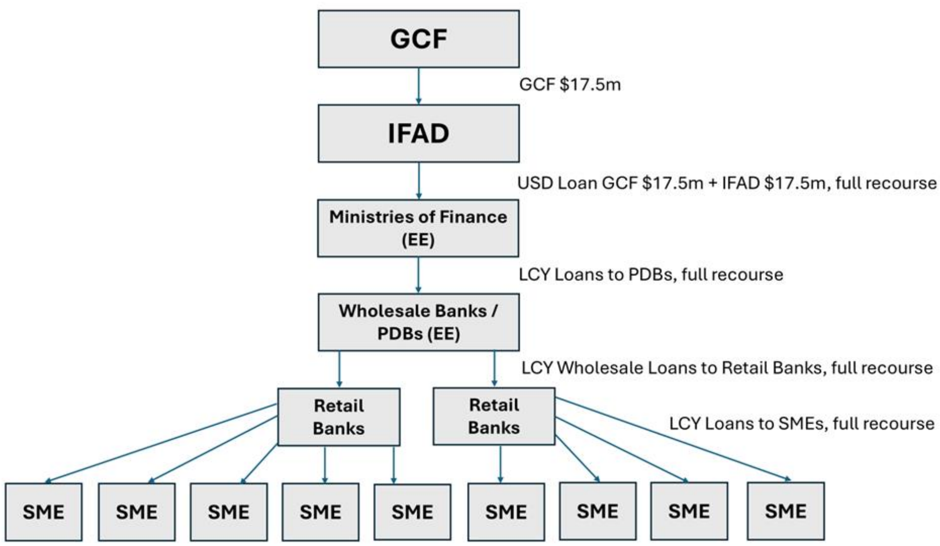
548. **End-use of GDFF finance and green dairy taxonomy.** To achieve the development objectives and impact of DaIMA and its Component 3, it is critically important that there is a clear joint understanding and agreement on what types of investments can be considered for the end-use of green dairy finance. A great deal of work has been carried out in recent years on rural green finance taxonomy in East Africa, particularly during the IFAD/GCF design process for ARCAFIM. This taxonomy development process, including dairy and livestock sectors, has progressed through CC risk assessment and adaptation and mitigation models mapping to the assessment of the bankability of the related investment options for the private sector financial institution implementation. Furthermore, there are various other green finance taxonomy policy processes ongoing in the targeted countries.

549. The Taxonomy of investments for the GDFF lending will build on the findings of the Market Study carried out as a part of the DaIMA design (full Study attached to the Funding Proposal), and will include both agri-input supply investments (e.g. cooling tank producers, AI service producers, dairy meal producers, PV/solar solution producers, agri-fintech providers, fodder producers, and biodigester providers) and investments in technologies that reduce GHG emissions and improve productivity (e.g. milking machines, solar milk coolers, bio-digesters, milk pasteurizers, UTH treatment equipment, milk transfer tanks, renewable energy solutions and water recycling technologies), as well as biochar production.

550. The guidelines on appropriate dairy sector greening options for private sector finance in the participating four countries will be included in the Loan Agreements and Implementation Guidelines of the GDFF credit lines. They will form a core part of the training and capacity building activities with the participating banks and the borrowing SMEs (see more below in Sub-Component 3.2). As a key development objective during the DaIMA implementation, the development of the dairy sector green financing taxonomy will continue, based on the documented experiences from the GDFF credit line operations. The target will be to distribute the results for wider audience, to support the mainstreaming of green finance activities in private banking institutions in Africa.

551. **Lending terms to end-users**. The DaIMA/GDFF financing package will proactively encourage the Retail Banks to expand their operations in green dairy financing with the programme target group using appropriate and favourable loan products. The long loan period of the IFAD loans to the Governments will make it possible for the Retail Banks to offer appropriate loan and grace periods to support the SME investments. This will be important particularly in innovative capital investments that improve the CC resilience and mitigation but require longer repayment periods to attract investors from the business community.

552. The GDFF financing chain is illustrated in the diagram below. Concerning the interest rates throughout this GDFF financing chain from GCF to end-borrower loans, (i) GCF's USD-lending highly concessional terms (0.25% annual interest rate including fee) apply for Rwanda, Tanzania and Uganda, and the less concessional (1.25% annual interest rate including fee) apply for Kenya; (ii) The estimated interest rate on DaIMA funding from the Governments to the GDFF Wholesale Banks, before final negotiations, is projected at 2%-5% on local currency per annum fixed over the programme period; (iii) With this low price for on-lending capital, it is expected that the interest rates offered by the Wholesale Banks to the Retail Banks would be at the range of 5%-8% on local currency per annum; (iv) This will enable the Retail Banks' pricing to end borrowers to be highly competitive, below the lowest market-based interest rates charged by commercial banks for this type of loans in the target countries.



553.

554. To define the appropriate market-based interest rate for GDFF lending at SME level, in collaboration with the GCF/IFAD ARCAFIM project, an interest rate survey will be carried out periodically during the programme implementation, IFAD annual DaIMA performance assessments will include a review of the materialised GDFF interest rate structure and provide recommendations for any required revision of the GDFF interest rates for the future operations. To support the start-up of GDFF, the existing ARCAFIM interest rate survey summary table below gives indication of the regoion's interest rate levels, and the full survey is available at the ARCAFIM Funding Proposal annexes. It should be noted, the lowest indicated interest rates are supported by blended finance instruments similar to what DaIMA GDFF proposes.

Country	Commercial banks	Microfinance institutions	International and national - project facilities	SACCOs and Fintech
Kenya	• Average 13% - annually • Maturity up to 5 years	• Range from 18-24% - annually • Maturity up to 48 months	• Up to 10% annually • Grace period 3 months • Up to 5 years	• On lending annual interest rate of 8-10% • Retail annual interest rate 10.5% to 13%
Uganda	• Range from 10% to 18% - annually • Maturity up to 15 years	• Range from 12-48% - annually • Maturity up to 3-36 months	• Up to 13% annually • Grace period 3 years • Maturity from 6 months to 3 years	• Interest rate of 30% • Short term - unspecified
Tanzania	• Range from 9% to 25% - annually • Maturity up to 15 years	• Range from 18-96% - annually • Short term - several months (seasonal)	• No data/not applicable	• Interest rate range from 24%-36%% • Short term - unspecified
Rwanda	• Range from 15% to 18% - annually • Maturity up to 15 years	• Range from 18-25% - annually • 6 months to 10 years	• Interest rate subsidy of 8% • Maturity up to 10 years	• Interest rate range from 22%-24%% • Short term - unspecified

8.3.1 Output 3.2: Capacity Building for Green Dairy Investments

555. GDFF will proactively use the TA facility of Sub-Component 3.2 to (a) build the capacities of the Wholesale Banks and Retail Banks to understand and finance green dairy sector projects, and (b) maximise both the impact and returns of the financed investments by enhancing the capacity of borrowers to implement effective strategies, improve their operational efficiencies, and achieve sustainable growth. In doing so, the TA facility will address non-financial barriers currently preventing greater climate-smart financing in the GDFF target countries.

556. The technical support activities of Sub-Component 3.2 with both the participating banks and the SMEs will be managed and implemented by experienced Technical Assistance Service Providers, to be identified and selected through regional competitive bidding organised by the DaIMA PCU staff for each of the four DaIMA countries.

557. Operating with a total TA budget of US$ 10 million (financed by a GCF grant), Sub-Component 3.2 includes three activities: (a) Awareness Raising and Capacity Development of Participating Banks in Green Dairy Finance, (b) Green Dairy Investment Support Services to SMEs, and (c) Regional Coordination, Reporting and Knowledge Management.

1.3.2.1 Activity 3.2.1 Awareness raising and capacity development of participating banks in Green Dairy Finance.

8.3.1.1 Activity 3.2.2 Green dairy investment support services to SMEs

558. The aim of the GDFF capacity building services to potential and actual SME borrowers is to strengthen the knowledge of rural businesses of viable CC mitigation and adaptation options, benefits, and related financial services, and to develop their business planning, investment start-up, and operational and financial management capacity. These actions aim to increase the demand for green dairy finance and improve the investment success rate, at the same time lowering the investment risk for the Retail Banks. With this TA support, bankability assessments and the related loan applications can be completed for agribusinesses, helping to inform the Retail Banks of the real investment opportunities and risks. **The capacity building packages, which can cover both pre-investment activities and post-investment capacity building operations for dairy sector SMEs, will be demand-driven and tailor-made.** They can differ significantly in content and size depending on the development stage of the company and the type of investment financed. The TA support aims to ensure that GDFF financing will target well planned, productive, and screened investments in the dairy sector that are professionally executed, to ensure both the economic growth impact and the highest possible positive impact on climate change resilience and mitigation.

1.3.2.2 Monitoring, Reporting and Evaluation of GDFF Financial Investment Activities

559. Sub-Component 3.2 will provide top end expertise to the national Wholesale Banks and their Retail Bank partners, to ensure that the credit provided with GSFF funding will deliver real, effective, and transformational adaptation and mitigation impact and is channelled to the intended purposes and beneficiaries. The participating Wholesale and Retail Banks will be sensitized to the importance of adaptation and mitigation taxonomy and targets and receive a demand-driven package of technical support and innovation services, with the aim to develop and offer appropriate green dairy financial services, manage risks of this lending, and report on portfolio performance and impact. Initiation of the Technical Assistance to the Retail Banks is a condition to access to GDFF financing for on-lending.

560. Before the GDFF lending operations commence, the Wholesale Banks will receive international and local TA support to introduce green dairy wholesale financing products into their mainstream financing operations. The Wholesale Banks will also receive systematic support to establish effective GDFF management systems, to coordinate the programme implementation and report on the performance. Through cost-shared continuous TA, in medium term, the aim is that DaIMA Wholesale Banks will strengthen their internal capacities to independently mobilize and implement similar green finance projects to support green transformation in dairy and other sectors of the rural economy.

561. Participating Retail Banks (commercial banks and prudentially supervised microbanks and commercial development banks) involved in GDFF financing activities will receive technical support packages tailored for their specific needs under green dairy finance. A preliminary demand analysis for the services was conducted during the DaIMA design and earlier, during the ARCAFIM design in the same countries, to enable TA action planning and detailed budgeting. The GDFF TA support will be launched against expressions of demand by Retail Banks after the DaIMA start-up. DaIMA experts, the Wholesale Bank, and GDFF-hired Specialists will work with the Retail Banks to develop technical assistance packages to be delivered to small and medium dairy businesses with GDFF grant financing. Potential technical support areas will include:

562. Development of green dairy finance strategy and costing of its implementation;

563. Development or strengthening of green dairy lending products targeting medium and small businesses;

564. Support to rural outreach and social inclusion strategies, including CC adaptation and mitigation finance advisory capacities;

565. Strengthening of Digital Finance Services by inclusion of functions for climate finance;

566. Support to improved Management Information Systems (MIS) to follow up and report progress achieved in GDFF lending.

567. A Senior Programme Officer will be recruited at IFAD Kenya Regional Office to support the overall coordination, M&E, reporting and knowledge management of the GDFF, for the entire project period.

568. DaIMA/GDFF will establish a comprehensive monitoring, reporting and evaluation system for the GDFF climate finance operations. The Wholesale Banks, which are the hubs in the financing operations of Component 3, are selected with the requirement that they have prior experience on the management and monitoring of the performance of the wholesale lending operations financed with public funds. They will report quarterly, semi-annually, and annually on the financing progress of GDFF to the PMUs and IFAD in each country based on a pre-defined reporting schedule, indicators, and formats. The key financial/portfolio reporting requirements, which reflect the DaIMA logical framework requirements, will be included in the GDFF Loan Agreements between the Governments and the Wholesale Banks.

569. The selected Wholesale Banks, as leading PDBs in their countries, are expected to have computerised data management systems in place, as well as dedicated staff experienced in reporting requirements of key international development financiers. Furthermore, the Retail Banks all report on a monthly basis to the Central Banks on a large number of indicators that also cover the reporting requirements of DaIMA on such standard financing performance indicators as disbursements, repayments, portfolio levels, interest rates, and data on non-performing loans. Therefore, in the books of accounts of both the Wholesale Banks and the Retail Banks, all the loans issued from the pooled GDFF to medium and small dairy-related enterprises will be specifically coded as “GDFF loans”. This will make possible to establish a systematic on-line reporting and tracking system for the GDFF portfolio, as well as a basis to conduct separate annual audits on its accounting if/when required, with audit reports submitted to all investors in this programme. Prior to ARCAFIM launch, dedicated design resources are used for start-up preparations of the monitoring and reporting system of the GDFF lending, funded by GCF grant funds.

570. **Monitoring and Reporting on GDFF TA Activities**

571. Throughout the DaIMA implementation period, the PMUs in the four countries will continuously coordinate and organise the monitoring of the progress in TA activities of GDFF against the performance and impact targets included in the TA AWPBs. This progress will be followed up also during the IFAD’s Supervision and Implementation Support missions.

572. Reporting on the progress of TA activities of GDFF will be organised and carried out in close co-operation with the Wholesale Banks in each country, based on data collected from GDFF Technical Service providers, Retail Banks, borrowing SMEs and their smallholder partners/clients. Key reports on the performance of the TA activities of GDFF consist of the following:

- Semi-Annual Reports, focusing on activities and outputs based on indicators used in Annual Work Plans and Budgets, providing data on training and capacity building work carried out by the TA Service Provider staff with the participating banks and the actual and potential SME borrowers in the GDFF scheme.Annual Reports, providing comprehensive data on TA activities carried out during the period, providing comparative data to the GDFF loans disbursed and recovered in each TA area and location, with a narrative on key challenges encountered, lessons learnt, and corrective actions taken to improve performance. Reports on comprehensive periodical (every 3 years) SME Surveys and Evaluations on TA, assessing the contributions of the TA activities of Component 3 to outcome and impact indicators, combining the data on trainings conducted to the loan portfolio performance data (disbursements and recoveries) and to the results of the SME/household surveys and the changes in CC resilience and mitigation among the GDFF borrower population.

9 FINANCIAL MANAGEMENT

9.1 FLOW OF FUNDS AND LEGAL ARRANGEMENTS TO BE DESCRIBED BY IFAD

573. Designated accounts (DAs) will be administered following "revolving fund arrangements'. The Recipients/Borrowers will enter into MoU with the Implementing Partners (IPs) before any funds transferred to the IPs. Each project will open and maintain separate DAs in USD to receive GCF funds from IFAD. Similarly, separate project accounts in local currency will be opened by PCUs, district offices and IPs to receive funds from the project designated/operating accounts. Countries where single treasury account is used, adequate chart of accounts will be used to segregate GCF sources and uses of funds from other financiers. In case of flow of fund issues to ILRI, direct payments to ILRI may be considered based on the MoUs signed between the Borrower and ILRI. However, all Withdrawal Applications and IFRs need to be submitted by the PCU of each Country. The country-specific arrangements are presented in the tables below.

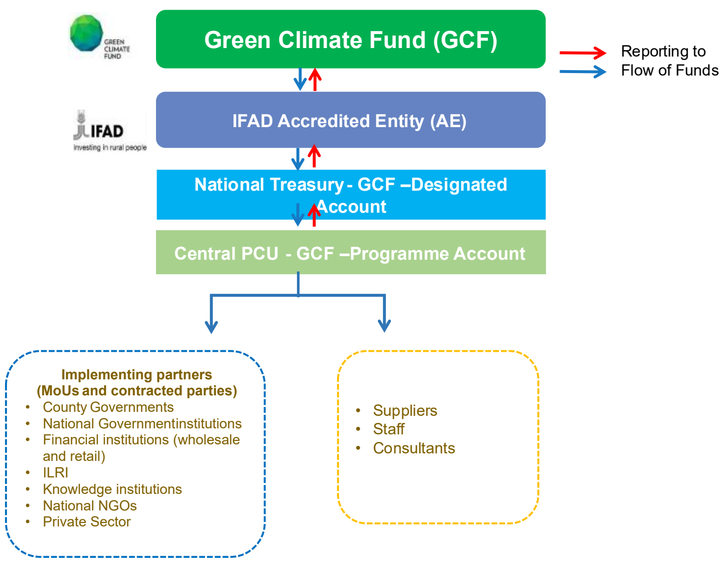


Figure 100: Flow of funds – Kenya

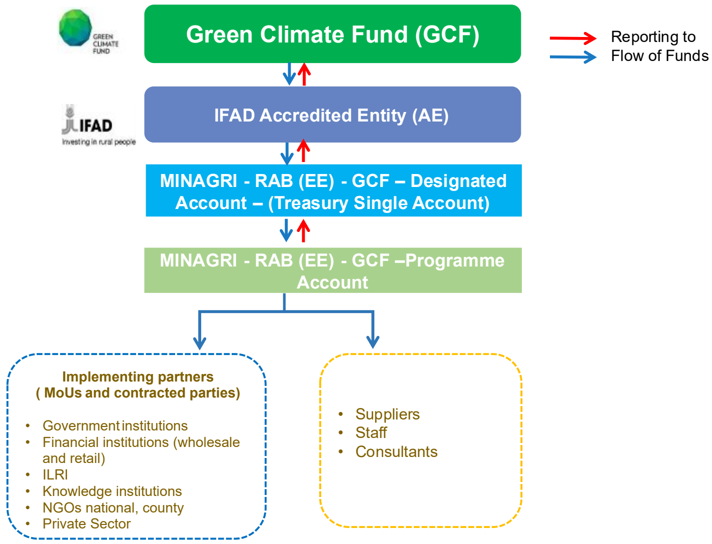


Figure 101: Flow of funds – Rwanda

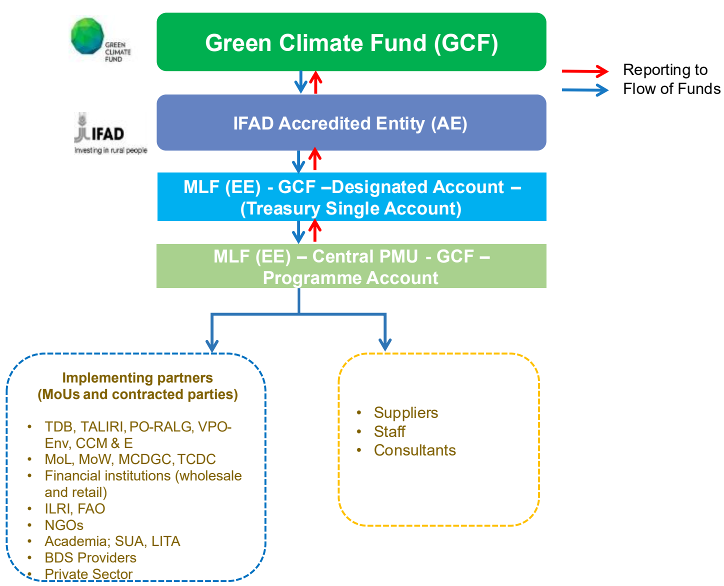


Figure 102: Flow of funds – Tanzania

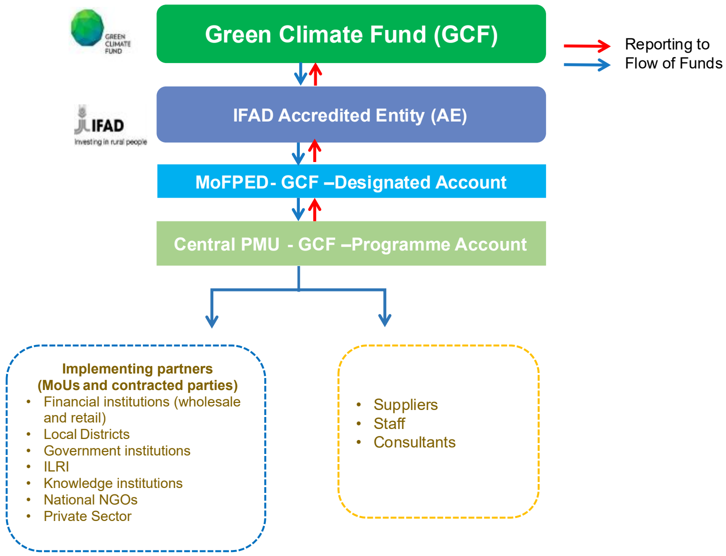


Figure 103: Flow of funds – Uganda

574. Disbursements will be based on submission of quarterly Interim Financial Reports (IFRs) within 30 days after the period ends and upon availability of funds. IFRs and the Withdrawal Applications will be submitted to IFAD by PCUs through IFAD's Client Portal and will include a cash forecast for the next two quarters. As per GCF rules, there will be no disbursement unless 70% of GCF proceeds are utilized and all other GCF disbursement conditions are met.

2 PLANNING, M&E, LEARNING, KNOWLEDGE MANAGEMENT AND COMMUNICATION

2. PLANNING AND MONITORING

575. The details of these activities are provided in Annex 11 to the Funding proposal. They processes include participatory planning, budgeting and reporting; monitoring and evaluation; supervision and implementation support; evaluation and related studies, including baseline, mid-term and project completion reports, as well as knowledge management, communication and learning. In **Kenya,** the project will follow the Kenyan Government calendar year. In **Rwanda,** the project will be monitored jointly with the RDDP-2, by the SPIU, against the DaIMA results framework, and in line with GCF requirements. The M&E system will be an integral part of the SPIU, used jointly to monitor other projects.

576. In **Tanzania**, a phased roll out approach of C-STDP will be followed. Since the geographical area covered is large and heterogeneous. The baseline study will inform on potential locations for implementation of project activities. Supervision and implementation support missions will be joint, however, specialised technical expertise may be provided and specific supervision missions organized if required, or in case of challenges with specific GCF requirements. Separate MTR and PCR reports will be produced, as well as specific baseline studies, capturing the specific project indicators.

577. In **Uganda,** a robust M&E system will be developed which will as much as possible be aligned with GCF requirements and ReLIV M&E system to avoid duplication and difficulties in its implementation. It will be embedded in project management, coordinated by the PCU and supported by additional professional staff who will work closely with the PCU subject matter specialists to strengthen learning and knowledge management. The M&E system will be fully aligned with the IFAD's Operational Results Management System (ORMS), and respond to the GCF Integrated Results Monitoring Framework (IRMF) requirements.

9.2 KNOWLEDGE MANAGEMENT, COMMUNICATION AND LEARNING

578. The Programme will elaborate and implement a KM and Communication Strategy/plan that will: (i) provide Project beneficiaries with the necessary material to sustain the technical knowledge acquired with the support of the Project (production of training materials and communication platforms for sensitization) and continuously assess their adoption; (ii) generate shared knowledge acquired from the experience of the Project in various fields based on the information collected as part of the monitoring of results or thematic studies; (iii) share this knowledge with the Technical Departments of the Ministry, IFAD, GCF , and implementing partners using various dissemination strategies. Knowledge Management and Communication (KMC) will play an important role in planning, supervision, monitoring, and evaluation system, helping to inform activities, replication and scaling, be an integral part of the Programme to ensure implementation is a continuous learning process. Evidence-based data from innovative technologies will continuously be collected, analysed, packaged and disseminated as KM Products through appropriate communication channels /media, targeting different audience mainly for policy dialogues and change influence, specifically on behaviour.

In each country, the Programme will elaborate and implement a KM and Communication Strategy that will: (i) provide Project beneficiaries with the necessary material to sustain the technical knowledge acquired with the support of the Project (production of training materials and communication platforms for sensitization) and continuously assess their adoption; (ii) generate shared knowledge acquired from the experience of the Project in various fields based on the information collected as part of the monitoring of results or thematic studies; (iii) share this knowledge with the Technical Departments of the Ministry, IFAD, other donors, and implementing partners using various dissemination strategies. In achieving the Policy Component, the KM and Communication Strategy will strongly aim to develop and create channels of policy influence and dialogue through development policy briefs/strategies to be disseminated to an audience of high-level policy stakeholders in the Dairy Sector. As much as possible, the PCU Monitoring, Evaluation and Learning Specialist will work closely with the Financial Controller to ensure that the budgeting is adequate and conforms to the right categories and components. Subsequent AWPB processes will offer the opportunities to the PCU to reflect on the lessons from the implementation experience of the previous years, and to propose activities and expenditures required to achieve the intended project outcomes.