ADAPTATION BENEFIT MECHANISM
ACTIVITY DESIGN DOCUMENT (ABM-ADD)
Version 01, 14/09/2022

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ABM Activity – General Description	
ADAPTATION BENEFIT ACTIVITY DESCRIPTION	
Title of the activity	Promoting the use of a solar powered, climate-friendly cold storage system for storing seed and ware potatoes in Kenya
Activity goal (an observable and measurable aspired end-result with long-term impact)	Reduction in post-harvest and food losses that occur due to the adverse effects of climate change as a result of potato storage in simple facilities without improved artificial cooling systems.
Activity objective(s) (more specific result(s) to be achieved within the project duration)	To establish a cold storage system with cooling technology that utilizes refrigerants with negligible global warming potential which is powered by solar PV that guarantees adequate storing conditions for ware and seed potatoes.
Activity type (scope)	Installation of cold stores for storage of ware and seed potatoes. The cold store employs an energy efficient cooling system which utilizes environmentally-friendly refrigerants having no ozone depleting potential (ODP) and negligible global warming potential (GWP) and which is powered by solar PV.
Geographic coverage (city, community, region, nation)	Kenya (national level)
Co-benefits beyond adaptation (mitigation, socio-economic, list SDGs addressed)	SDG 2. Zero Hunger SDG 7. Affordable and Clean Energy SDG 8. Work + Economic Growth SDG 12. Responsible consumption and production SDG 13. Climate Action Mitigation co-benefits: 948.75 tCO_2e
Version number of the ABM ADD	Version 1
Completion date of the ABM ADD	14.09.2022
Project coordinator and contact details	To be included
Project participant(s)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Host Party	Kenya
Applied methodology(ies)	ABM-NM001: Reduction of post-harvest losses of stored potatoes through improved storage facilities
Value of one Adaptation Benefit expressed in indicator(s)	1 USD equals 1 AB
Expected annual issuance of Adaptation Benefits	21,681 (average)
Activity start date (mm-yy)	n.a.
Activity end date (mm-yy)	n.a.

1. ACTIVITY DESCRIPTION

1.1 Summary Information

1.1.1 Activity Title

Promoting the use of a solar powered, climate-friendly cold storage system for storing seed and ware potatoes in Kenya

1.1.2 Activity Location

The activity will be located in the counties of Nakuru and Nyandarua in Kenya, which are two of the four main potato-growing counties in Kenya (GIZ 2014).

1.1.3 Activity Summary Information

Kenya's population is highly vulnerable to the impacts of climate change. About 80% of the land in Kenya is arid and semi-arid and the remaining 20% is classified as arable (Kenya National Bureau of Statistics, KNBS, 2018). The primary drivers of the country's economy are agriculture and tourism contributing 30% and 11.6% of the GDP respectively (UN Women 2019). In particular, agriculture contributes 70% of total employment in the country and almost 69% of all households are involved in farming activities. Women participate in 80% of food production, however, benefit from only 7% of the agricultural extension services.

Climate change impacts are clearly noticeable in Kenya. There has been a general warming trend of about 1°C (0.21°C per decade) since 1960 (Government of Kenya 2018b). According to Global Climate Modelling, the increasing trend will continue with a projected mean temperature rise of 0.8 to 1.5°C by 2030s and 1.6°C to 2.7°C by 2060s (Government of Kenya 2016b). Extreme weather events, and especially droughts are considered major disasters in Kenya. For example, the drought in the years 2014-2018 was declared a national emergency. The rise in temperatures has severe implications for future extreme heat and drought events and such livelihood activities as crop production. Hence, extreme heat periods cause the greatest economic impact; on average, a 0.6 % decline in GDP growth is observed in Kenya in years of poor rains and extreme temperatures (Government of Kenya 2018b).

Kenya's GDP growth is therefore directly correlated with growth in the agriculture sector. Since the agriculture sector is 98% rain-fed in Kenya, it is highly exposed to disruptions emerging from changes in temperature, extreme weather events, unsustainable natural resource management, loss of forest, droughts and floods (Government of Kenya 2018b). The majority of agricultural producers are small-scale farmers (80%) with average field sizes between 0.2 and 3 ha. After maize, potatoes are the second most important food crop in Kenya and represent a main source of income for many smallholder farmers. The Kenyan potato sector faces various challenges such as limited availability and access to quality seeds, low value addition, insufficient post-harvest storage infrastructure resulting in considerable post-harvest losses and inefficient market structures (SNV 2019). A large quantity of potatoes is sold to distributors that usually offer very low prices. Among other things, this is an effect of poor market structures, but it also results from poor or non-existent storage facilities, as farmers thus must sell their products immediately after harvest when prices are usually very low. In addition, an inadequate transport system contributes to the trade barriers farmers are confronted with (MoALF 2016). In case farmers store the potatoes for a longer period, they usually experience severe quality losses, such as greening and sprouting of tubers. Further losses occur along the value chain due to poor transport infrastructure and insufficient storage options at markets. Although Kenya's economy benefits from an expanding food processing industry, potato processors have to import good quality potatoes from neighboring countries due to a shortage in supply during the months between harvest periods and a lack of good quality potatoes. Both are due to the fact that there are no adequate storage facilities which allow for the storage of potatoes under adequate conditions in terms of temperature and humidity.

The installation of a solar photovoltaic (PV) powered cold storage system will enable farmers to store potatoes at appropriate storing conditions (temperature and humidity level) for four months with significantly reduced food losses (5% instead of up to 29% (in 2035)). Potatoes are also sold to local potato processers who produce crisps and fries. The good quality of potatoes offers the famers the possibility to sell them at higher market prices, depending on the season. Thus, the installation of the cold stores will contribute to significant improvements of the local potato value chain and support to transform it in a sustainable manner. It will enable the potato processors to guarantee uptake of significant volumes of quality potato from contracted farmers which provides farmers with a secured and stable income. At the same time, imports of good quality potatoes from abroad will no longer be necessary. Hence, the activity will contribute to increased food production and additional income.

The off-grid system (PV) which feeds the cold store guarantees that there are no greenhouse gas (GHG) emissions from the use of grid electricity. In addition, the cold store uses propane as climate-friendly refrigerant which has a negligible global warming potential (3) and therefore does not result in significant GHG emissions.

In summary, the activity improves agricultural productivity and increases resilience to increasing temperatures and extreme weather shocks such as droughts or heavy rainfalls. In poor rural areas, having access to modern cooling systems allows households to enhance their food production with positive implication in terms of income. In addition, the technology involves no disadvantages with regard to negative climate impacts, i.e., an increase in GHG emissions.

1.1.1 Activity goals

The main activity goal is to introduce a solar-powered and climate-friendly cold storage system that guarantees appropriate storing conditions for ware and seed potatoes in order to reduce post-harvest potato losses that do occur due to increased temperatures. The overall objective is to enhance smallholder farmers' resilience to negative impacts of rising that temperatures that affect harvested potatoes.

The activity goals will be achieved through the installation of a cold storage system including cooling technology powered by solar photovoltaic (PV) energy and the use of refrigerants with a negligible global warming potential (GWP). The cold storage system will be used by small-scale farmers to store the harvested potatoes for seed, home consumption or sale. It will replace simple storage facilities without artificial cooling systems, such as simple wooden sheds or storage in pits. By reducing the share of potato losses through improved storing conditions, the farmers will increase their income from potato sales.

The activity will deliver also quantifiable mitigation co-benefits contributing to reducing greenhouse gas (GHG) emissions.

1.2 Project location

1.2.1 Description of Location and Activity Size

The activity will be located in the counties of Nakuru and Nyandarua in Kenya.

The County of Nyandarua lies in the Central part of Kenya, with borders to Nyeri County to the east, Nakuru County to the west, Laikipia County to the North and Kiambu County to the South. The total surface is about 3,245 square kilometres (km^2) (GoK, 2013). The county is crossed by 8 permanent rivers namely Malewa, Chania, Kitiri, Pesi, Mkungi, Turasha, Ewaso Narok and Kibiru, and Lake Ol'bollosat. The landscape is characterised by plateaus that gently slope and areas in the savannah zone with grass cover. The temperature in the County varies between 12 °C (July) to 25 °C (December). During the wet season in March and May, maximum rainfall is about 1700 mm. From September to December, also known as the dry season, minimum rainfall of about 700 mm is received (GoK, 2014).

Nakuru County is located within the Great Rift Valley, bordering the following eight counties: Kericho and Bomet to the west, Baringo and Laikipia to the north, Nyandarua to the east, Narok to the south-west and Kajiado and Kiambu to the south. The County stretches across an area of 7,495.1 km^2 (GoK, 2013). Agriculture is the most important economic pillar of Nakuru County. It represents a major basis for provision of food and employment. Besides agriculture, tourism and geothermal power generation are most relevant economic activities. The agricultural sector encompasses the following sub-sectors: livestock, fish farming and food and cash crops farming including horticulture and floriculture. Both large-scale commercial and subsistence farming is practiced (MoALF 2016).

The activity scope comprises in total 100 farmers that are located in the two counties described above.

1.2.2 Activity Location Maps

a. Location of the host country

b. Counties where solar-powered cold stores for potatoes will be implemented

1.2.3 Activity Timescales

Crediting Period: 15 years from the activity start date, corresponding to the expected lifetime of the cold store technology.

Monitoring period: 15 years from the project start date

1.3 Activity Coordination and Management

1.3.1 Activity Legal Entities

Table Activity Legal Entities	
Activity Owner	Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Activity Coordinator	Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

1.3.2 Activity Structure

- GIZ Proklima
- GIZ Kenya develoPPP
- Solidaridad

2. RELEVANT RULES, REGULATIONS AND NATIONAL POLICIES

In 2016, Kenya ratified a Climate Change Act 2016 which is the first legislation in Africa providing a regulatory framework for an enhanced response to climate change (Government of Kenya 2016). Section 13 of the Act provides for the development of National Climate Change Action Plans (NCCAP) to define measures and mechanisms for incorporating adaptation and mitigation actions into sector functions of national and county governments. NCCAP 2018-2022 is a framework for Kenya to deliver on its Nationally Determined Contribution (NDC) under the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC).

In the updated version of the NDC (Government of Kenya 2020), which was submitted by the Ministry of Environment and Forestry (MoEF) to the UNFCCC in December 2020, Kenya commits to enhance its adaptive capacity and climate resilience across all sectors. In the agriculture sector, climate smart actions shall be introduced to improve agricultural value chains and transform the sector into an innovative, commercially oriented, competitive and modern sector. For the mitigation component, the NDC foresees to promote clean, efficient and sustainable energy technologies to reduce over-reliance on fossil and non-sustainable biomass fuel as well as climate smart agriculture (Government of Kenya 2020).

The NCCAP identifies priority areas for adaptation and mitigation actions, including to enhance food and nutritional security through the improvement of crop productivity by introducing climate-smart actions. The climate change actions to improve food and nutritional security shall result in, among others, increased agricultural production and enhanced resilience of farmers through reductions in postharvest losses. At the same time, the NCCAP promotes the increase of renewable energy for electricity generation as well as a climate proof development of the energy infrastructure which reflects the needs of rural areas (Government of Kenya 2018a).

The Adaptation Technical Analysis Report (ATAR) 2018-22 has been developed under the NCCAP and delivers analysis of sectors and vulnerabilities in different counties resulting in lists of priority adaptation actions. Among the prioritized sectors for actions are agriculture, environment, sustainable livelihoods and energy infrastructure which are in line with the Sustainable Development Goals (SDGs) that the project activity aims to address. It also aligns with the Governments Big Four Agenda where Food and Nutrition Security is one of the priority actions pillars (Government of Kenya 2018b).

Agriculture has continuously suffered negative effects emerging from climate change which in turn leads to reduced productivity and insecure livelihoods. This sector is one of the key contributors to the country's economy, accounting for about a third (34% in 2019, World Bank 2020b) of the GDP. Besides, there is a large focus on reducing GHG emissions in the sector as agricultural emission accounted for approximately 40% of total national emissions in 2015 (Government of Kenya 2018a). Therefore, as a result of the country's determination to develop climate-smart agriculture methods to enhance resilience against the climate crisis, Kenya has developed the Climate Smart Agriculture Strategy 2017-2026. It aims to improve the adaptive capacity and resilience of agricultural systems at the same time minimizing GHG emissions (Government of Kenya 2018a). In this way, the project contributes to the NDC, particularly to the priority adaptation actions aiming to:

- Enhance the resilience of the agriculture, livestock and fisheries value chains by promoting climate smart agriculture and livestock development;
- Enhance the adaptive capacity of the population, urbanization and housing sector;
- Support innovation and development of appropriate technologies that promote climate resilient development.

It also supports the Climate Smart Agriculture Strategy in terms of sustainable development and poverty reduction, including adaptation, capacity building, infrastructure and technology advancement. Concrete measures listed in the Climate Smart Agriculture Strategy comprise:

- Enhance productivity and profitability of agricultural enterprises, through promotion of use of improved technologies; post-harvest approaches such as improved storage and distribution of agricultural products and market access.
- Promotion of energy-efficient technologies and innovations, including the promotion of the promotion of alternative techniques/innovations, along agricultural value chains that either use fuel efficiently or green energy (Government of Kenya 2017).

The Ministry of Agriculture, Livestock and Fisheries (MOALF) of Kenya has initiated the National Potato Strategy which is aligned with the country's Kenya Vision 2030 as it significantly contributes to the food and nutritional security. Potato is a widely accepted crop which has a high nutritive value compared to other crops, such as maize, wheat or beans. The tubers are highly efficient in terms of production and maintain relatively stable yields also under conditions which other crops might not resist (FAO 2013). Thus, the objective is to achieve sustainable growth in the potato industry ensuring food availability, and surplus for export and increasing incomes. The challenges such as inadequate technologies in production and inappropriate storage facilities still exist causing post-harvest losses which shall be addressed in line with the strategic interventions listed in the National Potato Strategy. Among others, the strategy lists the installation of cold storage facilities for potato seed at strategic locations, improvement of access to extension services and other entrepreneurial skills in agriculture as well as the dissemination of technologies for value addition. The operationalization of the strategy shall be a joint effort of various national stakeholders, ranging from different ministries, such as MOALF, over county governments to farmer and industry associations (Government of Kenya 2016a). Thus, the activity aligns with objectives of the strategy to increase potato production, improve post-harvest handling and value addition, and enhance research in the potato industry.

In a broader sense at the regional level, and more specifically in countries that are members of the East African Community (EAC), there are several regulations, policies and strategies aiming at harmonizing the efforts in the agricultural sector including potato production. In most EAC countries, climate change directly affects people's livelihoods, since the majority of households rely on rain-fed agriculture. On average, the agricultural sector contributes 27% to the GDP of the countries. The impacts of climate change are far-reaching, affecting not only food security but also other economic factors, up to and including the collapse of the agri-business sector, which depends on raw materials from agriculture. Due to the close interconnectedness of EAC economies, vulnerabilities in one country can easily be transferred to others, meaning that policy responses to and mitigation of climate change impacts can best be achieved through increased regional cooperation and cross-border investments. Therefore, the EAC partner states established different plans and strategies targeting the strengthening of the agriculture sector and food security at the regional level, such as i) the EAC Comprehensive Africa Agriculture Development Programme (CAADP) Compact, ii) the EAC Food Security Action Plan and the East African Community Regional Agricultural Investment Plan (EAC RAIP). These initiatives seek to identify, prioritize and formulate strategic interventions that would catalyze sustained agricultural transformation in the region, focusing on different thematic areas, such as regional food supply, value addition, sustainable natural resource management and strengthening of regional agricultural institutions and stakeholders. Post-harvest management, including adequate storage of products, is explicitly mentioned as challenge in the EAC RAIP which shall be addressed by specific interventions, for example optimal use of infrastructural capacity along transboundary value chains (EAC 2019).

With regard to potato production and processing, it is evident that there is a significant supply-demand gap in the EAC region, including a lack of high-quality potatoes required by potato processors. On the one hand, this is due to the growing of varieties that are not entirely suitable for processing. On the other hand, inadequate infrastructures including storage and cold chains affect the processing and even the entire cold chain. As a result, prices for seed and ware potato decrease significantly. As a consequence, seed certification standards were developed in the EAC, in line with the Organization for Economic Co-operation and Development (OECD) Seed Schemes and the International Seed Testing Association (ISTA) laboratory testing procedures and methods. These standards were transferred into EAC certification standards for seed potatoes, which have now come into force as national standards. Although the adoption of the OECD and ISTA standards can raise the level of quality assurance, most EAC Partner States still face difficulties in meeting these standards due to lack of trained staff and the required laboratory facilities. The status of EAC partner states with regard to seed legal frameworks is shown in Table 1.

Table 1: Availability of seed policy, seed law, seed regulation and seed potato protocols in EAC countries

	Burundi	Kenya	Rwanda	South Sudan	Tanzania	Uganda
Seed policy	Yes	Yes	Yes	Draft	Yes	Yes
Seed Law	Yes	Yes	Yes	Draft	Yes	Yes

	Burundi	Kenya	Rwanda	South Sudan	Tanzania	Uganda
Seed Regulations	Yes	Yes	Yes	Draft	Yes	Yes
Seed Potato Certification Protocols	Under development	Yes	Under development	No	Yes	Yes

Source: EAC (2021)

Moreover, in terms of climate change policies and strategies at the regional level, the EAC secretariat was mandated by the EAC states to develop a respective policy and strategies to address the negative impacts of climate change. The overall objective of the EAC Climate Change Policy is to provide guidance to partner states and other stakeholders in developing and implementing joint actions to address climate change in the region, while ensuring sustainable social and economic development. Especially considering the region's high vulnerability to the adverse effects of climate change which negatively impacts food security, adaptation to climate change is a major priority. In alignment with the EAC Climate Change Policy, the Climate Change Master Plan 2011 – 2031 was developed with the goal to "to strengthen regional cooperation to address climate change issues that concern regionally shared resources". The individual EAC Partner States have adopted various climate finance-related policies and set out in official communications to the UNFCCC current and planned measures to support the implementation of mitigation and adaptation actions. Some of these national climate-related policies are compiled in

Table 2: National climate change related policies, standards, guidelines and strategies of EAC member countries

Country	Policy/strategy/regulation name	Objectives	Date published
Burundi	NDC 2018	Mitigation, adaptation, access to finance	2018
	National Climate Change Policy	Mitigation, adaptation	2013
	National Strategy and Action Plan on Climate Change	Mitigation, adaptation	2013
Rwanda	National Environment and Climate Change Policy, 2019	Mitigation, adaptation	2019
	Law No. 48/2018 of 13 August 2018 on Environment	Mitigation, adaptation	2018
	National Environment and Climate Change Policy, 2019	Mitigation, adaptation	2019
	Five-Year Strategic Plan for the Environment and Natural Resources Sector, 2014–2018	Mitigation, adaptation	2014

Country	Policy/strategy/regulation name	Objectives	Date published
	Updated NDC	Mitigation, adaptation, access to finance	2020
	Rwanda Vision 2020	Mitigation, adaptation	2000
South Sudan	National Environment Policy, 2015–2025	Mitigation, adaptation	2015
	NDC	Mitigation, adaptation	2021
Uganda	National Climate Change Policy, 2015	Mitigation, adaptation	2015
	National Environment Management Policy, 1995	Mitigation, adaptation	1995
	NDC	Mitigation, adaptation	2016
	National Policy for Disaster Preparedness and Management	Mitigation, adaptation	2010
United Republic of Tanzania	Updated NDC	Mitigation, adaptation, access to finance	2021
	Agriculture Climate Resilience Plan	Mitigation, adaptation	2014
	National Climate Change Strategy	Mitigation, adaptation, access to finance	2014
	SREP Tanzania	Mitigation, adaptation, energy access	2013

Source: UNFCCC (2021)

The agriculture sector, together with water resources, is the sector prioritised by all EAC states for their adaptation actions (see table below).

Table 3: Priority sectors for adaptation in the East African Community

	Energy	Infra-structure	Environ ment/ forestry	Trans-port	Agri-culture	Human health	Coastal marine/ blue economy	Water re-sources	Tourism	Human settle-ments	Risk manage-ment
Burundi	✓	✓		✓	✓	✓		✓			
Kenya	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rwanda	✓	✓		✓	✓	✓		✓	✓		
South Sudan					✓			✓			
Uganda	✓	✓		✓	✓	✓		✓		✓	✓
Tanzania	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

Source: UNFCCC (2021)

3. METHODOLOGY

3.1 Methodology

The methodology ABM-NM001 "Potato storage using green cooling technology" is quantifying the adaptation benefits of installing cold stores including cooling technology powered by solar energy photovoltaic (PV) and use of refrigerants with a negligible global warming potential (GWP).

3.1.1 Applicability conditions

The applicability conditions defined by the methodology ABM 001 are presented and discussed in the following table:

Table 4: Overview of applicability criteria and justification

Criterion	Justification
Activity developers must demonstrate that in the project area the maximum ambient air temperature is likely to exceed a critical value of 12.0°C during the storage months, during the technical lifetime of the cooling technology. It shall further show that available climate models for the area project has a rise in temperature in the project area until the end of the technical lifetime	As it is demonstrated in section 3.1.2 Description of the Baseline, different climate models project an increase of average temperatures of 0.8°C to 1.5°C by 2030. Since historical and current average temperatures are already in the range of 14°C to 16°C, depending on the month, it is assumed that average temperatures will regularly exceed the 12°C threshold by 2036 (see 3.1.3 Justification of the Baseline).
Activity developers need to demonstrate that the activity:	a) Solar-powered cold storage facilities are not widely used in Kenya. Farmers rely on

Criterion	Justification
a) is an integrated, innovative and transformational action that has significant potential to deliver higher adaptation ambitions; b) supports the implementation of NDCs of host Parties and contribute to achieving the long-term temperature goal of the Paris Agreement; c) is conducted in a manner that respects, promotes and considers respective obligations of Parties on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity, consistent with the eleventh preambular paragraph of the Paris Agreement; d) minimizes and, where possible, avoids negative environmental, economic and social impacts.	traditional storage methods which do not offer adequate storage conditions. The introduction and installation of green cooling technologies has an innovative and transformational character. b) See section 2: The introduction of solar-powered cold stores is in line with Kenya's updated NDCs. c) The activity ensures and promotes the livelihood of local smallholders. It specifically promotes the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, and family farmers. d) see section 9.
Project activities are deemed automatically additional if it is demonstrated that all of the following conditions are met: a) The farm size is below 2 ha. b) Cooling technology utilizes a natural refrigerant, avoiding regulated substances. c) Storage temperature of below 8°C must be guaranteed	a) The majority of agricultural producers are small-scale farmers (90%) with average field sizes of less than 1 ha (Janssens et al. 2013). b) Cooling technology utilizes R290 (propane) as refrigerant: GWP = 3 c) Cold store (cooling technology) guarantees storage temperature of maximum 8°C.
Activity developers must show that there is no private or public finance available at that moment or planned within the next five years to fully cover the costs for installation of the cold store including the PV system as well as installation, operation and maintenance costs (co-financing is acceptable).	Assuming that a smallholder farmer on average harvests 7 tonnes of potato per year with average losses during storage of about 9% in 2021 (see table 6), he would be able to sell in total 6.38 tonnes per year. With an average market price of 189 USD/tonne this

Criterion	Justification
	would result in 100 USD[1] revenues per month. However, the estimated total cost per month for a decent living standard for a reference family (5.5 people) in the rural areas of Kenya is estimated at 213 USD (Anker 2017). Therefore, it can be assumed that the smallholder farmer cannot raise financing to fully cover the costs for the installation of the cold store.
The ABM activity is new and not business as usual, e.g., not mandated by law or common practice.	Potato storage conditions and technology are not regulated by law nor common practice in Kenya.
Activity must guarantee safe handling and operation of system including regular servicing of the equipment and, if necessary, provide adequate training to the operating and servicing personnel.	Training of maintenance personnel and regular servicing is planned and will be monitored throughout the activity duration the lifespan of the project (see description of monitoring plan (10.1.2)).
Activities must be greenfield activities where no cooling technology is existing yet.	Baseline storage facility is a covered shed without artificial cooling system.

3.1.2 Description of the Baseline

Climatic conditions and projections

Kenya is located on the eastern part of the African continent and is divided into 47 counties with devolved governments according to the Kenya Constitution 2010 (UN Women 2019). About 80% of the land is arid and semi-arid lands (ASALs) and the remaining 20% is classified as arable or high potential. Traditionally, the country has a patriarchal society and 30.2% of female-headed households are poorer compared to 26.0% of those headed by men (Kenya National Bureau of Statistics, KNBS, 2018). On average, more female-headed households are below the poverty limit than male-headed ones.

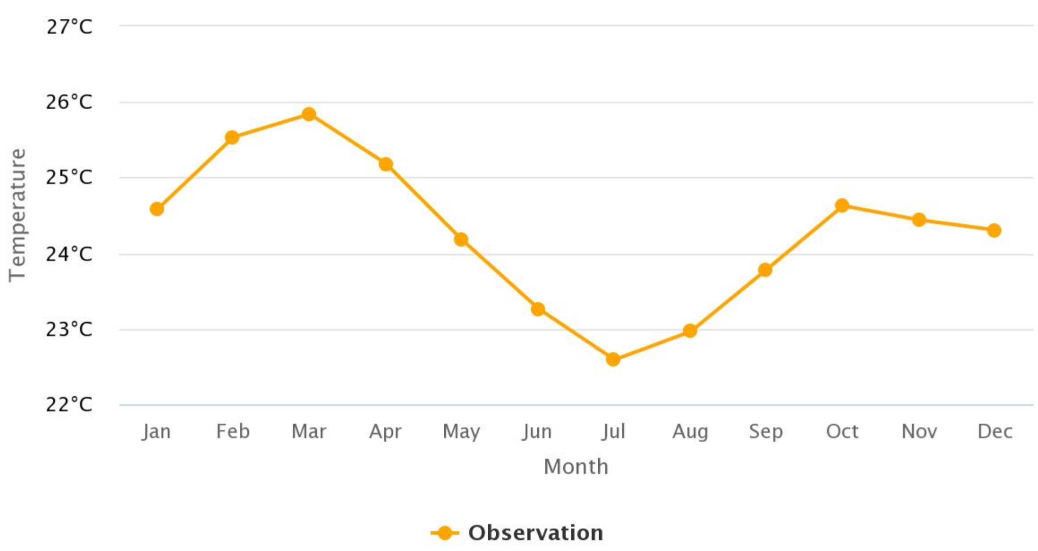
The primary drivers of the country's economy are agriculture and tourism contributing to 30% and 11.6% of the GDP respectively (UN Women 2019). In particular, agriculture contributes to 70% of total employment in the country and almost 69% of all households are involved in farming activities. Women participate in 80% of food production, however, benefit from only 7% of the agricultural extension services.

Climate change impacts are clearly noticeable in Kenya. There has been a general warming trend of about 1°C (0.21°C per decade) since 1960 (Government of Kenya 2018b). Between 1960 and

[1] https://www.npckviazisoko.com/prices

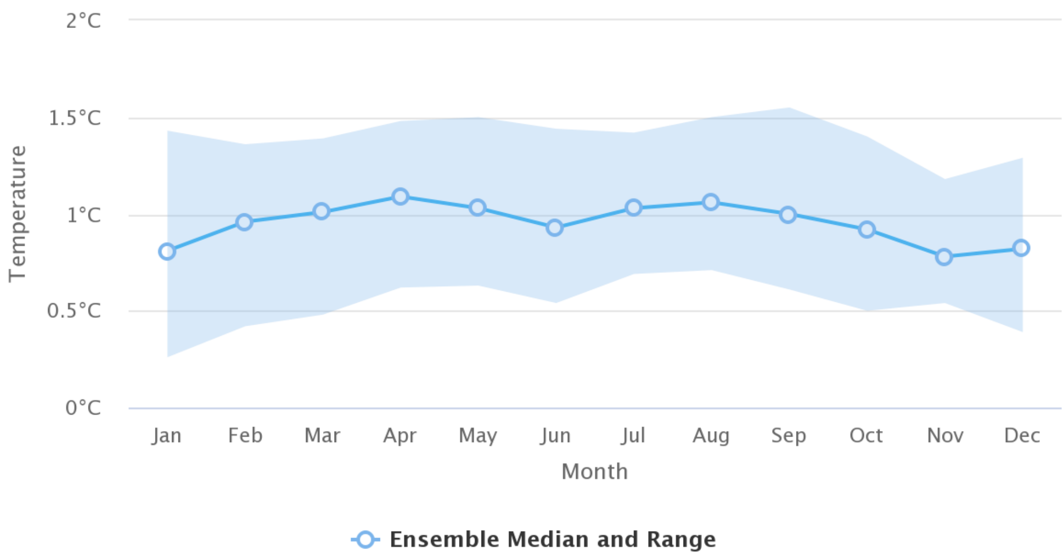
2013 the mean annual minimum temperature increased from 0.58°C to 1.69°C in the country as a whole and from 0.58°C to 1.91°C in Arid and Semi-Arid Lands (ASALs) where Nakuru is located.

Figure 1: Historical observed monthly temperature for Kenya for 1986-2005



Source: World Bank 2020

Figure 2: Projected change in monthly temperature for Kenya for 2020-2039



Source: World Bank 2020

According to Global Climate Modelling, the increasing trend will continue with a projected mean annual temperature rise of 0.8 to 1.5°C until the 2030s and 1.6°C to 2.7°C until the 2060s (Government of Kenya 2016b). Climate modelling for the East Africa region projects that mean annual temperatures will increase by 0.9 °C by 2035, 2.2 °C by 2065 and 4.0 °C by 2100 (RCP8.5 scenario). Extreme weather events, and especially droughts are considered major disasters in

Kenya. For example, the drought in the years 2014-2018 was declared a national emergency. Increased temperatures and accelerated water depletion are occurring across most ASALs in Kenya. Rise in temperatures has severe implications for future extreme heat and drought events and livelihoods activities such as crop production. Hence, extreme heat periods cause the greatest economic impact; on average, a 0.6 % decline in GDP growth is observed in Kenya in years of poor rains and extreme temperatures (Government of Kenya 2018b).

Socio-economic context

As mentioned above, agriculture is one of the key contributors to the national economy through the provision of employment, food security and livelihoods. Kenya's Gross Domestic Product (GDP) growth is therefore highly correlated with growth in the agricultural sector. Within the agriculture sector, horticulture represents the largest sub-sector accounting for around one third of the agricultural GDP and 38% of the sector's export revenues. However, most of these earnings derive from the export of flowers, only 5 % of vegetables and fruits are produced for export. The majority of agricultural producers are small-scale farmers (80%) with average field sizes between 0.2 and 3 ha. Production for domestic use mainly includes cultivation of potato, cabbage and kale (84% of the value of vegetables produced and consumed in 2017). After maize, potato is the second most consumed crop in Kenya and is grown by approx. 500,000 farmers on a total land area of 128,000 ha. Therefore, it is considered essential for the country's food security. According to Janssens et al. (2013), average potato productivity is estimated at around 7.7-9.5 tonnes per ha. Gildemacher et al. (2009) indicate average potato productivity to be at 9.1 tonnes per ha whereas GIZ (2014) provides a value of 13 tonnes per ha. This is rather low compared to North America and European countries where average yields are around 40 tonnes per ha (Gildemacher et al. 2009; Janssens et al. 2013). The following table provides an overview of the estimated composition of potato grower groups.

Table 5: Estimation of composition of potato grower groups

Potato grower groups	% farmers	No. farmers	Average potato area per farm (ha)	Total potato area (ha)	% area
Small scale	98	490,000	0.2-0.4	106,000	83
Small-medium scale	1.95	9,750	2	19,500	15
Large scale	0.05	250	10	2,500	2
Total	100.00	500,000		128,000	100

Source: Janssens et al. 2013

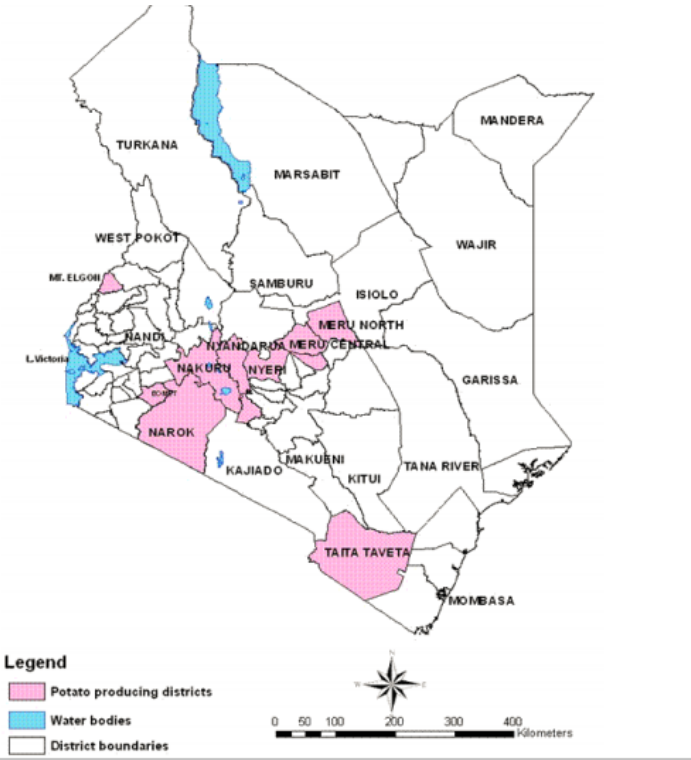
Vulnerability context

Since the agriculture sector is 98% rainfed in Kenya, it is highly exposed to disruptions emerging from changes in temperature, extreme weather events, unsustainable natural resource management, loss of forest, droughts and floods (Government of Kenya 2018b). This results in increased food insecurity due to shortage in availability, accessibility, utilization and stability in the food supply. Moreover, climate change threatens agricultural productivity and land degradation causing a decrease in the production, lack of income from the sector, food shortage and malnutrition.

In addition, high water insecurity with water resources covering only 2% of the total surface area and low replenishment rate of freshwater resources creates a larger vulnerability to climate change and exacerbates competition over resources in the country. Having less economic power women as primary providers of food and fuel are more vulnerable to the effects of climate change. Increasing temperatures have significant consequences such as drastic heat and drought. In the periods of deficient rainfall in Kenya an average of 0.6% decline in GDP growth is experienced and an increase of food insecurity can be observed (Government of Kenya 2018b). Desertification, especially in ASALs, has undesirable implications on land productivity and food security. As a result, land degradation brings changes in the chemical, physical and biological properties of the soil reducing its ability to sustain the quality and quantity of plant growth.

Potatoes are mainly cultivated in high-altitude areas of 1,500 – 3,000 m above sea level. The four main producing areas are Bomet and Nakuru Counties in the Rift Valley area, Nyandarua County in Central Kenya and Meru County in Eastern Kenya (Janssens et al. 2013).

Figure 3: Potato producing areas in Kenya



Source: Janssens et al. 2013

There are two seasons with abundant rainfalls that have different lengths depending on the region (Gildemacher et al. 2009). The longer rainy season starts in March/April and lasts to June/July, while the short rainy season is from October to December (Janssens et al. 2013). In areas of higher altitude (above 2,000m above sea levels) limited offseason cultivation can be observed where there is sufficient intermittent rainfall. Consequently, the majority of farmers cultivate potato twice a year, consistent with the rainy seasons (Gildemacher et al. 2009). June to August is usually the season with higher yields while December, April and May are the scarce periods. Farm gate prices during the scarce periods are often 2-4 times higher than the price during the glut season (Janssens et al. 2013).

Table 6: Two seasons for potato harvest: long and short rain period

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Short rains		H	H							P	P	
Long rains			P	P			H	H				

P = planting; H = harvesting

Source: Janssens et al. 2013

Both, in Nakuru County as well as in Nyandarua County, potato farming represents a main source of income for many smallholder farmers. These counties are two of the major sources of potatoes sold in Nakuru, Nairobi and Mombasa. Together, they account for approx. one third of Kenya's total production area. Farmers often harvest potatoes before they reach their full maturity since they are requested by distributors to do so or because they want to benefit from the higher prices. Usually, farmers store potatoes for home consumption or in order to wait for better prices and as seed for future planting (GIZ 2014). Seed potatoes are often stored underground, i.e., in pits which are covered with straw. In many cases, these tubers sprout before they are planted again. The storage period between harvest and next planting is usually two months. Ware potatoes are stored in covered and air-cooled sheds for about one month longer than seed potatoes, i.e., up to three months (Janssens et al. 2013).

Across various studies, it is observed that the absence of proper storage facilities leads to several problems in the entire post-harvest value chain. In general, the Kenyan potato sector faces various challenges such as limited availability and access to quality seeds, production with low value added, insufficient post-harvest storage infrastructure resulting in considerable post-harvest losses (up to 20%) and inefficient market structures (SNV 2019). A large quantity of potatoes is sold to distributors that usually offer very low prices. In addition, an inadequate transport system contributes to the trade barriers farmers are facing (MoALF 2016). Similar challenges have been reported for potato farmers in Ethiopia. Due to the lack of appropriate storage technologies for ware and seed potatoes, farmers keep their potato harvest in the field for a prolonged period. This leads to insect infestation of the tubers and consequently to lower yields and a reduced quality of the potatoes. An analysis of the extended harvesting period in Ethiopia showed that the yield of marketable potatoes decreased by 60% when tubers were left in the ground 90 days longer (210 instead of 120 days) (Degebasa 2020).

Modern cold rooms are hardly prevalent in Kenya and especially in rural areas. Isolated pilot project, such as the installation of a 500-tonne cold storage unit in Naivasha in the context of a project implemented by SNV and funded by the Embassy of the Kingdom of the Netherlands, demonstrate the feasibility of the technology (SNV 2019). However, a financing gap in combination with difficult or no access to public and private finance impedes the uptake of cold stores, and even more so when it comes to climate-friendly technologies that are associated with higher costs.

Due to the unavailability of adequate storage facilities, most farmers are forced to sell their products immediately after harvest. In case they store them for a longer period, they usually experience severe quality losses, such as greening and sprouting. Further losses occur along the value chain due to poor transport infrastructure and insufficient storage options at markets. A survey conducted by Musita et al. (2019) reveals that approx. 69% of potatoes sold at markets are exposed to direct sunlight. Three quarters of traders leave potatoes in the open covered with a plastic bag when the market closes at the end of the day. It is common practice to sell greening, sprouting or bruised potatoes to restaurants, potato processors or consumers at lower prices without considering that consumption of greened potatoes is unhealthy. Even more, inadequate post-harvest handling can lead to the accumulation of glycoalkaloids. These are toxic substances which can be harmful if consumed in large quantities (Musita et al. 2019).

Furthermore, Kenya's economy benefits from an expanding food processing industry. There are several potato processing companies that produce crisps and fries. Kaguongo et al. (2014) indicate that Kenyan processing companies buy and process between 5 and 15 tonnes of potatoes per week. However, they face serious problems with supply of good quality potatoes. It is estimated that processors reject up to 5% of the potatoes supplied since these are damaged, immature or rotten. In addition, some companies experience supply shortages especially in the months between the harvest periods (Kaguongo et al. 2014). Both circumstances lead to the fact that processors import good quality potatoes from neighboring countries, which, in turn, weakens the local potato value chain.

The baseline scenario includes 100 farmers located in Nayandarua and Nakuru County, belonging to one potato cooperative. These farmers harvest potatoes at least twice per year. The quantity of harvested potatoes is estimated at 7 tonnes per farmer and year[2]. The potato variety that is grown by these farmers is Dutch Robijn. Baseline storage facilities are traditional covered sheds (see picture below) which are air-cooled (no artificial cooling) (Solidaridad 2020). Potato losses are estimated to account for approx. 9% in 2021 compared to the pre-climate change period (1979 – 1989) and will increase up to 31% in 2036 in relation to increasing ambient temperatures. The next sections provide detailed explanation and results of the modelling.

Figure 4: A typical and simple potato storage facility in Nyandarua County

Source: IFDC 2019

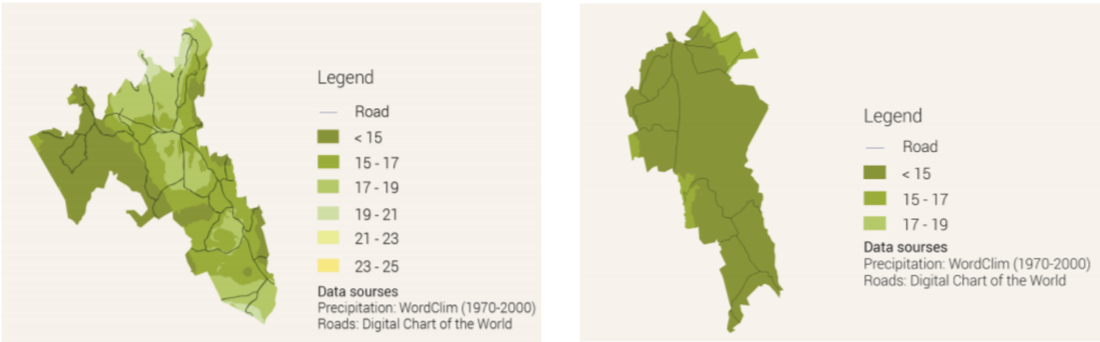
3.1.3 Justification of Selected Baseline

Historical mean average temperatures in Nayandarua and Nakuru County range between < 15 °C (especially in Nyandurua County) and around 20°C (see Figure 6). However, extreme temperatures are in the range of up to 30°C (maximum temperatures mostly in the period from December to March) and rather low temperatures of around 12°C in June and July (mean temperature). Annual precipitation is rather high in the eastern region (> 1250 mm per year) and

[2] Information provided by Solidaridad Kenya based on implemented projects. The indicated range of 7-12 tonnes of potato yield per farmer and year corresponds to values for average potato productivity found in literature: Janssens et al (2013): 7.7-9.51 tonnes per ha; Gildemacher et al. (2009): 9.1 tonnes per ha; GIZ (2014): 13 tonnes per ha.

drier in the norther area. Generally, as mentioned before, the short rainy season is during October, November and December, whereas the long rains fall between March and May (MoALF 2016).

Figure 5: Historical annual mean temperature in Nakuru County and Nyandarua County

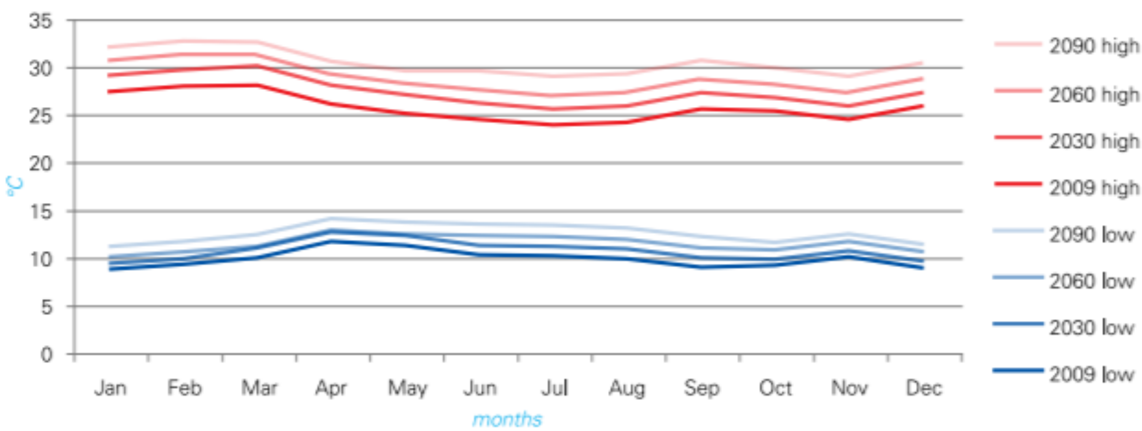


Source: MoALF 2016

Overall climate modelling for Kenya shows that the projected change in monthly temperature will be around 0.8 to 1.0 °C by 2030 (compare

Figure 2). Projections of mean high and low temperatures for Nakuru County until 2030 show that temperatures will increase by approx. 1.0°C to 2.0°C compared to 2009 levels (see Figure 6). Consequently, the average annual temperature will rise by at least 1.0°C to a range between 13°C and 21°C.

Figure 6: Mean high and low temperature projections for Nakuru

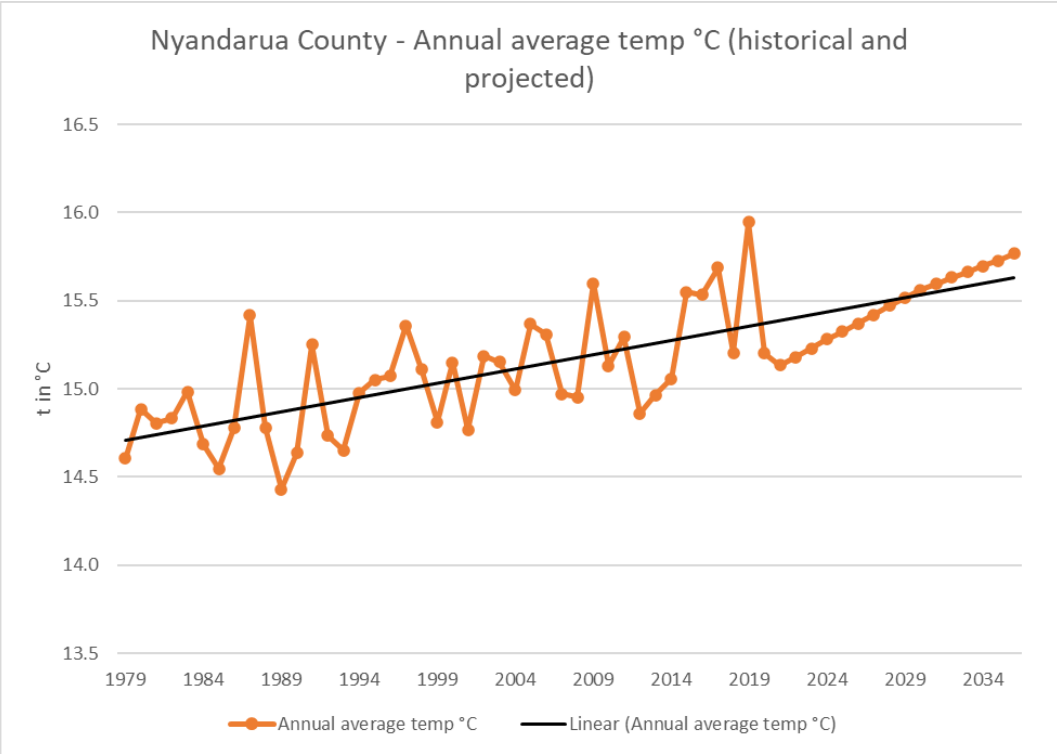


Source: UNICEF n.d.

Measurement data on ambient temperatures (hourly basis) gathered from a weather station in Nyandarua County (-0.366592, 36.28307) provide the basis for modelling historical and future temperature trends in the activity region for the period 1979 – 2036. Projected trends of future ambient temperatures according to existing modelling (see above) are used to make projections based on historical data.

Figure 7 shows the modelling results.

Figure 7: Historical and projected annual average temperature in Nyandarua County



Source: Authors

3.1.4 Justification for Excluding Alternative Baseline Scenarios

Baseline is defined as per methodology ABM 001, and fulfills all applicability criteria as shown in section 3.1.1. If applicability conditions are met, no alternative baseline scenarios are considered.

3.1.6 Baseline Revision

The baseline will be reviewed every 5 years, to ensure that updated data and information is used, that the applicability conditions of the methodology are met over time and no significant changes occurred. In case the initial activity conditions are different from the current situation, the applicability of the methodology would have to be re-checked and demonstrated again.

4. ADAPTATION BENEFIT MECHANISM ACTIVITY

4.1 Description of Adaptation Benefit Mechanism Activity

The installation of a solar photovoltaic (PV) powered cold store will enable the farmers belonging to the cooperative to store potatoes at appropriate storing conditions (temperature and humidity level) for four months with significantly reduced food losses (5% instead of up to 29% (in 2035)). Potatoes are sold to a local potato processer that produces crisps and fries. The good quality of potatoes offers the farmers the possibility to sell them at higher market prices, depending on the season.

In addition, the installation of the cold store contributes to significant improvements of the local potato value chain and supports to transform it in a sustainable manner. On the one hand, it enables the potato processor to guarantee uptake of significant volumes of quality potato from contracted farmers which provides farmers with a secured and stable income. On the other hand, the firm no longer depends on the import of good quality potatoes from abroad. Hence, the entire potatoes value chain can be organized locally and be sustainably secured. Thus, the activity contributes to increased food production and additional income.

The off-grid system (PV) which feeds the cold store guarantees that there are no greenhouse gas (GHG) emissions from the use of grid electricity. In addition, the cold store uses propane as climate-friendly refrigerant which has a negligible global warming potential (3) and therefore does not result in significant GHG emissions (in contrast to for instance hydrofluorocarbons (HFCs) which have higher GWP values in the range of 100-10,000). Another advantage of using propane as refrigerant is that it is readily available in Kenya and is a lot more cost-effective than HFCs (Government of Kenya 2020b; GIZ 2019).

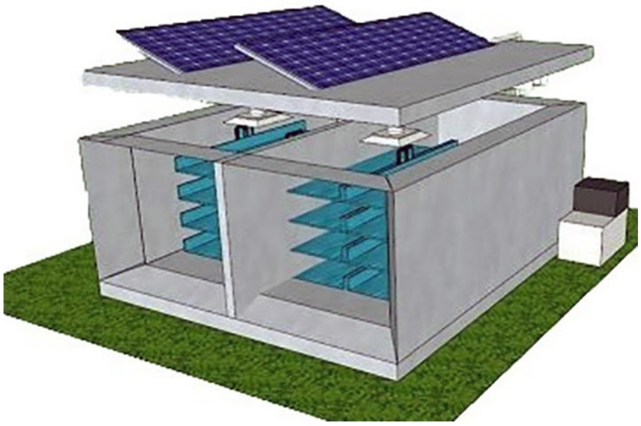
The following table provides the technical details of the cold store.

Table 7: Technical details of the cold store

Technology used for cold store and cooling system:	Insulated cold store with mechanical cooling and ventilation
Dimensions of cold store	19.21 m x 15.28 x 6.4 m (W,L,H)
Cooling capacity	53.0 kW, evaporation temperature -4°C and condensation temperature 40°C
Cooling temperature range	3-7°C
Electricity consumed per month	9,000 kWh
Type of refrigerant used for cold store	R290
Initial charge of refrigerant	12 kg

The cold store will be powered by a PV system (80 kWp) which includes battery storage in order to ensure security of power supply (see graph below)

Figure 8: Sketch of solar-powered cold storage facility



Source: Agarwal 2018

Thus, the activity will improve agricultural production and enhances resilience to increasing temperatures and extreme weather shocks such as droughts or heavy rainfalls. In poor rural areas, having access to modern cooling systems allows households to enhance their food production with positive implication in terms of income. In addition, the technology involves no disadvantages with regard to negative climate impacts, i.e., no increase in GHG emissions. By bridging the funding gap, the feasibility and socio-economic benefits of the technology can be demonstrated. The activity can be replicated for other farmer cooperatives, SMEs or public-private- partnerships, and thus could function as a catalyzer for the establishment of a supply chain of sustainable cold rooms and a roll-out of the technology across the country.

4.2 Core Adaptation Benefits

The core adaptation benefit will be the increased income (saved wealth) of smallholder potato farmers from potatoes that are protected from rotting due to temperature increases. The quantity of good quality potatoes after storage is the central benefit that is subject to monitoring.

In addition, the activity contributes to the following indirect benefits:

- Increased food availability for farmers and other consumers and overall increased national food and nutritional security.
- Increased income for farmers

The cold storing of potatoes therefore leads to reduced impacts of climate change related higher ambient temperatures on smallholder famers. It results in reduced vulnerability and strengthened resilience of farmers.

5. QUANTIFYING ADAPTATION BENEFITS

5.1 ABM Activity Performance

The core adaptation benefit that will be measured is the amount of saved wealth due to decreased risk of rotting of potatoes that are stored in the cold store per year. Methodology ABM-NM001 specifies that an AB corresponds to 1 USD saved.

5.2 Definition of the Adaptation Baseline Scenario

The baseline scenario considers a quantity of 700 tonnes (7 tonnes per farmer a year; 100 farmers) being stored per year in covered sheds. After the harvest, farmers in the counties of Nyandarua and Nakuru store potatoes for up to four months. This results in 120 days of storage per year (two harvests with two months of storage each). Average projected daily ambient temperatures ($t_{average,d,y}$) in the activity period (2022-2036) is derived from the modelling carried out based on historic measurements and projected trends (see 3.1.3). The storage base temperature required for potatoes is 12°C. The market value of potatoes is estimated at 189 USD/tonne.

Table 8: Overview of adaptation baseline parameters

Quantity of potatoes stored in storing facility in baseline year	$QB_{P,y}$	t	700
Quantity of ware potatoes harvested per farmer in baseline year		t	7
Storage base temperature required for potatoes	t_{base}	°C	12
Market value of potatoes in the activity area	$MV_{BL,P,y}$	USD/tonne	189[3]

According to the equation (1) of the methodology, the quantity of potatoes that are in good quality after storage is calculated as follows:

$$NB_{P,y} = QB_{P,y} * \left(1 - \frac{SDD_y - SDD_{pre-cc}}{SDD_{pre-cc}}\right) \tag{1}$$

Where

$NB_{P,y}$ = quantity of good quality potatoes after storage in year y (tonnes)

$QB_{P,y}$ = quantity of potatoes stored in storing facility in year y (tonnes)

SDD_y = Storage Degree Days during storage period in year y in °C[4]

[3] https://www.npckviazisoko.com/prices

[4] “SDDs are accumulated whenever ambient temperatures are higher than the storage base temperature required for potatoes.” (Lesinger et al. 2020)

SDD_{pre-cc} = Average Storage Degree Days during storage period in pre-climate change period (for at least 3 years pre-1990) in °C

$$SDD_{\ y} = \sum \Delta\, SDD_{y,d} \tag{2}$$

Where

$\Delta SDD_{\ y,d}$ = daily incremental SDD during storage period in year y in °C

$$\Delta SDD_{\ y,d} = \ max\ (t_{average,d,y} - t_{base}, 0) \tag{3}$$

Where

$t_{\ average,d,y}$ = average temperature on day d in year y in °C

Data on projected average daily temperatures may be derived from official documents including climate change modelling, trends and scenarios for the project country or region, such as for example National Adaptation Plans (NAPs), Adaptation Communications (Acs) or National Communications to the UNFCCC.

$t_{\ base}$ = storage base temperature required for potatoes (12 °C)[5]

$$SDD_{\ pre-cc} = average\ (\ \Delta\, SDD_{pre-cc,d}) \tag{4}$$

Where

$\Delta SDD_{\ pre-cc,d}$ = daily incremental SDD during storage period in the pre-climate change period

(before 1990) in °C

Table 9 shows the annual average temperatures, calculated average SDDs for the pre-climate change period (1979-1989), as well as for the period of 1990-2020 and the activity period of 2022-2036 (during the storage periods December/January and May/June) and the resulting losses.

[5] According to Winkler et al. (2018) storage temperature should start at 12°C, Winkler, J.A., Soldo, L., Tang, Y. et al. (2018): Potential impacts of climate change on storage conditions for commercial agriculture: an example for potato production in Michigan, in: Climatic Change, 151, p. 275–287

Table 9: Overview of annual temperatures, calculated SDDs and potato losses in the baseline scenario

Year	Annual average temperature in °C	SDDs per storage period in °C	Average SDD per storage period in °C	Additional SDD compared to pre-cc period in °C	Potato losses in %
1979-1989 (pre-cc)	14.79	n.a.	354	n.a.	n.a.
1990-2020	15.15	n.a.	393	39	11
2021	15.13	385	n.a.	31	9
2022	15.18	391	n.a.	37	10
2023	15.23	397	n.a.	43	12
2024	15.28	403	n.a.	49	14
2025	15.32	409	n.a.	55	15
2026	15.37	415	n.a.	61	17
2027	15.42	421	n.a.	66	19
2028	15.47	427	n.a.	73	21
2029	15.51	432	n.a.	78	22
2030	15.56	438	n.a.	84	24
2031	15.60	442	n.a.	88	25
2032	15.63	447	n.a.	93	26
2033	15.66	450	n.a.	96	27
2034	15.70	454	n.a.	100	28
2035	15.73	459	n.a.	104	29
2036	15.76	463	n.a.	109	31

The amount of economic losses of the potatoes in storage is calculated as follows (equation (3) of ABM-NM001):

$$Eclos_{BL,P,y} = QB_{P,y} * \left(\frac{SDD_y - SDD_{pre-cc}}{SDD_{pre-cc}}\right) * MV_{BL,P,y} \quad (5)$$

Where

$Eclos_{BL,P,y}$ = economic losses of potatoes due to climate change in storage in year y (USD)

$MV_{BL,P,y}$ = market value of potatoes in the activity area during storage period in year y (USD/tonne)

The following table provides an overview of the calculated quantity of potatoes that are in good quality after storage and the economic losses related to potato losses due to climate change under the baseline scenario in the activity period.

Table 10: Overview of quantity of potatoes that are in good quality after storage and economic losses

Year	Quantity of potatoes that are in good quality after storage in tonnes	Economic losses in USD
2022	627	13,850
2023	615	16,038
2024	603	18,412
2025	592	20,414
2026	580	22,602
2027	569	24,790
2028	556	27,164
2029	546	29,166
2030	534	31,354
2031	526	32,886
2032	517	34,598
2033	510	35,949

2034	502	37,481
2035	494	39,012
2036	485	40,725
Total	**8,254**	**424,442**
Average per year	**550**	**28,296**

In the baseline scenario, the quantity of good quality potatoes after storage in one year is calculated to be **550 tonnes on average**. For the entire activity t period of 15 years, this would result in **8,254 tonnes**.

The loss of potatoes due to rotting would result in economic losses of **28,296 USD per year on average**, and **424,442 USD over the activity period**.

5.3 Definition of the Adaptation Activity Scenario

The proposed activity seeks the installation of a cold store which is powered by solar PV and uses a refrigerant with negligible GWP value. The cold storing of the same quantity of potatoes as in the baseline scenario (700 tonnes per year) will result in decreased losses due to increased ambient temperatures. Average potato losses are estimated at 5% per year.

The quantity of potatoes that can be stored in the cooled storage facility and thus are protected from rotting due to temperature increases is calculated as follows:

$$N_{P,y} = Q_{PSt,y} * (1 - PL_{St,y}) \quad (6)$$

Where

$N_{P,y}$	= Amount of potatoes protected from rotting due to temperature increases by the activity in year y (tonnes)
$Q_{PSt,y}$	= Quantity of potatoes stored in cooled storing facility in year y (tonnes)
PL_{Sty}	= Average potato losses in year y (share) in cold storage

Considering the activity scenario parameters as mentioned above, the quantity of good quality potatoes after storage is increased to **665 tonnes per year**.

The amount of economic losses of potatoes due to rotting in the cold store are calculated as follows:

$$Eclos_{P,y} = Q_{PSt,y} * PL_{St,y} * MV_{P,y} \quad (7)$$

Where

$Eclos_{P,y}$ = economic losses of potatoes in storage in year (USD)

$MV_{P,y}$ = market value of potatoes in the activity area in year y (USD/tonne)

Assuming there are 5% losses occurring during the storage of potatoes, the expected economic losses in the activity scenario are **6,615 USD per year** and **99,225 USD cumulated over the activity period.**

5.4 Quantifying the Adaptation Benefits Units generated by the activity

Adaptation Benefits (ABs) are calculated as the amount of saved wealth due to decreased risk of rotting of potatoes. Hence, this is the difference between economic losses in the baseline scenario deriving from potatoes in bad quality after storage due to climate change and economic losses from potatoes due to rotting in the activity scenario:

$$AB_y = SW_{P,y} = Eclos_{BL,P,y} - Eclos_{P,y} \quad (8)$$

Where

$SW_{P,y}$ = saved wealth in activity year y (USD)

AB_y = total volume of ABs generated in year y (USD)

Table 11: Summary of AB calculation

Baseline scenario			
Average quantity of good quality potatoes after storage in baseline year	$NB_{P,y}$	t	550
Total quantity of good quality potatoes after storage in baseline period		t	8,254
Average economic losses of potatoes in storage in baseline year	$Eclos_{BL,P,y}$	USD	28,296

Total economic losses of potatoes in storage in baseline period		**USD**	**424,442**
Quantity of potatoes stored in storing facility in baseline year (tonnes)	$QB_{P,y}$	t	700
Quantity of ware potatoes harvested per farmer in baseline year		t	7
Average potato losses during storage due to climate change in baseline year		%	21
Market value of potatoes in the activity area in year baseline year	$MV_{BL,P,y}$	USD/tonne	189
Activity scenario			
Quantity of good quality potatoes after storage in activity in year y	$N_{P,y}$	**t**	**665**
Economic losses of potatoes in storage in year y	$Eclos_{P,y}$	**USD**	**6,615**
Quantity of potatoes stored in cooled storing facility in year y	$Q_{P,St,y}$	t	700
Average potato losses in year y (share) in cold storage	$PL_{st,y}$	%	5
Adaptation Benefits			
Average amount of saved wealth due to decreased risk of rotting of potatoes	ABs	USD/year	**21,681**

On average **21,681 USD** will be saved per year by protecting potatoes from rotting through the installation and storage in the cold store. Since one AB equals one USD, this translates into **21,681 AB per year (on average).** Over the entire activity period, **325,217 ABs** will be generated.

5.5 Quantifying the costs of 1 AB

In order to calculate the price of one AB, the total additional costs of the cold store including the solar PV system compared to traditional potato storage plus the costs of the ABM activity cycle and capacity building need to be divided by the number of ABs. The calculation is shown in **Error!**

Reference source not found. It results in an AB price of USD 1.78. The underlying technical and costing data is coming from various field studies.[6]

Table 12: AB price calculation

Cost for cold store		
Costs for cold room equipment (greenfield) incl. installation and transport	USD	90,000
Further extra costs, e.g. import costs, etc.		15,000
Costs for capacity building (e.g. training for technicians)		2,500
Servicing costs	USD	9,000
ABM activity cycle costs	USD	150,000
Cost difference to grid-powered cold store		
Energy costs over lifetime	USD	226,800
TOTAL cold store	**USD**	**271,000**
Cost for PV system		
PV system incl. battery, cables, installation[7]	**USD/kW**	**6,668**
PV system (80kWp) incl. battery, cables, installation	**USD**	**533,440**
TOTAL cold store + PV system	**USD**	**577,640**[8]
AB price **(Activity cycle costs + capacity building costs + costs cold store + costs PV system)/number of ABs per crediting period**	**USD**	**1.78**

6. Activity risks

Potential risks of reversal of the adaptation benefits are mainly due to:

- The solar system installed under the activity could cease to operate due to malfunction, lack of solar radiation. If that is the case no ABs will be claimed for the period when the cold store is not operational.
- Negative carbon footprint if grid electricity or diesel generators are used instead of solar PV (e.g., in case of malfunctioning of PV system).

[6] Please note that these are preliminary cost estimates for illustrative purposes since they are not based on in-depth feasibility analysis but rather different field studies and desk research. Resources for the ABM project cycle are rough estimations based on the authors' judgement.

[7] Based on Day et al. 2018

[8] Energy costs are subtracted, since those do not occur in the case of solar PV; assumption: monthly electricity consumption of 9,000 kWh; electricity price of 0.14 USD/kWh (EPRA 2018)

- Increase in GHG emissions due to the use of high GWP refrigerants. However, eligibility criteria of ABM methodology safeguard the use of low GWP refrigerants.

7. QUANTIFYING MITIGATION BENEFITS

7.1 Definition of the Mitigation Baseline Scenario

According to ABM 001, baseline emissions consist of direct and indirect emissions. Direct baseline emissions are calculated for refrigerants with a high GWP (GWP > 1000) that would be used in a similar cooling system (i.e., with similar technical specifications, such as cooling capacity), applying the same emission factors for leakage during servicing and disposal of the cooling system as for the cooling technology implemented under the activity scenario. Indirect baseline emissions are calculated assuming that the cold store is connected to the local electricity grid and would consume the same amount of electricity as generated by the PV system installed under the activity scenario.

$$BE_{y} = BE_{dir,y} + BE_{ind,y} \quad (9)$$

Where

BE_y = total baseline emissions in year y (tCO_2e)

$BE_{dir,y}$ = direct baseline emissions in year y (tCO_2e)

$BE_{ind,y}$ = indirect baseline emissions in year y (tCO_2e)

Direct baseline emissions:

$$BE_{dir,y} = BE_{SB,y} + BE_{DB,y} \quad (10)$$

Where

$BE_{SB,y}$ = baseline emissions for the cold store entering the servicing boundary within the year y (tCO_2e)

$BE_{DB,y}$ = baseline emissions for the cold store entering the disposal boundary within the year y (tCO_2e)

$$BE_{SB,y} = R * EF_{SB} * GWP_{ref} * \frac{1}{1000} \quad (11)$$

$$BE_{DB,y} = R * EF_{DB} * GWP_{ref} * \frac{1}{1000} \quad (12)$$

Where

R = initial refrigerant charge (kg)

EF_{SB} = fugitive emission factor of refrigerant during servicing of cooling system expressed as fraction of initial charge (%)

EF_{DB} = fugitive emission factor of refrigerant during disposal of cooling system expressed as fraction of initial charge (%)

GWP_{ref} = global warming potential of high GWP refrigerant

Indirect baseline emissions:

$$BE_{ind,y} = EC_{BL,y} * EF_{grid,y} * (1 + TD_y) \quad (13)$$

Where

$EC_{BL,y}$ = baseline electricity consumed in year y (MWh)

$EF_{grid,y}$ = electricity grid emission factor for year y (tCO_2e/MWh)

TD_y = average technical grid losses in year y (%)

The following tables present the underlying parameter for the calculation of baseline emissions as well as the results.

Table 13: Calculation of direct emissions under the baseline scenario

Direct emissions			
Parameters			
Refrigerant	R507a		
Initial refrigerant charge high GWP refrigerant	R	kg	12[9]
Global Warming Potential high GWP refrigerant	GWP_{ref}		3985[10]

[9] based on IPCC/TEAP 2015

[10] Based on IPCC AR 5

Fugitive emission factor of refrigerant during servicing of cooling system expressed as fraction of initial charge	EF_{SB}	%	15[11]
Fugitive emission factor of refrigerant during disposal of cooling system expressed as fraction of initial charge	EF_{DB}	%	75[12]
Results			
Baseline emissions for the cold store entering the servicing boundary within the year y	$BE_{SB,y}$	tCO_2e	7.17
Baseline emissions for the cold store entering the disposal boundary within the year y	$BE_{DB,y}$	tCO_2e	35.87
Direct baseline emissions in during lifetime/crediting period	$BE_{dir,y}$	tCO_2e	**143.46**

Table 14: Calculation of indirect emissions under the baseline scenario

Indirect emissions			
Parameters			
Baseline electricity consumed in year y	$EC_{BL,y}$	MWh	108
Electricity grid emission factor for year y	$EF_{grid,y}$	tCO_2e/MWh	0.603[13]
Average technical grid losses in year y	TD_y	%	17.552[14]
Results			
Indirect baseline emissions in year y	$BE_{ind,y}$	tCO_2e	**53.69**
Indirect baseline emissions during lifetime/crediting period	$BE_{ind,y}$	tCO_2e	**805.40**

[11] Based on IPCC 2006

[12] Based on IPCC 2006

[13] IGES 2020

[14] World Bank 2014

Total direct and indirect baseline emissions would equal **948.86 tCO_2e** over the activity lifetime.

7.2 Definition of the Mitigation Activity Scenario

Activity emissions consist of direct and indirect emissions. Direct emissions are calculated for the negligible GWP refrigerant used in the cooling system, applying the same emissions factors for leakage during servicing and disposal as in the baseline scenario. It is assumed that indirect emissions do not occur as the cooling system is based on renewable sources of energy.

$$AE_{y} = AE_{dir,y} + AE_{ind,y} \tag{14}$$

Where

AE_y = total activity emissions in year y (tCO_2e)

$AE_{dir,y}$ = direct activtiy emissions in year y (tCO_2e)

$AE_{ind,y}$ = indirect activity emissions in year y (tCO_2e)

Direct activity emissions:

$$AE_{dir,y} = AE_{SB,y} + AE_{DB,y} \tag{15}$$

Where

$AE_{SB,y}$ = activity emissions for the cold store entering the servicing boundary within the year y (tCO_2e)

$AE_{DB,y}$ = activity emissions for the cold store entering the disposal boundary within the year y (tCO_2e)

$$AE_{SB,y} = R * L_{SB,y} * GWP_{neg.ref} * \frac{1}{1000} \tag{16}$$

$$AE_{DB,y} = R * L_{DB,y} * GWP_{neg.ref} * \frac{1}{1000} \tag{17}$$

Where

R = initial refrigerant charge (kg)

$GWP_{neg.ref}$ = global warming potential of HC or other negligible GWP refrigerants

$L_{SB,y}$ = leakage of refrigerant during servicing of cooling system expressed as fraction of initial charge (%)

$L_{DB,y}$ = leakage of refrigerant during disposal of cooling system expressed as fraction of initial charge (%)

Indirect activity emissions:

No indirect activity emissions are assumed since the cooling system is based on renewable energy (PV), thus

$$AE_{ind,y} = 0 \quad (18)$$

Table 15: Calculation of direct emissions under the project scenario

Direct emissions			
Parameters			
Refrigerant	R290 (propane)		
Initial refrigerant charge HC or negligible GWP refrigerant	R	kg	12
Global Warming Potential HC or negligible GWP refrigerant	$GWP_{neg.ref}$		3[15]
Leakage of refrigerant during servicing of cooling system expressed as fraction of initial charge	$L_{SB,y}$	%	15[16]
Leakage of refrigerant during disposal of cooling system expressed as fraction of initial charge	$L_{DB,y}$	%	75[17]
Results			

[15] Based on IPCC AR 5

[16] Based on IPCC 2006

[17] Based on IPCC 2006

Activity emissions for the cold store entering the servicing boundary within the year y	$PE_{SB,y}$	tCO_2e	0.01
Activity emissions for the cold store entering the disposal boundary within the year y	$PE_{DB,y}$	tCO_2e	0.03
Direct activtiy emissions in during lifetime/crediting period	$PE_{dir,y}$	tCO_2e	**0.11**

Since indirect emissions under the activtiy scenario are assumed to be 0 due to the electricity generation by the solar PV system, total emissions are calculated to be **0.11 tCO_2e** over the activity lifetime.

7.3 Quantification of the Mitigation benefits generated by the activity

Mitigation benefits of the activity are calculated as follows:

$$ER_y = BE_y - AE_y \tag{19}$$

Where

ER_y = emission reductions in year y (tCO_2e)

BE_y = baseline emissions in year y (tCO_2e)

AE_y = activity emissions in year y (tCO_2e)

Over the entire activity period of 15 years, the mitigation benefits are **948.75 tCO_2e.**

8. SUSTAINABLE DEVELOPMENT GOALS

8.1 SDG selection

The following SDGs have been identified as relevant for this activity [18]:

- SDG 2: Zero hunger
- SDG 7: Affordable and clean energy
- SDG 8: Decent work and economic growth
- SDG 12: Responsible consumption and production

[18] Full list of SDGs is available here: http://www.un.org/sustainabledevelopment/sustainable-development-goals/

8.2 SDG Target Performance

The NAMA SD tool[19] has been applied to identify relevant indicators and their respective SDG targets:

Table 16: Overview of relevant SDG targets

SDG goal	Relevant sub targets
SDG 2: Zero hunger	Target 2.3 by 2030 double the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets, and opportunities for value addition and non-farm employment
SDG 7: Affordable and clean energy	Target 7.1 by 2030, ensure universal access to affordable, reliable, and modern energy services
SDG 8: Decent work and economic growth	Target 8.1 sustain per capita economic growth in accordance with national circumstances, and in particular at least 7 per cent GDP growth per annum in the least-developed countries Target 8.4 improve progressively through 2030 global resource efficiency in consumption and production, and endeavour to decouple economic growth from environmental degradation in accordance with the 10-year framework of programmes on sustainable consumption and production with developed countries taking the lead
SDG 12: Responsible consumption and production	Target 12.3 by 2030 halve per capita global food waste at the retail and consumer levels, and reduce food losses along production and supply chains including post-harvest losses

9. ENVIRONMENTAL IMPACT ASSESSMENT

- At the end of its economic life, the system needs to be decommissioned. It has to be guaranteed that the decommissioning is done in a proper way and the parts are correctly disposed.
- The possibility to store potatoes is an incentive for farmers to increase potatoes production compared to the baseline scenario, which can lead to an increased consumption of agricultural inputs (e.g., fertilizers) and water if in the baseline land was

[19] UNDP (2014): Nationally Appropriate Mitigation Action (NAMA) Sustainable Development Evaluation Tool; available at http://www.undp.org/content/undp/en/home/librarypage/environment-energy/mdg-carbon/NAMA-sustainable-development-evaluation-tool.html

used for less-resources-intensive crops. The activity will ensure to define appropriate guidelines for the use of agricultural inputs and sustainable water management.

10. MONITORING

10.1. Adaptation Benefit Activity Monitoring

10.1.1. Monitored and Non-Monitored Parameters – Adaptation and mitigation Benefits

Monitored and non-monitored Adaptation Benefits parameters are listed in the table below. For parameters needed for the calculation of ABs that are not included in the table, default values should be used in accordance with the ABM-NM001 methodology.

Table 17: Overview of monitored and non-monitored parameters

Notation	Parameter	Unit	Equation[20]	Origin	Monitored
	Minimum and maximum outside temperature	°C	3	Nearest weather station	Daily recording
	Quantity of potatoes stored in cooling facility	tonnes	6	Inventory/recording of cold store operator	Every time the cold store is loaded
	Number of beneficiaries	unit	-	Survey	Once upon activity commencement
	Loss factor in cold store	%	6	Inventory/recording of cold store operator	Every time the cold store is unloaded
	Market value of potatoes in the activity area in year y	USD/tonne	7	a) Local market/ buyers b) Regional/ national data, e.g. FAO statistics	yearly/ at the time of storage
	Operation of the cooling equipment	°C	3	Continuous measurement of inside temperature by	Continuous monitoring, hourly

[20] This is a cross reference to respective equation from the methodology that has been used.

Notation	Parameter	Unit	Equa-tion[20]	Origin	Monitored
				automated temperature recording through sensor	measurement and at least monthly recording
	Electricity consumed by cooling system/ equipment in year y	MWh	14	Meter readings	yearly
	Refrigerant refilled during service of cooling system/ equipment in year y expressed as fraction of initial charge	%	17,18	Service book of cold store operator	yearly

The following tables provide detailed information on the respective parameters:

Data / Parameter table 1.

Data / Parameter:	$\mathbf{t_{average,d,y}}$
Data unit:	°C
Description:	Continuous recording of outside temperature
Source of data:	Nearest weather station
Measurement procedures (if any):	Recording of daily minimum and maximum temperature
Monitoring frequency:	Daily recording
QA/QC procedures:	
Any comment:	-

Data / Parameter table 2.

Data / Parameter:	$\mathbf{t_{base}}$
Data unit:	-
Description:	Continuous operation of the cooling equipment/system below 12°C
Source of data:	-
Measurement procedures (if any):	Continuous measurement of inside temperature by automated temperature recording through sensor

Monitoring frequency:	Continuous monitoring, hourly measurement and at least monthly recording
QA/QC procedures:	
Any comment:	-

Data / Parameter table 3.

Data / Parameter:	$\mathbf{Q_{PST,y}}$
Data unit:	tonnes
Description:	Quantity of potatoes stored in cooled storing facility in year y
Source of data:	Operator of cold store
Measurement procedures (if any):	Inventory/recording of cold store operator
Monitoring frequency:	Every time the cold store is loaded
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 4.

Data / Parameter:	$\mathbf{PL_{St,y}}$
Data unit:	%
Description:	Loss factor in cold storage
Source of data:	Operator of cold store
Measurement procedures (if any):	Inventory/recording of cold store operator
Monitoring frequency:	Every time the cold store is unloaded
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 5.

Data / Parameter:	$\mathbf{MV_{P,y}}$
Data unit:	USD/tonne
Description:	Market value of potatoes in the activity area in year y
Source of data:	a) Local market/ buyers b) Regional/ national data, e.g. FAO statistics

Measurement procedures (if any):	-
Monitoring frequency:	yearly/ at the time of harvest
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	$EC_{BL,y}$
Data unit:	MWh
Description:	Electricity consumed by cooling system/ equipment in year y
Source of data:	PV system
Measurement procedures (if any):	Meter readings
Monitoring frequency:	yearly
QA/QC procedures:	Meter shall be calibrated according to national standards
Any comment:	-

Data / Parameter table 7.

Data / Parameter:	$L_{SB,y}$ $L_{DB,y}$
Data unit:	%
Description:	Refrigerant refilled during service of cooling system/ equipment in year y expressed as fraction of initial charge
Source of data:	Operator of cold store / service technician
Measurement procedures (if any):	Service book of cold store operator
Monitoring frequency:	yearly
QA/QC procedures:	
Any comment:	-

10.1.2. Description of the monitoring plan, monitoring team

The purpose of the monitoring plan is to ensure the completeness, consistency, accuracy of the monitoring and calculation of the ABs and also for the quantification of the mitigation benefits. The activity owner is responsible for the implementation of the monitoring plan. The objective of the monitoring plan is the monitoring of the following data:

- Operational status of the cold store;
- Quantity of ware and seed potatoes (tonnes) protected from decay due to increased temperature;
- Market prices of potatoes;
- Technical parameters of the cold store: refrigerant leakage during servicing and electricity consumed.

Activities for the monitoring of the impacts of the activity will be carried out with local stakeholders, especially for accessing the information regarding beneficiaries of the cooled storage facility.

The activity owner will arrange a monitoring team which is in charge of all the related operations. It will perform visits and also ensure documents and data are correctly recorded and stored for at least 5 years. The monitoring team is composed by:

- Monitoring supervisor
- Monitoring team components
- Data Verifier

At the end of every month, the monitored data should be archived in the computer and backup onto disk. All paper documents and evidence will be stored and will be available for verification purposes. At the end of each year, a monitoring report will be produced by the monitoring team and it will cover all the parameters listed in section 10.1.1 and the procedures in place.

The monitored data will be kept during the whole crediting period and 2 years thereafter. The activity owner will be responsible for data holding. For the extra 2 years it will be an in-kind contribution of the activity owner.

Monitoring procedures defined above will be used also for the monitoring of the SDGs goals.

11. SDG IMPACT MONITORING

11.1. Monitored and Non-Monitored Parameters SDGs

Monitored and non-monitored community impact data are listed in Table below.

Table 18: Overview of monitored SDG parameters

Monitored and Non-Monitored Parameters – SDGs				
Notation	Indicator	Unit	Origin	Monitored
	SDG 2: Zero hunger	Number of beneficiaries of the activity	MRV of activity	Yes
	SDG 7: Affordable and clean energy	Power produced	MRV of activity	Yes
	SDG 8: Decent work and economic growth	New jobs created, unemployment reduction	Survey	No
	SDG 12: Responsible	Food security (Access to land	MRV of activity	Yes

	consumption and production	and sustainable agriculture)		

12. ACTIVITY PARTICIPATION PROTOCOL

12.1. Summary of Process

To be determined once activity development progressed

12.2. Stakeholder Analysis and Consultation

To be determined once activity development progressed. There is a need for a stakeholder engagement and public participation plan.

12.3. Grievance

To be determined once activity development progressed. There is a need to develop a grievance redress mechanism that will be operationalized during the implementation of the activity.

References:

Agarwal, Nikhil (2018): IITians build unique, affordable solar-powered cold storage, https://www.rediff.com/money/report/pix-special-iitians-build-unique-affordable-solar-powered-cold-storage/20140918.htm (accessed February 15, 2022)

Anker, Richard (2017): Living wage report Kenya, Global Living Wage Coalition, https://www.isealalliance.org/sites/default/files/resource/2017-12/Kenya_Living_Wage_Benchmark_Report.pdf (accessed November 24, 2020)

Day, Thomas; Kurdziel, Marie-Jeanne; Barasa, Murefu (2018): The role of renewable energy minigrids in Kenya's electricity sector. Evidence of a cost-competitive option for rural electrification and sustainable development, New Climate Institute

Degebasa, Abebe Chindi (2020): Prospects and Challenges of Postharvest Losses of Potato (Solanum Tuberosum L.) in Ethiopia, Department of Agricultural Research, Holetta Agricultural Research Center, Ethiopia

EAC (2021): Regional situation analysis of the potato sub-sector in the East African Community, EAC Secretariat, Arusha, https://www.eacgermany.org/storage/app/uploads/public/611/f6c/5eb/611f6c5eb01b9308243649.pdf (accessed September 13, 2022)

EAC (2019): East African Community. Regional Agricultural Investment Plan (RAIP) 2018 – 2025, http://repository.eac.int/bitstream/handle/11671/24121/EAC%20Regional%20Agriculture%20Investment%20Plan.pdf?sequence=1&isAllowed=y (accessed 13 September 2022)

EPRA (2018): Approved Charge Rates for 2018/19, https://www.epra.go.ke/wp-content/uploads/2018/06/Approved-Tariffs-Aug-2018.pdf (accessed November 23, 2020)

FAO (2013): A policymaker's guide to crop diversification: The case of the potato in Kenya, FAO, Rome.

Gildemacher, Peter, R.; Kaguongo, Wachira; Ortiz, Oscar; Tesfaye, Agaje; Woldegiorgis, Gebremedhin; Wagoire, William W.; Kakuhenzire, Rogers; Kinyae, Peter M.; Nyongesa, Moses;

GIZ (2019): R290 Split Air Conditioners Resource Guide, Version 1.0, GIZ, Eschborn

Government of Kenya (2020): Kenya's updated Nationally Determined Contribution, Ministry of Environment and Forestry, Nairobi

Government of Kenya (2020b): Greenhouse Gas Inventory for the Refrigeration & Air Conditioning Sector in Kenya & Kenya National Cooling Strategy. Draft Version, Ministry of Environment and Forestry, Nairobi

Government of Kenya (2018a): National Climate Change Action Plan (Kenya): 2018-2022, Ministry of Environment and Forestry, Nairobi

Government of Kenya (2018b): National Climate Change Action Plan (Kenya): Adaptation Technical Analysis Report 2018-2022, Volume 2, Ministry of Environment and Forestry, Nairobi

Government of Kenya (2017): Kenya Climate Smart Agriculture Strategy-2017-2026, Ministry of Agriculture, Livestock and Fisheries, Nairobi

Government of Kenya (2016a): The National Potato Strategy 2016-2020, Ministry of Agriculture, Livestock and Fisheries, Nairobi

Government of Kenya (2016b): Kenya National Adaptation Plan: 2015-2030, Ministry of Environment and Natural Resources, Nairobi

IFDC (2019): PCB Project Assists Farmers to Improve Potato Seed Storage, https://ifdc.org/2019/10/28/pcb-project-assists-farmers-to-improve-potato-seed-storage/ (accessed 15 November, 2022)

IGES (2020): List of grid emission factors, Sept. 2020

IPCC/TEAP (2005): Special Report: Safeguarding the Ozone Layer and the Global Climate System

Janssens, S.R.M.; Wiersema, S.G., Goos, H., Wiersma, W. (2013): The value chain for seed and ware potatoes in Kenya. Opportunities for development. LEI Wageningen UR, Den Haag

Kenya National Bureau of Statistics (KNBS) (2018): Basic Report on Well-being in Kenya, KNBS, Nairobi

Kaguongo, Wachira; Maingi, Gladys; Giencke, Sigrid (2014): Post-harvest losses in potato value chains in Kenya. Analysis and recommendations for reduction strategies, GIZ, Frankfurt.

MoALF (2016): Climate Risk Profile for Nyandarua. Kenya County Climate Risk Profile Series. The Kenya Ministry of Agriculture, Livestock and Fisheries (MoALF), Nairobi, Kenya.

Musita, Consolata Nolega; Oktoh, Michael Wandayi; Abong' George Ooko (2019): Postharvest Handling Practices and Perception of Potato Safety among Potato Traders in Nairobi, Kenya, in: Hindawi International Journal of Food Science, Volume 2019

Schulte-Geldermann, E. (2013): Tackling low potato yields in Eastern Africa: an overview of constraints and potential strategies. In: Woldegiorgis, G.; Schulz, S.; Berihun, B. (eds.). Seed potato tuber production and dissemination, experiences, challenges and prospects: Proceedings. National Workshop on Seed Potato Tuber Production and Dissemination. Bahir Dar (Ethiopia). 12-14 Mar 2012. (Ethiopia). Ethiopian Institute of Agricultural Research (EIAR); Amhara Regional Agricultural Research Institute (ARARI); International Potato Center ISBN 978-99944-53-87-x. pp. 72-80.

SNV (2019): HortIMPACT: The story 2015-2019, SNV, Nairobi.

Struik, Paul C.; Leeuwis, Cees (2009): Improving Potato Production in Kenya, Uganda and Ethiopia: A System Diagnosis, European Association for Potato Research

World Bank (2014): The World Bank data. Electric power transmission and distribution losses, https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?locations=KE (accessed November 23, 2020)

UN Women (2019): Kenya National Gender Statistics Assessment, UN Women, Nairobi

UNFCCC (2021): Technical assessment of climate finance in the East African Community, UNFCCC, Bonn, https://unfccc.int/sites/default/files/resource/NBF_TA_Climate_Finance_EA_final.pdf (accessed September 13, 2022)

UNICEF (n.d.): Climate Change in Kenya: special focus on children

World Bank (2014): The World Bank data. Electric power transmission and distribution losses, https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?locations=KE (accessed November 23, 2020)

World Bank (2020a): Climate change knowledge portal. Climate data. Projections Kenya, https://climateknowledgeportal.worldbank.org/country/kenya/climate-data-projections (accessed November 23, 2020)

World Bank (2020b): The World Bank data. Agriculture, forestry, and fishing, value added (% of GDP) – Kenya, https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=KE (accessed November 23, 2020)