IGREENFIN

INCLUSIVE GREEN FINANCE INITIATIVE

IFAD

Greening Agricultural Banks & the Financial Sector to Foster Climate Resilient, Low Emission Smallholder Agriculture in the Green Great Wall (GGW) countries - Phase I

FEASIBILITY STUDY: INCLUSIVE GREEN FINANCE INITIATIVE (IGREENFIN)

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Part I – IGREENFIN I to advance the great green wall initiative for the Sahara and the Sahel

1. Introduction

To address climate change, restore and sustainably manage land and reduce poverty, the GGWI was launched as a Pan-African initiative with the endorsement of the African Union (AU). The GGWI is one of the earliest international land restoration initiatives that brings together African countries and international partners under the leadership of the AU and Pan-African Agency of the Great Green Wall (GGWPAA). A broad set of African and international partners are involved in the initiative through project implementation and development, or through the funding of several ongoing and future projects in all GGW countries. Combining the intervention zones reported by the eleven sub-Saharan GGW member states, the GGW initiative extends over a total area of 152 million ha, with the largest intervention zones located in Niger, Nigeria, Mali, Ethiopia and Eritrea. Several regional and transboundary programmes to support the implementation of the GGWI at the regional level have been implemented in recent years.

The GGW Initiative objective: The goal of GGWI is to restore 100 million hectares of degraded land, sequester 250 million tons of carbon and create 10 million green jobs in rural areas across the Sahel by 2030. With a span of 8,000 km (from Senegal in the west to Djibouti in the east) and 15 km wide, the intervention zone is to become the home of a mosaic of trees, grasslands and other vegetation. The initiative currently involves more than 20 partner countries in Africa, of which the following 11 countries have been selected as intervention zones for IGREENFIN 0, I and II: Burkina Faso, Cameroon, Chad, Djibouti, Eritrea, Ethiopia, Ghana, Mali, Mauritania, Niger, Nigeria, Senegal and Sudan. These countries are among the world's most vulnerable and least resilient countries to climate change and the least ready to mobilize investments and convert them to adaptation actions, as evidenced by their low ranking on the ND-GAIN index. A number of initiatives have been implemented by GGW partners to contribute achieving the GGW objectives.

In 2012, the GGW Initiative adopted a Harmonized Regional Strategy (HRS) that consolidated national strategies of the GGW member states and arrived at a coordinated approach for implementation, structured into five-year planning steps. Drawing on this HRS, member countries have elaborated National Action Plans to develop clear steps for the implementation of the GGW national objectives.

1. The first strategy (2011-2015), aimed at the establishment of the institutional and organizational framework of the GGW structures, the conceptualization, the awareness raising and the appropriation of the concept, as well as the establishment of pilot activities at country level.
2. The second strategy (2016-2020) focused more on operational activities and aimed at accelerating concrete actions, and set 2020 as a marker to assess achievements under the PAAGGW,
3. The third strategy (2021-2025) is expected to consolidate the implemented activities and measures.

Table 1. GGW intervention area per country (UNCCD, 2020)

Country	GGW intervention area (ha)	Information source
Burkina Faso	9 270 900 (10 967 400)	GGWPAA 2018 (as per Country data Dakar 2019)
Chad	3 000 000	GGWPAA 2018
Djibouti	342 826	GGWPAA 2018
Eritrea	12 432 000	GGWPAA 2018
Ethiopia	13 150 194	Country data Dakar 2019
Mali	44 419 000	Country data Dakar 2019
Mauritania	n/a	n/a
Niger	2 250 000 (47 250 000)	GGWPAA 2018 Country data Dakar 2019
Nigeria	17 417 200	Country data Dakar 2019
Senegal	817 500	GGWPAA 2018
Sudan	2 280 000	GGWPAA 2018
TOTAL[1]	~ 152 000 000	

In aggregate, in the intervention zones reported by the eleven Sub-Saharan GGW member states, the total area of the GGW initiative extends to 152 million ha, with the largest intervention zones located in Niger, Nigeria, Mali, Ethiopia and Eritrea1. The elaboration of the GGW strategy 2021-2025 will consider Agenda 2063, the Comprehensive Africa Agriculture Development Programme (CAADP), as well as all the national plans and strategies related to the GGW activities. Figure 1 below presents the countries of proposed interventions under the IGREENFIN programme.

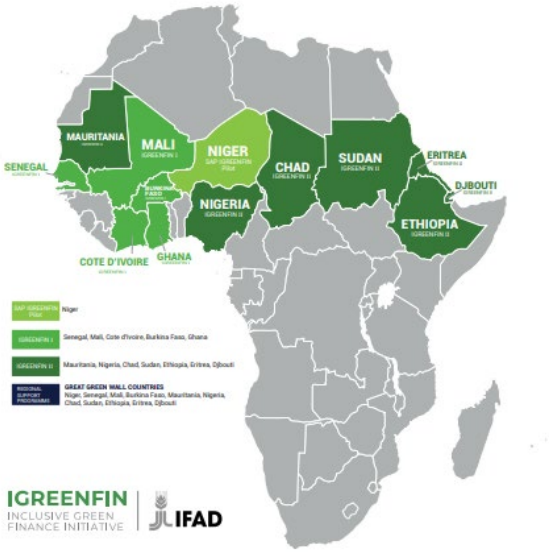


Figure 1 : IGREENFIN's programme intervention countries.

Between 2007 and 2019, in the GGW intervention area, land rehabilitation activities were carried out on a total of 4 million ha, and another 17.8 million ha of land were under restoration within GGW countries, but outside the intervention zones. This represents, an estimate of only four per cent of the wall completed as of 2020. This figure increases to 18 per cent when considering the

1 Intervention areas in Burkina Faso and Niger are subject to confirmation by countries, as they do not coincide between the two sources used.

associated improvements outside the direct intervention areas. According to the GGWI 2020 implementation report published by UNCCD, the GGW member states have engaged in a variety of sustainable land management (SLM) activities, including water and soil conservation measures, as well as ones in the forestry and agriculture sectors. In this context, land restoration and conservation activities to strengthen resilience to climate change and ensure sustainable food production has been carried out, using agroforestry techniques, shelterbelts, and reforestation. Other measures include the establishment of fruit orchards, multipurpose gardens, and community nurseries for plant production and the exploitation of non-timber products.

Following a brief progress report focusing on the implementation of the initiative in the three (3) GGW countries also participating in the IGREENFIN I programme. Since its launch in 2007, substantive progress has been made in restoring the fertility of Sahelian lands in Burkina Faso, Mali, and Senegal as indicated in the 2020 UNCCD status report on the GGW:

1. In Burkina Faso, four regions are covered by the GGWI interventions (central plateau, north-central, Sahel, and east). Key results include 29,602 ha of restored land, 16.6 million of plants/seedlings produced, 20,383 ha of reforested land, 12,500 ha under assisted natural regeneration (ANR), and 45,383 jobs created.

2. Mali is among the four countries where the largest GGW intervention zones are located. Seven administrative regions (Kayes, Koulikoro, Segou, Mopti, Gao, Timbuktu, Menaka) out of the ten are covered, 120 ha of land have been restored; 6,297 ha of land, reforested, and more than 135,000 plants/seedlings produced.

3. In Senegal, the GGW band extends along 545 km of land and covers an area of 817 500 in the Tambacounda, Matam, and Louga regions. A total of 119,202 ha of land has been restored; more than 18 million seedlings/plants produced; 72,452 ha, reforested and 332 221 inhabitants, affected.

Recently, the GGWI has entered a new phase, with the Pan-African movement receiving greater support from a number of countries across Africa as well as international partners and donors under the political auspices of the African Union. Key partners have pledged US$16.85 billion in international finance over the next five years. This will contribute to addressing the gaps in technical and financial support, as well as monitoring aspects needed to achieve the GGWI targets.

The IGREENFIN Programme will contribute to the implementation of the GGWI and will be the first official programme executed under the Green Climate Fund (GCF) Great Green Wall Umbrella Programme (GGW-UP). This GGW-UP, which will be a sub-set of the broader "GGW Accelerator", will focus on the climate-related activities of the GGWI, covering all the projects and programmes financed by the GCF. The GGW Accelerator ambition is: i) leverage additional resources at national and international levels to reach US$10 billion of investments for 2021-2025; ii) enhance the coordination and collaboration of technical and financial assistance provided by the international community to the GGWI to reduce the fragmentation of support provided to the GGW countries; and iii) improve the monitoring, verification, and reporting of progress and achievements.

2. Study Background

In West Africa, agriculture accounts for 35 per cent of GDP and generates 78 per cent of food economy jobs. Smallholder farmers dominate the agricultural regional landscape with 90 per cent of agricultural production provided by family farms. In the countries targeted in this study (Burkina Faso, Côte d'Ivoire, Ghana, Mali, and Senegal), agriculture employs more than 70 per cent of the labor force and is the main source of livelihood for rural communities and job creation, particularly for youth and women. Moreover, Côte d'Ivoire, Ghana, and Senegal, together with Nigeria dominate the agricultural market in the West Africa. They represent two-thirds of the

population, account for over 80 per cent of the regional GDP, three-fourths of agricultural imports, and over 80 per cent of agricultural exports while serving as major sources of demand for their neighbors and recipients of large intra-regional labor flows.

Despite its importance on the economy and people's livelihood, agriculture in the region is highly vulnerable to the impacts of climate change. West Africa has been identified among the primarily observed climate change hotspots and the most persistent and early emerging prominent ones foreseen for the twenty-first century because of the observed and projected widespread increase in mean temperature and extreme hot season occurrence. Projections on climate extremes are widely expected to be severe with the increasing global warming. According to the IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels, West Africa and the Sahel are likely to experience increases in the number of hot nights and longer and more frequent heatwaves even if the global temperature increase is constrained to 1.5°C, with further increases expected if global warming raises temperatures 2°C or more. Moreover, daily rainfall intensity and runoff are expected to increase with 2°C and higher levels of global warming. Even though there are uncertainties on precipitations projections, most West African countries are likely to experience decreasing rainfall.

As a climate change hotspot, West Africa is likely to experience negative impacts from climate change on crop yields and production. An increase in warming to 2°C by 2040 would result in further yield losses and damages to crops (such as maize, sorghum, wheat, millet, groundnut, and cassava) according to the IPCC report. For maize specifically, a study assessing the land suitability for rainfed maize under current and future climates found that future climate change will affect the suitability for maize in at least 43 per cent of West Africa. Generally, for cereal production in West Africa, a recent study calculated that total cereal production per capita will decrease between 60 and 80 per cent by 2050 with the highest population growth under a RCP 8.5 scenario. Apart from the negative impacts of climate change on agriculture, smallholder producers in West Africa are facing other challenges such as low adaptive capacities and lack of access to investment, which are particularly limited by their lack of access to financial services (bank loans, agricultural insurance, investment funds, etc.). Four out of five countries covered by this study, namely Burkina Faso, Côte d'Ivoire, Mali, and Senegal, are members of the West African Economic and Monetary Union (WAEMU).

Credit to the agricultural sector accounts for roughly two per cent of total credit offered, and when credit is available, the interest rate is more than 10 per cent and repayment periods are short. In the WAEMU zone, agriculture receives only 6.10 per cent of total short-term credits, 4.59 per cent, and 2.15 per cent for medium and long-term credits respectively. The difficulties associated with access to credit for smallholder producers place women in an even more disadvantaged and vulnerable position. Women's lack of access to credit reduces their access to input, land, other productive resources, and extension services. The challenge of adequately financing the agricultural sector and creating lines of credit for smallholder farmers is further aggravated by the economic recession resulting from the COVID-19 outbreak. In the pandemic context, Africa suffered its worst recession in more than 50 years, and GDP in West Africa is estimated to have contracted by 1.5 per cent in 2020. Moreover, the pandemic has wiped out decades of progress in addressing food insecurity and ending extreme poverty in the region, particularly in the Sahel.

The COVID-19 crisis, coupled with the impact of the conflicts and violence, the effects of climate change, and the myriad vulnerabilities in the region, is expected to push almost 1.3 million more, Sahelian people, into extreme poverty in 2021 according to the World Bank. In West Africa, 23.6 million people are projected to face crisis-level food insecurity, an increase of 40 per cent from already record levels. In this context, building back better requires affordable financing to scale up and accelerate countries' efforts in pursuing a greener, more inclusive, and resilient COVID-19 recovery.

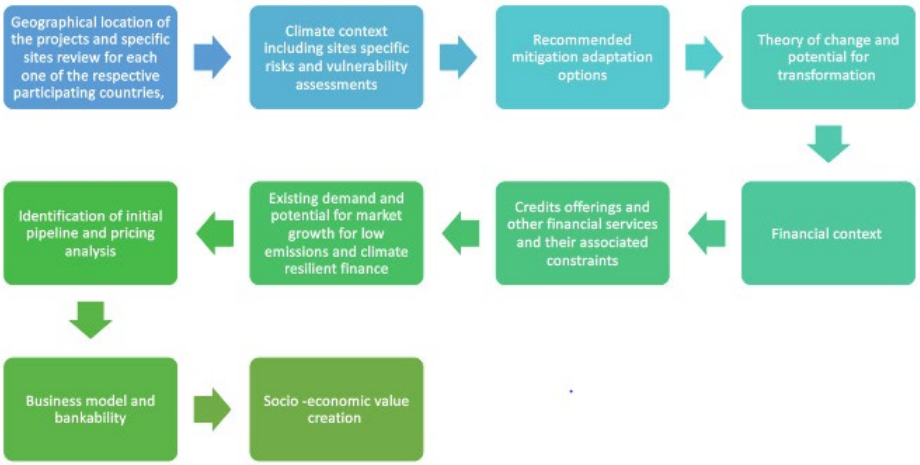
Despite the countries' efforts to address climate change through their National Adaptation Plans and various other investments, their fragmented approaches to climate risk, current climate financing gaps, and a high debt ratio limit their ability to scale up domestic investments in adaptation strategies and to overcome barriers that hamper effective climate change adaptation. This feasibility study is undertaken from a dual perspective. First technical and operational feasibility, and second economic and financial to assess the potential of mobilizing the necessary investments to strengthen the resilience of the food system to future climate shocks and for the most vulnerable actors as a priority in climate adversely affected regions.

3. Methodology and approach

This study assesses the major components that will confirm the feasibility of implementation of the IGREEFIN project primarily in the five targeted countries under this phase I and the feasibility of implementing concomitantly the Umbrella Programme for the countries of the GGWI. The ten (10) major and interconnected components presented below have been identified as critical elements of investigation to ascertain the feasibility of the Programme and associated umbrella Programme (See Figure 2).

For IGREENFIN

Figure 2: Approach for the study



1. Geographical location of the projects and specific sites review for each one of the respective participating countries.
2. Climate context including risks assessment and vulnerability, including on targeted sites.
3. Recommended mitigation adaptation options and associated costs.
4. Theory of change and potential for transformation.
5. Financial context.
6. Credits offerings and other financial services and their associated constraints.
7. Existing demand and potential for market growth for low emissions and climate resilient finance.
8. Identification of initial pipeline and pricing analysis.
9. Business model and bankability.
10. Socio -economic value creation.

The following two questions have also driven the overall logic guiding the feasibility study.

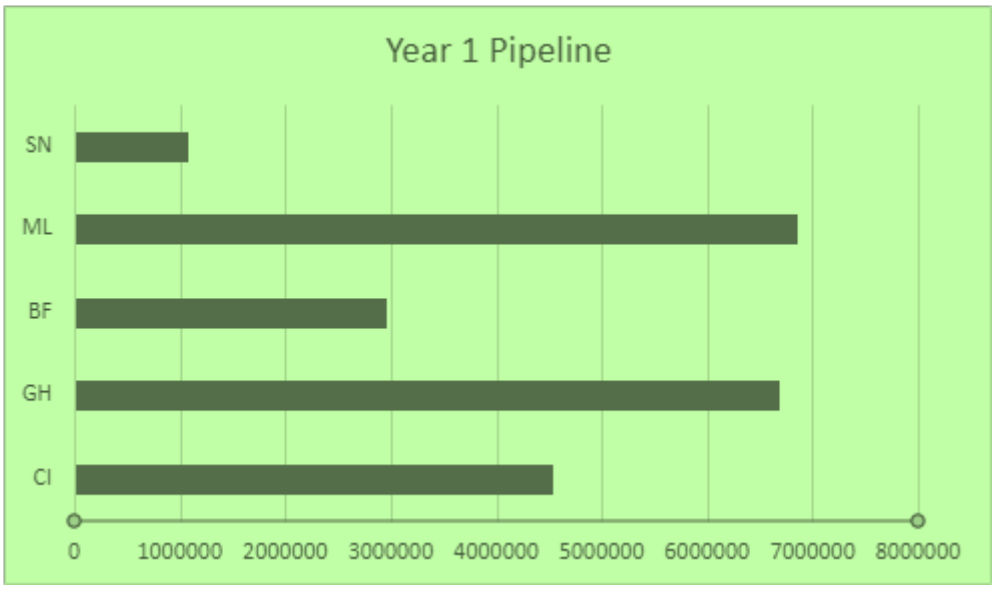
1. *What are the key value chain interventions that can deliver low carbon and climate resilient benefits in the targeted countries in the IGREENFIN, with the assessment presented in this study focusing on the five countries of the phase I?*

The two funding windows envisioned under the component I and to be set up by the LDPBs will support transition towards low carbon and climate resilience in agriculture sector, nexus energy, water and land use. The ultimate goal of establishing these new windows is to incentivize the uptake in the demand of credits to address the urgent needs to build resilient vulnerable groups and ecosystems to committed climate change, ensuring interventions that promote these sectors bear low carbon footprint and no to limited impacts on environment, ultimately delivering positive climate mitigation and adaptation outcomes. By doing so, IGREENFIN shall also address the lack of access to finance by farmers through FOs, SMES or Cooperatives and incentivize the creation of enough value to compete successfully with ´business-as-usual´ activities. The IGREENFIN will support a diverse portfolio of sustainable agriculture and land-use practices as well as business models that are more effective at generating higher revenues (on a per hectare basis) and in creating employment opportunities (adaptation impact), while also effective at delivering emission reductions.

2. *What is the potential for the financial services including local national agricultural banks (LNABs), Micro Finance Institutions and other commercial banks to facilitate and increase access to finance to address the urgent need for low carbon and climate resilient finance? What are the key constraints to provide these offerings?*

By evaluating an initial set of eligible value chains, this study estimates current overall demand in the order of USD 22 million for the first twelve (12) months by the five (5) LNAB. This estimate should be considered a minimum, as the programme's objective is to create a robust market for these new products. Moreover, the evaluated portfolio of potential investments across the proposed value chain is indicative and not exhaustive. Attending the financial demand envisaged under this programme would support and improve the economic profitability of 1,500 MSMEs and 2,500 FOs comprised of vulnerable smallholder farmers.

Figure 3: Twelve (12) months initial portfolio



Source: Project Design Team based on data provided by the five Banks

For the Regional Support Programme

The feasibility study focuses on the approach towards the implementation of the Great Green Wall Initiative (GGWI). Since 2007, the GGWI's stakeholders have committed to achieve a common objective. Many lessons have been learned under this process. As of 2020, the GGWI is entered its second decade of implementation and has evolved into an African-led pioneer initiative, which receives strong support from the international community as a flagship program to combat land degradation, desertification, drought, climate change, biodiversity loss, poverty and food insecurity. The Great Green Wall is a growing reality that needs support, coordination, and systematic approaches towards implementation in order accelerate action and achieve its goals by 2030. Achieving these goals is the purpose of the GGW Accelerator. Through the GGW Accelerator, the ambition is to generate, by 2030, the following aggregate GGW results: 100 million hectares (Mha) of degraded land restored; 250 million tons of CO2 stored; and 10 million jobs created in rural areas. To achieve the aggregate target of 100 Mha of land to be restored requires an incremental achievement of 82 Mha when taking into account the 18 Mha already restored since GGW inception. Over the next decade (the period 2021-2030), this translates into an average annual result target of 8.2 Mha of land to be restored. Similarly, there are 10-year quantitative targets to be achieved with respect to the number of jobs to be created and the volume of CO2 to be stored.

The Great Green Wall Accelerator: In September 2020, at the online meeting of the GGW Ministers organized by the UNCDD, the GGW countries invited the GCF and the other international entities to boost their support for the GGWI. In response to this invitation, in January 2021, during the One Planet Submit, financial institutions committed to support the GGW objectives in the eleven GGW countries through the launch of a Great Green Wall that seeks to facilitate and strengthen the coordination and collaboration of donors and stakeholders involved in the GGWI and better monitor and measure the impact of their actions. The Accelerator will be coordinated through the Pan Africa Agency for the Great Green Wall (PAAGGW), with initial support from the United Nations Convention to Combat Desertification (UNCCD).

Objectives. The Accelerator aims to address several of the barriers presented above by providing a common M&E framework to all donors who pledged additional support to the GGW objectives during the One Planet Submit. The Accelerator will also give greater visibility to the GGWI and mobilize additional financial resources from the private sector to accelerate the pace of implementation. The Accelerator is organized around five pillars:

a. Investment in small and medium-sized farms and strengthening of value chains, local markets, organization of exports
b. Sustainable management of ecosystems and land restoration
c. Climate resilient infrastructures and access to renewable energy
d. Favorable economic and institutional framework for effective governance, sustainability, stability and security
e. Capacity-building

4. The Inclusive Green Finance (IGREENFIN): Programme presentation

The overall objective of the IGREENFIN program is to build the resilience of agricultural and water resource management practices to current and future climate risks in targeted countries. The first phase – IGREENFIN I will focus on five countries, three from the GGW (Burkina, Mali, Senegal) in addition to Côte d'Ivoire and Ghana. The program will contribute to climate resilience by i) providing support to selected local national agricultural banks (LNABs) to create green credit lines to finance low carbon, climate resilient and sustainable agriculture projects from smallholder farmers organized around FOs, Cooperatives and women and youth-led organizations and MSMEs ii) addressing capacity building, knowledge and policy gaps that hinder the transfer and adoption of adaptation and mitigation practices in green agricultural projects. The IGREENFIN I is presented together with a Regional Support Programme aiming at iii) enhancing the collective impact of all GCF funded projects including IGREENFIN program by establishing a coordination framework for knowledge generation and sharing, implementation and reporting, increased private investment, innovation at scale contributing to improved resilience of ecosystems. The Programme is structured around three (3) interconnected components.

Component 1: Green[2] Financing Facility: designed to provide concessional loans to foster best adaptation and mitigation practices for the selected agricultural value chains in each target country. Operated by the selected local agricultural banks, the facility will offer special lines of financing for green agricultural projects prepared by FOs, women and youth organizations, cooperatives and MSMEs (including agribusiness dealers, solar operators).

Component 2: Technical Assistance Facility (TAF): intended to address capacity, knowledge and policy gaps hindering the uptake of green agriculture projects in the selected countries. It will target agricultural banks and their clients (FOs, MSMEs and cooperatives), with a special emphasis on women and youth, as well as the central banks operating in these countries. The TAF will also provide support existing GCF Direct Access Accredited Entities, that will be engaged in a collaborative partnership with IFAD under the IGREENFIN. This partnership with DAE under the Programme will serve as a model for collaboration between international and national direct access entities across GCF portfolio of accredited entities. For IGREENFIN, collaboration is foreseen with three GCF DAEs.

1. the Agricultural Bank of Senegal to serve as a GCF accredited NEE, with a demonstration effect of the value of the GCF accreditation to the other targeted agricultural banks also serving as NEE under the programme,
2. the Centre de Suivi Ecologique (CSE), to serve as a strategic IGREENFIN partner, to perform the monitoring of land use and forest management activities in all selected countries, and
3. Attijarwafa Bank (an accredited commercial bank) to crowd in additional financing as a strategic partner of the selected local agricultural banks.

The Technical assistance facility will provide necessary technical assistance, policy and regulatory support to the Central Bank of the West Africa Economic and Monetary Union (WAEMU) for Burkina Faso, Côte d'Ivoire, Mali and Senegal, and the Central Bank of Ghana to create an enabling environment for the financing of the uptake of green agriculture projects.

2 The terminology "green" refers to investments in the selected agricultural value chains that promote climate resilient, low carbon practices in line with the GGWI objectives and the target countries' climate change adaptation and mitigation agenda.

Component 3: The Regional Support Programme specifically proposed to increase the collective impacts of GCF current and future funded activities (including IGREENFIN I and II) in the Great Green Wall countries through two outputs: (i) Enhanced knowledge management and exchanges accelerating the uptake of good practices, increasing learning and informing policy and investments across GCF projects and others and (ii) Innovation and digital transformation technologies mapped and ecosystem built.

The focus of the Programme is on building the resilience of agricultural practices nexus with energy, water resource management, forestry, land use and land use change to address current and future climate risks in the agro-ecological zones of the Green Great Wall. It will develop partnerships with selected financial institutions (primarily commercial banks including Islamic banks where they exist, MFIs). The IGREENFIN program will build the capacity of all relevant actors along agricultural value chains to foster green finance and the alignment of financing flows with a pathway towards low greenhouse gas emissions and climate-resilient development consistent with the Article 2(c) of the Paris Agreement. In accordance, all countries participating in the IGREENFIN program will use the GCF concessional finance (grants and loans) to set up innovative financial products and build the capacity and technical skills of credit providers, recipients, and governments, which are necessary for the development of green finance in the agricultural sector, with a special emphasis on women and youth. The grant portion of the financing will build the capacity of credit recipients such as FOs, cooperatives, and MSMEs to tap into investment opportunities to enable them to adopt mitigation and adaptation measures.

Together IGREENFIN I and the Regional Support Programme will build the resilience of 378,600 smallholder farmers, 2,500 FOs or cooperatives and 1,500 MSMEs. Approximately 2,494,000 indirect beneficiaries are targeted in the five targeted countries. It will further contribute to reducing GHG emissions to a potential total emission abatement of 19,406 million tCo2eq over project life span from the use of renewable energy technologies (RETs), sustainable land forest and land management. This mitigation potential represents 3.8 percent of the GGW emission reduction target (250 MtCO2).

Section I – Selection process and description of targeted areas and beneficiaries

1. Selection process for the targeted areas

The first phase of the IGREENFIN programme focuses on the five selected IFAD developing countries member states, namely Burkina, Cote d'Ivoire, Mali, Ghana, and Senegal. These targeted countries are IFAD member's state countries and eligible to IFAD resources under IFAD 11. These countries have identified in their country engagement strategy (COSOPs) the baseline projects to be developed under IFAD 11 (2019-2021) with possibility to mobilize additional climate finance. The baseline investment and additional climate investment (IGREENFIN) were defined during the IFAD baseline investments design process and IGREENFIN I. Following the country selection, specific criteria have been applied to further select regions and areas of intervention as described in the section below.

1.1. Selection of the regions:

In line with IFAD targeting strategy and the country's priorities, the regions within each country have been selected using following main selection criteria: i) poverty level and remoteness; ii) food insecurity and nutrition; iii) climate vulnerability and unsustainable management of natural resources; iv) rural gender disparities and youth unemployment; v) absence or lack of rural infrastructure including energy access; vi) opportunities for job creation both for youth and women with key prioritized climate resilient agricultural value chains and vi) possibility of creating synergies with other donor-supported programmes (IFAD main baseline investments, GGW national agencies projects; FAO and other relevant UN agencies projects. These targeted regions have been identified and the final selection completed taking into account climate and environmental concerns over a range of ecosystems and agricultural zones, such as savannahs, tropical forests, and semi-arid regions. Climate change present day effects and medium to long-term impacts combined with socio-economic considerations are central to the selection. A summary of determining criteria is as follow:

- High vulnerability to climate change with historical change in temperature and precipitation); climatic events (droughts, floods, heats, sandstorms),
- Poverty level, rural gender disparities and youth unemployment,
- Possibility of creating synergies with other donor-supported programmes, and
- Government willingness to work in these areas as defined in countries national development plan, local development plan

1.2. Selection of specific targeted areas

The targeted areas of the IGREENFIN I in the five selected countries were also identified and defined during the IFAD baseline investments design process. The main selection criteria were: i) poverty level and remoteness; ii) food insecurity and nutrition; iii) climate vulnerability and unsustainable management of natural resources; iv) rural gender disparities and youth unemployment; v) absence or lack of rural infrastructure including energy access; vi) opportunities for job creation both for youth and women, and vii) possibility of creating synergies with other donor-supported programs (IFAD main baseline investments, GGW national agencies projects; FAO and other relevant UN agencies projects) and viii) being in the GGW target areas (~isohyets). These targeted regions have a range of ecosystems and agricultural zones, such as savannahs, tropical forests, and semi-arid regions. Additionality of IGREENFIN I investments in these areas is summarize in table 2 below (See Table 2).

Table 2 : Selected countries, IFAD baseline investments and additionally of IGREENFIN I

	Project name	Interventions areas for both IFAD baseline investments and IGREENFIN I	Additionally of IGREENFIN I	Beneficiaries	
				Direct beneficiaries	Indirect beneficiaries
IFAD baseline investments (Country)	Agricultural Value Chains Support Project *(PAFA)*- **Burkina Faso**	Boucle du Mouhoun, Haut Bassin, Cascades	IGREENFIN, I Introduces innovative business models to improve risk-return profile of baseline projects, makes available much needed, concessional capital and crowd in private sector capital, while also providing Technical Assistance for subproject preparation, incentivize beneficiaries to adopt best adaptation and mitigation practices and technologies, capacity building and reporting & monitoring of GHG emissions	80,000	330,000
	Agricultural Emergency Support Project (AESP) – **Cote d'Ivoire**	Bagoue, Poro, Tchologo, Hambol and Gbeke Tonpki, Kabadougou, Folon, Bafing, du Worodougou and Bere		53,600	294,800
	Affordable Agricultural Financing for Resilient Rural Development Project (AFFORD) **– Ghana**	Northern, Savannah and North-east Regions, Bono, Bono East and Ahafo Regions		155,000	930,000
	In*clusive* Finance in Agricultural Value Chain Project (*INCLUSIF)*- **Mali**	Koulikoro, Sikasso Kayes, Segou,		40,000	440,000
	Rural Youth Agripreneur Support Project (*AGRIJEUNES)*- **Senegal**	Louga, Thiès, Diourbel, Fatick, Kaolack, Kaffrine, Sédhiou and Ziguinchor		50,000	500,000

In summary, the targeted regions in each country have been selected due to their vulnerability to climate change, historical and projected impact of climate (temperature and precipitation), historical change in temperature and precipitation); climatic events (droughts, floods, heats, sandstorms). The site selection methodology consisted of the following steps (1) determining

site selection criteria- previously established by IFAD in each country strategy (2) develop list of candidate sites and supporting information in each country and included in countries national plans, adaptation plans and agricultural sector plan; (3) apply site selection filter using the social, economic (poverty level and remoteness; food insecurity and nutrition, rural gender disparities and youth unemployment; absence or lack of rural infrastructure including energy access; opportunities for job creation both for youth and women with key prioritized climate resilient agricultural value chains) and climate criteria's (climate vulnerability and natural hazards risks) (4) site visit during IFAD design baseline and IGREENFIN I missions; (5) select candidate site(s) via team discussion and consultation with the government.

1.3. Description of targeted areas

Burkina Faso - Boucle du Mouhoun, Haut Bassin, Cascades

Boucle du Mouhoun is one of the most vulnerable regions in terms of poverty, food security and malnutrition. It is also one of Burkina Faso's most important "granaries" is the Boucle du Mouhoun region. However, increased farmed areas, population growth, unsustainable methods, and high herd pressure are causing agricultural land scarcity and degradation, endangering the medium-term future of agricultural activity. The Cascades and Hauts Bassins are among the moderately vulnerable regions. The Boucle du Mouhoun and the Hauts Bassins are also characterized by a high concentration of the population (more than 3.5 million inhabitants)[3]. The crops produced in these regions are sorghum, millet, peanuts, beans, rice, cotton and sesame[4]. In the Haut-Bassin, livestock occupies more than 80% of households and provides them with all or part of their cash income. It contributes more than 18% to the formation of GDP and nearly 26% of exports in value. Crops and animals Farmers in Burkina Faso's northern region, many of whom live in precarious situations, are also affected by climate change (high variability in rainfall and accelerated degradation of natural resources), particularly desertification and erosion, which exacerbate family vulnerability and food insecurity. Regarding access to credit for smallholder farmers, it has been improving in the recent years in the targeted regions[5].

Côte d'Ivoire - Bagoue, Poro, Tchologo, Hambol and Gbeke Tonpki, Kabadougou, Folon, Bafing, Worodougou and Bere

The total population in Cote d'Ivoire was more 26 million inhabitants in 2020[6]. The agriculture sector employs more than half of the economically active Ivorian population and accounts for 21 percent of GDP and over 60 percent of export earnings. Farming activities in Côte d'Ivoire follow the agro-ecological specificities of the country. The forest region in the South has higher and more reliable rainfall, better soils and produces the majority of export crops (cocoa and coffee) which account for more than two-thirds of the cultivated areas and dominate the export economy. The South is characterised by forest and fallow land and has two rainy seasons (March to June and September to November). However, traditional agricultural methods of clearing and burning are practiced, which reduces yields and combined with rapid population growth leads to widespread deforestation and loss of soil fertility. Farmers are also confronted with land tenure insecurity, as well as weather variability and climate change leading to increased incidents of floods and extended duration of the dry seasons. In the Savannah region in the North, the main crops are rice, maize, yams, groundnuts and cotton. The North is characterized by high poverty rates (above 50 percent in 2015) and youth emigration. While agriculture remains the main source of income and livelihoods in the North, farmers record low agricultural productivity with only one rainy

[3] https://www.populationdata.net/pays/burkina-faso/, 2020
[4] https://fondationsemafo.org/wp-content/uploads/2020/09/WassaWassaVol2No9.pdf
[5] Tableau de bord statistique de l'agriculture, 2019, http://cns.bf/IMG/pdf/tab_bord_agriculture_2019_def.pdf

season, they have limited access to markets, face difficulty of attracting seasonal labour, while climate change exacerbates the vulnerability of agricultural systems.

Ghana - Northern, Savannah and North-east Regions, Bono, Bono East and Ahafo Regions

Agriculture is the backbone of Ghana's economy, providing employment to 45% of its workforce, contributing to 21% of GDP and supplying over 70% of its national food requirements. Since Ghanaian agriculture is predominantly rain-fed (with only 4% of its irrigation potential developed), particularly in the semi-arid north, it is highly vulnerable to climate change. Agriculture is characterized by a low level of diversification, which makes farmers more vulnerable to crop failure. Farmers in the north of the country – and particularly in the Upper East – are most vulnerable. This is partly due to the hot and dry conditions of the area and the bad quality of agricultural lands (the Upper East is most exposed to land degradation and soil erosion), but also because of general poverty and limited access to alternative livelihoods. In the northern regional total crop failure is expected to occur approximately once every 5 years due to delayed or diminished rains. The main staple crops in the intervention areas are, in order of amount produced and consumed: cassava, yam, plantain, maize, and rice. Over a period of 25 years, bank lending to agriculture has been on the general decline, dropping from about 16% of total bank credit to about 4%. This is in spite of the various agri-financing mechanisms implemented. The financing of agriculture by commercial banks in the country is largely dominated by a few ones, indicating the low-risk appetite that commercial banks, generally, have for the sector. The public sector contribution to agriculture sector remains low, resulting in slower agricultural sector growth rate in Ghana over the last two decades.

Mali - Koulikoro, Sikasso Kayes, Segou,

Mali is still experiencing population growth, agriculture accounts for 40% of GDP (World Bank, 2017) and employs nearly 80% of the working population (the main activity in the targeted regions). The effects of climate change could severely affect the agricultural sector. An analysis specific to the southern regions of Mali shows that by 2050, in a scenario of warming overall moderate (RCP4.5), small producers may be unable to achieve their food self-sufficiency and this chronically unlike producers on medium to large farms. Small producers face insufficient access to extension services, inputs and financing of economic activities; their activities are strongly constrained by the degradation of natural resources and more generally by the effects of climate change. The security conditions, particularly in the north of the country, are a source of additional vulnerability. Faced with these constraints, the populations and the herds massively displaced to wetter areas in the south of the country. These migrations result in increased pressure on natural resources, and an increase in conflicts related to their appropriation and use, especially between farmers and herders, but also between agro-pastoral populations and artisanal miners, lumberjacks, etc.

Senegal - Louga, Thiès, Diourbel, Fatick, Kaolack, Kaffrine, Sédhiou and Ziguinchor

According to the last General Census of Population and Housing, Agriculture and Livestock (RGPHAE7), 73.8% of households' farmers live in rural areas. The regions of Thiès and Louga have the most important number of agricultural households, with 12.8% and 9.5% of households respectively, residing there. In the other regions of the project intervention area, the share of agricultural households is 8.5% in Diourbel, 7.7% in Kaolack, 7.6% in Fatick, 5.8% in Kaffrine, 5.6% in Ziguinchor and 4.3% in Sédhiou. In total, nearly 84% of Senegalese households live in eight regions of the project intervention area, or more than five out of four households. Agriculture, mainly subsistence and rain-fed, is dominated by family farms which occupy nearly 95% of agricultural land. Rainfed agriculture is practiced by 87.1% of farm households and the main food crops are millet (38%), cowpeas (24%), maize (20%), rice (9%) and sorghum (8%). Groundnuts are the main cash crop and predominate in cropping systems in areas of the Groundnut Basin

such as Kaolack, Kaffrine, Diourbel and Louga. As for arboriculture, it concerns the cultivation of mango trees, especially in the regions of Thiès (66.3%), Kaffrine (59.7%) and Kaolack (57.2%), the cultivation of bananas and that of citrus fruits, which are respectively practiced by 30.3% and 39.7% of households in Ziguinchor. Silvicultural activities are more practiced by households in the regions of Sédhiou, Ziguinchor and Thiès, and to a lesser extent those of Kaolack, Kaffrine, Diourbel and Louga. Fishing or aquaculture is one of the main livelihood activities for households in Thiès, Ziguinchor, Fatick and Sédhiou. Market gardening is more practiced in the regions of Thiès, Louga, Fatick and Ziguinchor; while breeding remains one of the sources of income for households in Diourbel, Thiès, Louga and Fatick. These regions cover four agroecological zones, in particular the Groundnut Basin, the Niayes, the Sylvo-pastoral Zone, and the Lower and Middle Casamance. Although the environmental situation changes from one area to another, it remains generally characterized by degradation of natural resources. This manifests itself by wind and water erosion, land salinization, reduction of vegetation cover, pollution and acidification of soils, declining soil fertility and degradation of resources pastoral care. The maps below present the IGREENFIN Programme targeted areas.

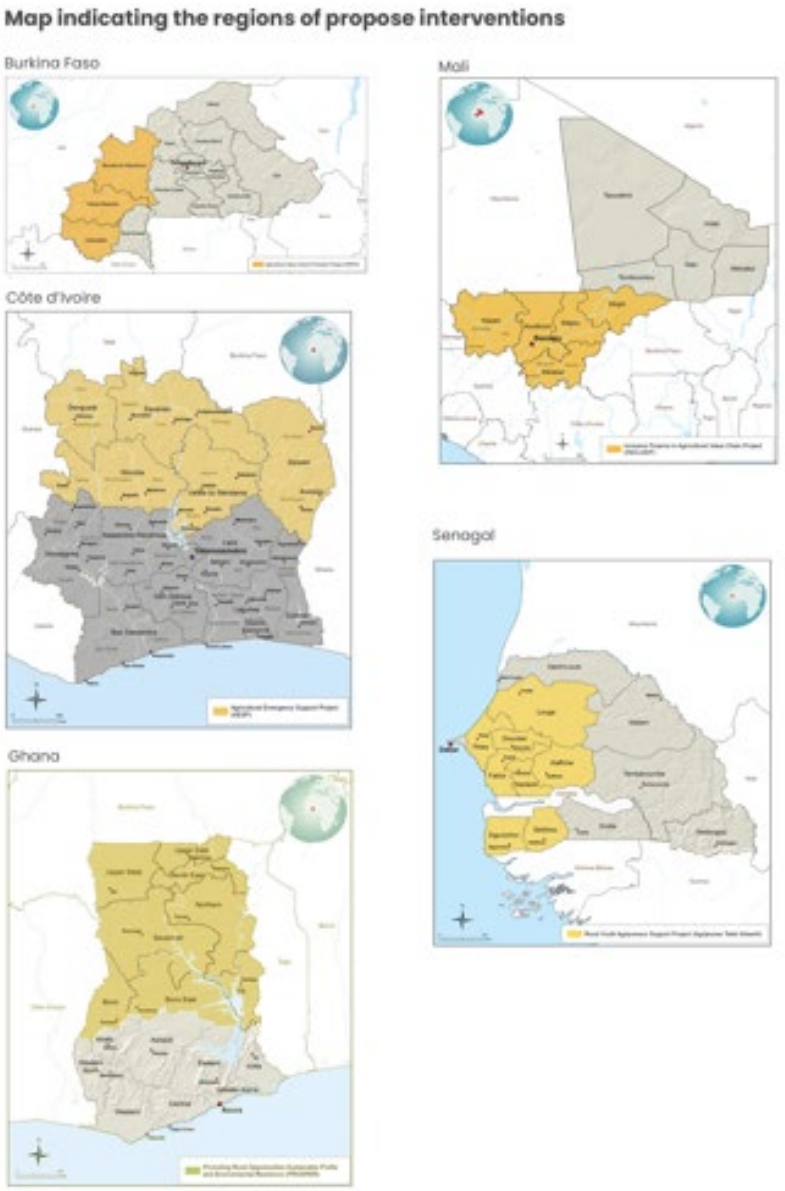


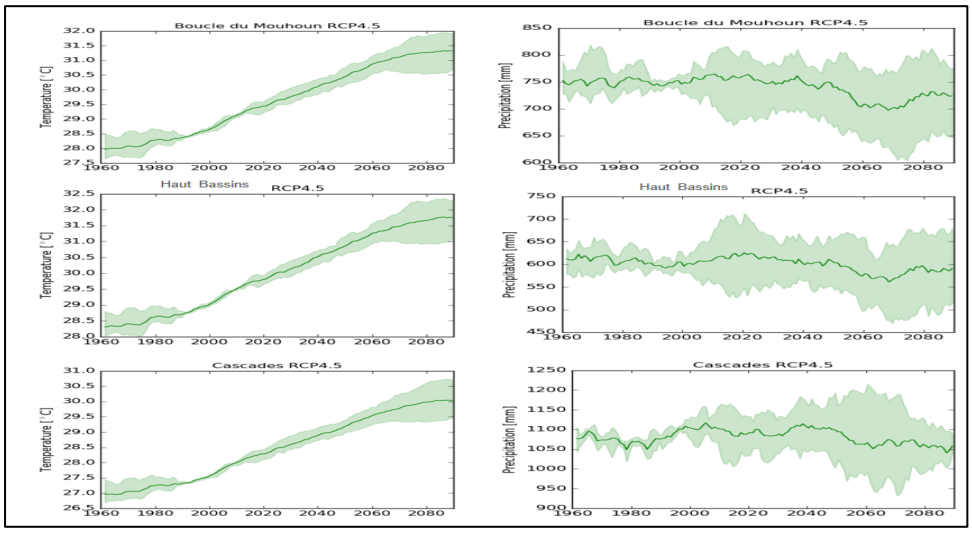
Figure 4. Maps showing the areas of interest

In the targeted areas, agriculture accounts for over 51 per cent of employment and is the main source of livelihood. Various tradable commodities are produced in the targeted regions such as maize, soybean, dairy, livestock, rice, tree crops (cashew), and horticulture, with fish farming in certain regions, including the Niger and Senegal River basins.

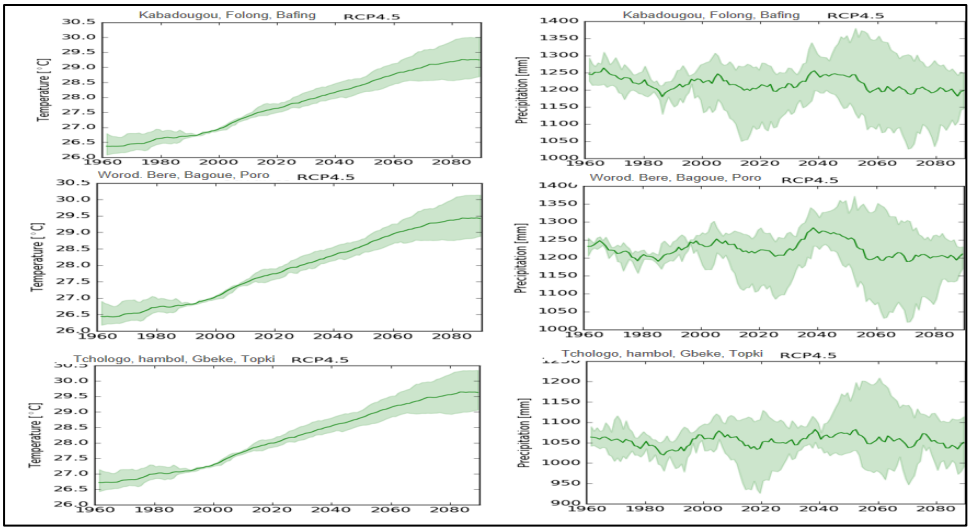
A series of maps presented as Map 1 present the climate change profile (current and projected climate for the targeted areas.

Map 1: Historical and projected impact of climate (temperature and precipitation) 1960-2080 in the selected sites per country.

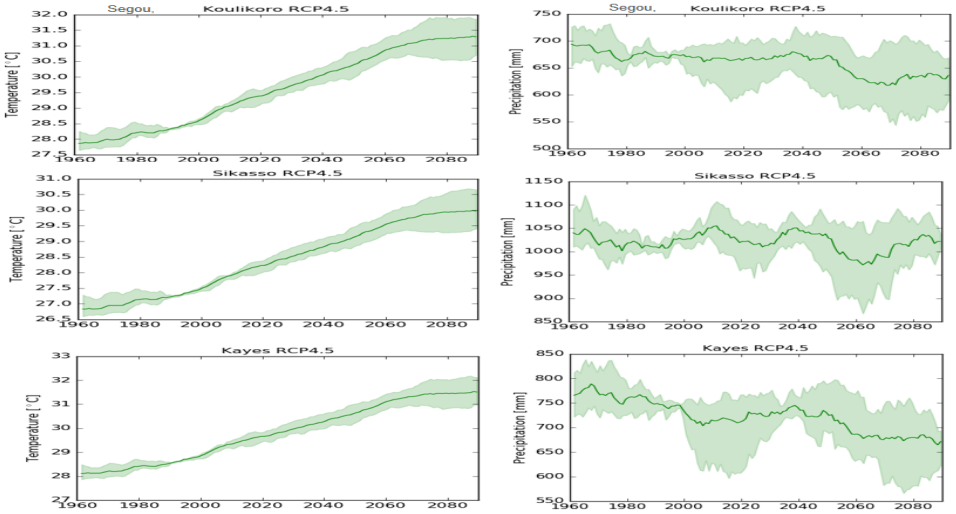
Burkina Faso



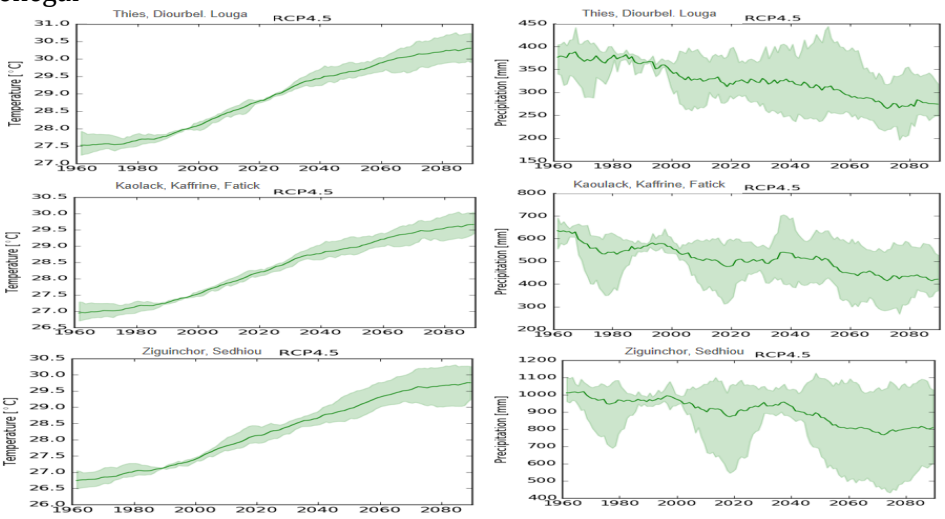
Cote d'Ivoire



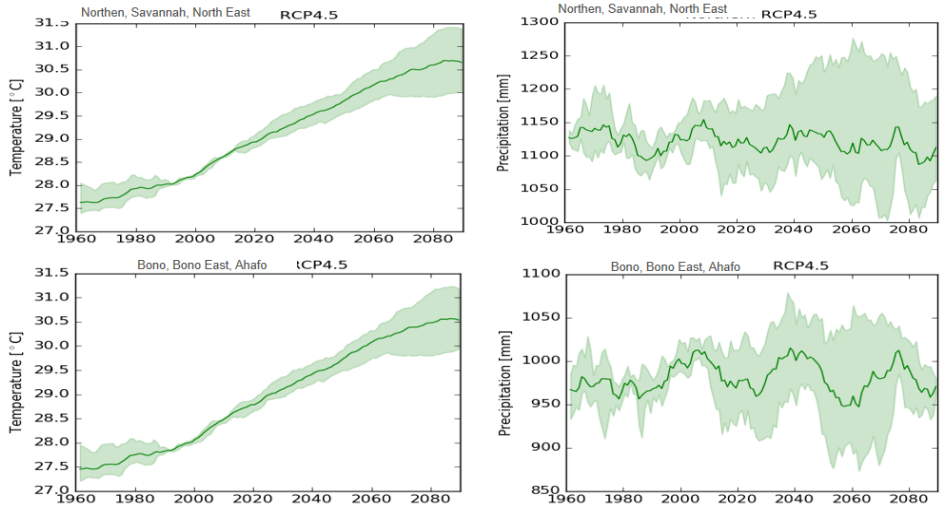
Mali



Senegal



Ghana



Source, climate analytics, 2021

2. Targeted beneficiaries' groups

Target groups are: (i) small producers organized under women and youth-led organizations, cooperatives, MSMEs, engaged in the value chains of staple crops (millet, maize, sorghum, and groundnuts), livestock (dairy and beef, sheep, goats, and chicken) and non-timber forest products characterized by subsistence production and the reduced size of their land and livestock capital; (ii) extremely vulnerable people to climate change and climate variability; iii) marginalized groups including persons living with disabilities, widows, and widowers; iv) young people (educated or not), women heads of households, which are all characterized by a pronounced weakness or lack of production capital (agricultural and livestock) and a lack of economic opportunities and jobs, and v) MFI or commercial banks including Islamic banks as partners that want to borrow and on-lend with the same conditions for end-users.

Typology of beneficiaries: The loans will directly benefit 378,600 smallholder farmers only organized around FOs, cooperatives, women and youth organization and MSMEs and indirectly, over 2,494,000 people, of which 50 per cent will be women, 50 per cent youth, by increasing their climate resilience through affordable long-term loans. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations, 2 commercial banks (Attijariwafa bank, Islamic Bank of Senegal) and potential LNABs partners such as the microfinance institutions (MFIs). Furthermore, 50 technologies and innovative solutions will be transferred or licensed to support low-emission development during the programme implementation. For Component 3 – Regional Support program, the target groups are (i) the governments through the NDAs, GGW Focal Points and where possible GEF Focal Points (ii) the Accredited Entities that are implementing projects funded by the GCF and (iii) the private sector that developing value chains and/or investing the GGW while contributing to climate resilience and value chain development.

The table below outlines the typology of the programme's beneficiaries

In the four West African Monetary Union member countries (Burkina Faso, Cote d'Ivoire, Mali and Senegal)

Category	Quantitative aspects
Medium enterprise	Employs between 10 and 100 people; subscription to the chamber of commerce; internal accounting system in place; annual profit above 50 million XOF, but not exceeding 500 million XOF[1]; minimum investment of 10 million XOF
Small enterprise	Employs between four and 10 people; subscription to the chamber of commerce; internal accounting system in place; annual profit above 10 million XOF, but not exceeding 50 million XOF; minimum investment of 1 million XOF
Very small and micro enterprises	Employs between one and three people; subscription to the chamber of commerce; internal accounting system in place; annual profit not exceeding 10 million XOF

[1] XOF: a common currency, the official currency of the eight member states of the West African Economic and Monetary Union (WAEMU): Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. 655.957 XOF = 1 EUR

In Ghana

Category	Quantitative aspects
Medium enterprise	Employs between 30 and 100 people; has a total annual turnover in the range of GHS138,000 to GHS 352,000; and with fixed assets not exceeding $1,000,000.
Small enterprise	Employs between 10 to 29 people; has a total annual turnover in the range of GHS 15,000 to below GHS 138,000; and with fixed assets not exceedingly more than $100,000.
Very small and micro enterprises	Employs between one to nine people; has a total annual turnover between GHS2,400 and GHS15,000; and with fixed assets not exceeding $10,000.

Section II – Climate rationale

The Sahel is one of the world's largest semi-arid and arid areas. It is wedged between the Sudanian Savannah to the south and the Sahara Desert to the north, which is expanding southward at a rate of 1-10 km per year. Considered as one of the poorest and most environmentally degraded regions in the world, it is also one of the most vulnerable to climate change. The already harsh living and growing conditions will be worsened by climate change, namely the rise in temperature, rainfall variability and extreme weather events. The Sahel region is home to over 500 million people and this population is expected to double by 2040. The region has a range of ecosystems and agricultural zones, including the savannah, the semi-arid regions, sub-humid Guinea and extensive coastal areas. Farmers in the region grow various tradable commodities such as maize, soybean, dairy and livestock across the Guinea Savannah; rice cassava in humid and sub-humid zones; tree crops (cocoa, coffee, cashew, mango and oil palm), horticulture and fish farming in other regions. More than 50 per cent of its population rely on agriculture for survival. The region is endowed with great potential for renewable energy sources, which can be used to power the agricultural sector and accelerate its industrialization. It has one of the most diverse cultural bases in the world and a vibrant, creative and large youth population. The countries of the GGW are committed to achieving the goals of the Paris Climate Agreement, as expressed in their INDCs (conditional and unconditional), by strengthening the mitigation and adaptation capacity of the agricultural sector.

Together with the Energy sector, Agriculture, Forestry and Land Use (AFOLU) represent the two largest and the fastest growing sources for all the 11 IGREENFIN participating countries. This programme addresses both the climate vulnerability of the agricultural sector as well as the challenge of ensuring a sustainable growth of the sector while limiting associated greenhouse gas emissions. The following assessment will be focused on the five (5) IGREENFIN I countries.

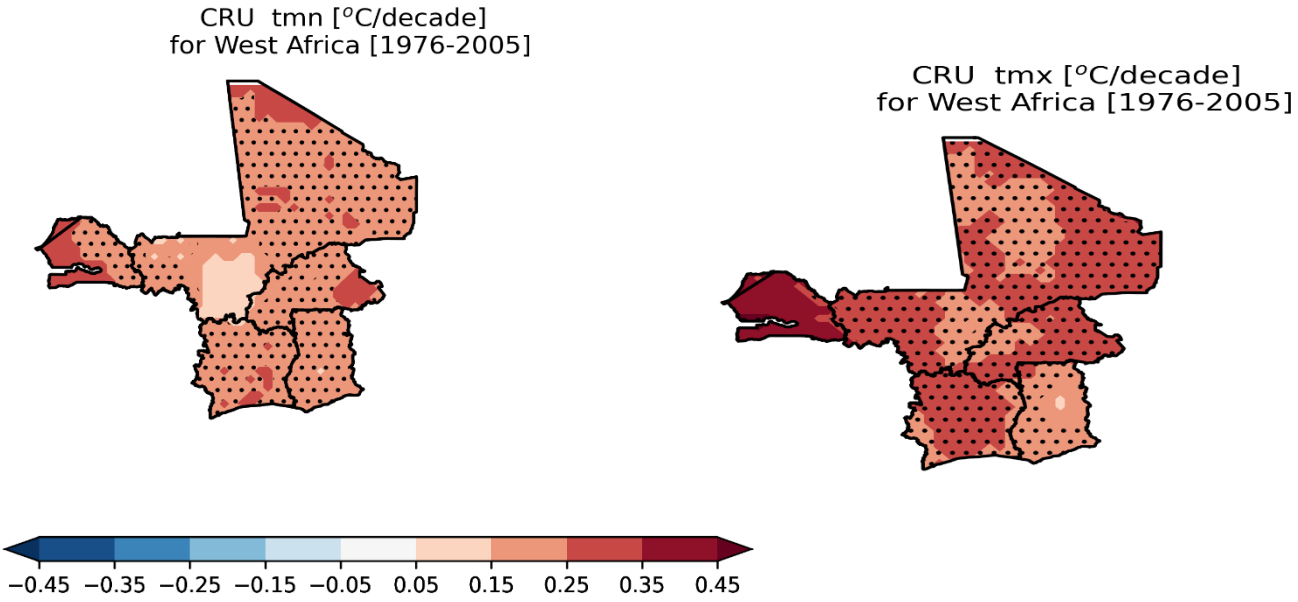
1. Climate profile

Observed trends and projected impacts in IGREENFIN I countries

1.1. Historical climate:

For the IGREENFIN I countries, data from the last 50 years show drier conditions and hotter temperatures in Burkina Faso, Mali and Senegal and the northern part of Côte d'Ivoire and Ghana. The average temperature increases range between 0.6-0.8°C, which is slightly higher than the global average. The rate of warming is higher during the day than at night, as shown in figure 5.

Figure 4 : Daily trends of minimum and maximum temperatures in the region



Note: Minimum temperatures are shown on the left and maximum on the right. The black dots represent regions with statistically significant trends at 0.05 significance level.

Shift in precipitation patterns: Between the 1970s and 1980s, the region experienced one of the most severe multi-year droughts in the last hundred years, resulting in a 30 per cent decrease in rainfall. Since the 1980s, rainfall has not returned to pre-1960s levels and droughts have become recurrent. The lengthening of the dry season and more frequent dry spells combined with less frequent and more intense rainfall over shorter wet seasons have affected the balance of the water cycle, resulting in a greater frequency of extreme rainfall events and severe flooding events. Frequent natural disasters (droughts, floods, intense rains and wildfires), soil erosion, increases in water stress, diseases and locust outbreaks have reduced agricultural yields in the region.

Extreme weather events: The three selected of the GGW countries under IGREENFIN (Burkina Faso, Mali and Senegal) plus Côte d'Ivoire and Ghana face a range of natural hazards risks, particularly droughts, flooding, wildfire, water scarcity, sandstorms and extreme heat. The main climate-related natural hazards observed in the targeted countries between 1970 and 2015 were drought (> 50 per cent) with extreme. As shown in table 1 below, all countries have at least one administrative area in the basin characterized as "high risk" of flooding, and nearly all countries are considered high or medium risk for wildfires (see tables 3 and 4).

Table 3 : Risks for climate hazards

Country	River flood	Landslide	Extreme heat	Wildfire	Water scarcity
Burkina Faso	High	Very Low	High	High	High
Mali	High	Very Low	High	High	High
Senegal	High	Very Low	High	High	High
Côte d'Ivoire	High	Low	High	High	High
Ghana	High	Medium	High	High	High

Source: GFDRR, n/d, https://thinkhazard.org/

Table 4 : Drought frequency and response by country

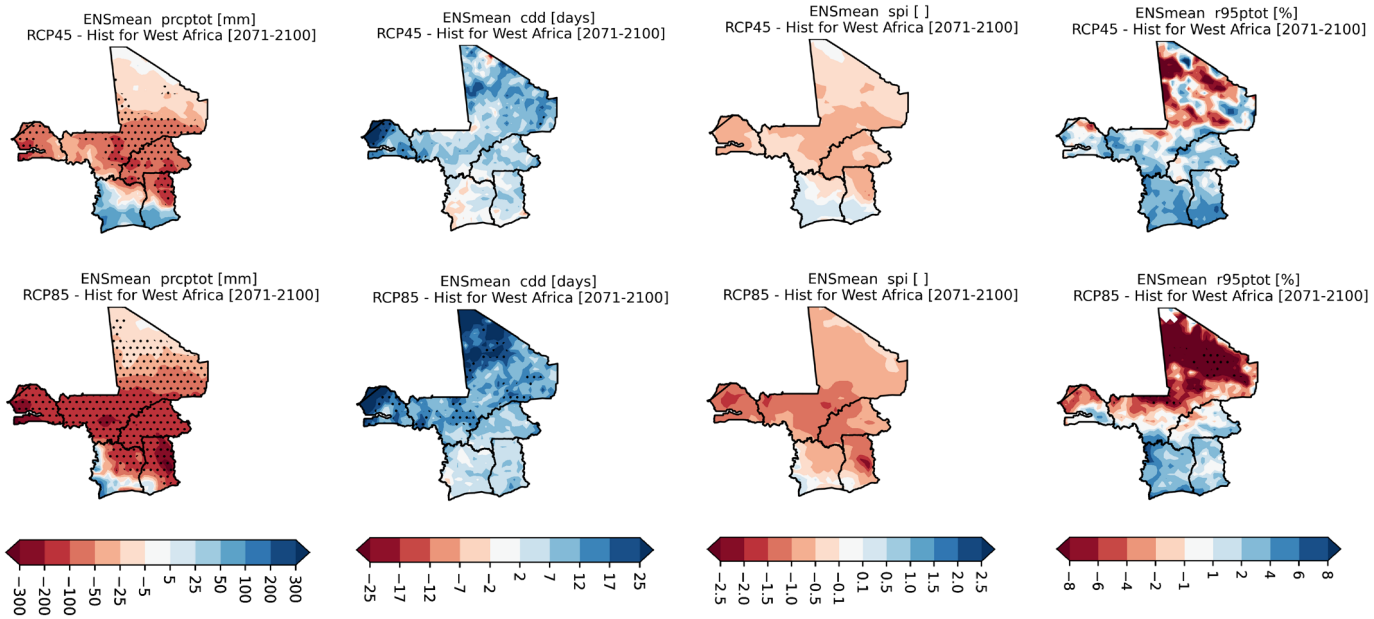
	Period	Number of severe droughts	Frequency of droughts (1 in x years)	Cost of response (average) US$ million
Burkina Faso	2000-2017	4.0	4.0	20.0
Côte d'Ivoire	1972-2016	4.0*	3.0	10.0**
Ghana	1983-2015***	3.0***	3.0***	10.0****
Mali	1983-2017	14.0	4.0	20.0
Senegal	1983-2017	12.0	5.0	56.0

1.2. Future climate

Temperature: Regional climate projections for temperature patterns suggest drier and warmer conditions with increased GHGs in all the five countries targeted under IGREENFIN – I.
According to climate projections, average temperature increases in the Sahel region are projected to be high, with an extremely marked north-south gradient, directly affecting soils and ecosystems due to a higher level of evapotranspiration. By mid-century (2031-2050), temperatures are expected to rise between 1 and 1.72˚C above those of the reference period 1986-2005. Projections for the Sahel for the end of the 21st century from both the CMIP3 GCMs (SRES A2 and A1B emission scenarios) and CMIP5 GCMs (RCP4.5 scenarios) point to temperatures that are 3°C above the late 20th century baseline. It is estimated that temperature increases of more than 2°C will cause millet and sorghum yields to decrease 15-25 per cent by 2080 under RCP8.5, with substantially higher impacts on sorghum yields. The highest increase in daily maximum temperature is expected over southern Mali and western Burkina Faso, where it is projected to reach >5°C above current temperatures in the RCP8.5 scenario by the end of the century.

Precipitation: While the projections indicate drying and increased GHGs across all five target countries, the countries to be affected the most are Senegal, southern Mali and western Burkina Faso. Over Senegal and parts of Mali, precipitation is projected to decline by as much as 30 per cent by the end of the century under the RCP8.5 scenario. While model uncertainty exists on the intensity and size of change over the southern part of the target region, the decline of precipitation over Senegal and southern Mali is consistent with other studies such as Diallo et al., (2016) and Sylla et al., (2016) who used a different set of models. Impact models predict a general reduction of crop yields by 10 to 20 per cent by 2050 as a result of drier and warmer climate conditions, with places where yield losses may be much more severe. Studies by UNEP suggested that as a result of changing rainfall patterns and land degradation, Burkina Faso could potentially lose its entire rainfed agriculture sector by 2100, while in Mali and Senegal cereal harvests might decline by as much as 30 per cent (See figure 6).

Figure 5: Climate Projections over IGREENFIN I countries



Projected change in (column a) annual total wet-day rainfall [prcptot], (column b) consecutive dry days [cdd], (column c) standardized precipitation index [spi] and (column d) contribution from very wet days [r95ptot] for the end of 21st Century (i.e., 2071-2100) under RCP4.5 (low-medium, first row) and RCP8.5 (high, second row) emission scenario. The black dots represent regions with statistically significant change at 0.05 significance level.

Projections of extremes related to floods (e.g., r1xday, r95ptot, prcptot, etc.) indicate a north-south spatial gradient (figure 5) with increased heavy precipitation (amount and occurrence) in the south and a decline in the north. This suggests that there will be a southward shift in the frequency and intensity of heavy precipitation events that produce floods. For the northern part of the target region (part of Burkina Faso, Mali and Senegal), the decline in the intensity (r1xday, r5xday, R95Ptot) and frequency (R20mm) of heavy precipitation events is accompanied by an increased in dry spell length (CDD) and droughts (SPI, SPEI), implying that the region will be more vulnerable to strain on water resources and thus, rainfed agricultural production. The CORDEX RCMs' projections of a regional decrease in the length of the rainy season, an increase in the length of dry spells and in heatwave frequency, intensity and duration highlight the importance of determining the right type and timing for planting and harvesting key crops, especially those prone to drought.

Shift of agro-ecological zones due to climate change: The combined effect of changes in precipitation and temperature will strongly affect the state of eco-climatic zones. Prevailing warmer and drier conditions in the projected future climate would lead to a shift in the agro-climatic zone (figure 6) towards dry to semi-arid zones in parts of the target region (Sylla et al., 2015), with major implications for the native vegetation and farming. Sylla (2015) investigated how combined temperature and precipitation changes will affect the climate characteristics of West Africa. His findings indicate that there will be a shift in climate zones from wet to semi-arid conditions (Figure 4). As for future changes (2080–2099), projected climate types based on the RCP4.5 and RCP8.5 scenarios using the Hamon PE for the ensembles of CMIP5, CORDEX, and HIRES and different sub-ensembles point to consistent future increases in torrid climate extent over most of West Africa and similar future moisture conditions that follow a well-defined north-south gradient altered by both the landcover and topography. They exhibit a prevalent arid climate type in the northern Sahel and the Sahara Desert, a southward shift of the semi-arid band located over the Sahel, and less extensive wet and moist climates around orographic areas and

the Gulf of Guinea coastline. A recent study (EXFAM, 2017) found that one in six trees in the region has died since the 1950s and a fifth of all species has disappeared locally because of rising temperatures and lower rainfall linked to climate change. It also found that in some sites in the Sahel, average temperatures rose by 0.8˚ Celsius and rainfall decreased by 48 per cent and, as a result, trees have shifted southward towards wetter areas, which could affect rural communities engaged in the extraction of NFTPs. Projected biomes change from the periods 1961–1990 to 2071–2100 using the MC1 Dynamic Vegetation Model. (b) Vulnerability of ecosystems to biome shifts based on historical climate (1901–2002) and projected vegetation (2071–2100), where all nine GCM emissions scenario combinations agree on the projected biome change.

2. Risks and impact assessment

The consequences of current warming in the GGW countries, Cote d'Ivoire and Ghana are already manifesting themselves in the form of recurrent extreme weather events such as floods, droughts, heatwaves, sandstorms, and desertification. These all have a heavy toll on rural communities' livelihoods and production systems. Four major drought-related emergencies have been reported in less than 10 years in Burkina Faso and Mali, causing decreases in yields of 25 per cent on average and increases in staple crop prices of up to 50 per cent. Furthermore, the cost of response to the severe drought events experienced in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal has been estimated at over US$100 million. Prolonged droughts have forced many pastoral communities to abandon their traditional way of life to become semi-agricultural (AGRHYMET, 2016). Over the past 30 years, over 75 per cent of the West African population has been affected at least once every two years by this type of hazard. The intensity of extreme weather phenomena is projected to increase, causing negative impacts on agricultural production. Below the assessments of risks posed for relevant sectors across the IGREENFIN I countries

1. Agriculture and food security**:** The main subsistence crops grown in the targeted countries are maize, pearl millet and sorghum while important cash crops include rice, groundnuts, cashew, and mango[7]. Smallholders also exploit a range of non-timber forest products (NTFP) such as Arabic gum, shea butter, tamarind, baobab, etch for their direct subsistence value, and for their contribution to a household's cash income[8] and better livelihood. The NTFP play a very important role in the local economies and account for over 60 to 98 per cent of the total crop production for the 2008-2019 period for Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal[9]. Climate change is expected to lead to significant declines in yields of the main crops in the area by 2100. The climate models of the IFAD Climate Adaptation in Rural Development Assessment Tool[10] (CARD, 2021) indicate that in the targeted countries, the production of millet is predicted to decrease on average by 10 per cent; groundnut, 11 per cent, and rice, 7.82 per cent over the next 20 years in Senegal, Burkina, Mali and Northern dry part of Cote d'Ivoire and Ghana. This will have negative impacts on the livelihoods and production systems identified in figure 7 below, which will push millions more people into poverty and generate acute levels of food insecurity. Climate change is a threat to livestock production because of the impact on quality of feed crop and forage, water availability, animal and milk production, livestock diseases, animal reproduction, and biodiversity[11]. Multi-hazard analyses (heat waves, extreme rain events and dry spells) conducted on each of the five countries at project sites for the RCP4.5 and RCP8.5 scenarios produce heterogeneous results for the different locations, but all point to impacts that affect crop suitability.

7 Farming Systems and Poverty (fao.org)
8 https://www.cifor.org/publications/ntfpsite/pdf/NTFP-Africa-R.PDF
9 FAOSTAT
10 Climate Adaptation in Rural Development (CARD) Assessment Tool (ifad.org)
11 Climate Risk Management, Volume 16, 2017, Pages 145-163

2. Water resources: Declines in rainfall, rising temperature and more frequent droughts contribute to a decrease in surface and groundwater availability and accessibility. However, total renewable water resources per capita range from 745,600 m3/year in Burkina Faso to 6,818,000 m3/year in Mali. It is projected that by 2025, even areas such as Burkina Faso that have low, but sufficient water resources per capita are expected to experience physical water scarcity (defined as when the water supply falls below the 1,000 m3 per person per year). Climate variability and change - in addition to stressors such as population and economic growth, poor water management and infrastructure, inefficient water provision, inadequate joint management of basin resources, declines in groundwater and land use/land cover changes - are expected to further reduce river basin water supplies in the future. All the above indicate that the implementation of sustainable practices, such as low emission, climate-resilient agriculture, is urgently required to mitigate the effects of climate change.

3. Vulnerability assessment

The countries included in IGREENFIN 1 (Burkina Faso, Côte d'Ivoire, Ghana, Mali, and Senegal) are among the world's most vulnerable and least resilient countries to climate change and the least ready to mobilize investments and convert them to adaptation actions, as evidenced by their low ranking on the ND-GAIN index (table 5 below). Rural populations in these countries are among the poorest and most vulnerable to climatic variability and land degradation12, who depend heavily on healthy ecosystems capable of sustaining their rainfed agriculture, fisheries, and livestock activities. The primary sources of employment in the region, these sectors generate at least 40 per cent of GDP in most of the countries13. Furthermore, ecosystem services provide much needed livelihood products, such as fuelwood and bushmeat. The rapidly growing population in the GGW area puts even greater pressure on natural resources for food, fodder, and fuelwood in an already vulnerable environment, accelerating the deterioration of natural resources, notably vegetation cover. Climate variability along with frequent droughts, floods and poorly managed land and water resources (surface and underground) have caused rivers and lakes to dry up and contribute to increased soil erosion14.

Table 5 : Adaptive capacity, vulnerability and readiness scoring for the five countries

Countries	Adaptive Capacity Scoring	Vulnerability Ranking	ND-Gain Index 11 (out of 181 countries)	
			Ranking	Vulnerability and readiness
Burkina Faso	0.687	0.572	161	19th most vulnerable, 34th least ready
Côte d'Ivoire	0.667	0.514	145	47th most vulnerable, 32nd least ready
Ghana	0.532	0.468	74	8th most vulnerable and 81st least ready
Mali	0.731	0.609	166	9th most vulnerable and 38th least ready
Senegal	0.595	0.535	131	42nd most vulnerable and 65th least ready

Source: ND-GAIN Country Index rankings. Available from https://gain.nd.edu/our-work/country-index/

12 FAO, 2020 (http://www.fao.org/3/ca8011en/ca8011en.pdf)
13 Ibid.
14 Ibid.

Climate change and adverse weather (droughts, floods, heatwaves, intense rains, and wildfires) associated with soil erosion and increases in water stress, diseases and locust outbreaks are the cause of numerous shocks on key agricultural value chains in the region, leading to crop losses, disruption of production, higher food prices and rising food insecurity15. The majority of the rural population in the GGW countries, Côte d'Ivoire and Ghana depends on rainfall as the main source of water for their subsistence farming and pastoralism16.

4. Current characteristics and future changes in water availability, crop water demand and irrigation requirements

An assessment of current characteristics and future changes in water availability, crop water demand and irrigation requirements has been performed for the five (5) IGREENFIN to investigate the present-day characteristics as well as the implications of future climate change on regional crop water demand (CWD), irrigation requirement (IR) and water availability (WA to inform implementation of IGREENFIN. Observed and simulated daily rainfall, minimum temperature, maximum temperature, and evapotranspiration were used to derive the above agro-meteorological and hydrological variables. For future periods, high resolution climate data from three regional climate models under two different scenarios, i.e., Representative Concentration Pathway (RCP) 4.5 and 8.5 were considered. Projections of CWD, IR and WA are analysed for three-time horizons, that is, near term (2011-2040), mid-term (2041-2070) and far future (2071-2100) and compared to the historical period (1976-2005).

Evaluation of the characteristics of present-day CWD, IR and WA derived from the regional climate models indicate that the ensemble mean of the models derived outputs reproduced the prevailing spatial pattern of crop water demand, and irrigation requirement. Moreover, they correctly delineated the wetter part of the domain such as Côte d'Ivoire and Ghana from the drier regions of northern Mali, despite having biases. The ensemble model also simulated the annual cycle of water supply, and the bimodal pattern of the water demand curves correctly. Both observational datasets and ensemble model simulations agree that the trend in water availability and demand is generally weak. They, however, disagree on the direction of trend in some of the study sites.

In terms of future projections, the outcomes from the study suggest an average increase in the CWD by up to 0.808 mm/day and IR by 1.244 mm/day towards the end of the twenty-first century compared to the baseline period. The hot-spot areas where the largest projected increment in crop water demand and irrigation requirement are over Senegal, southern Mali, and western Burkina Faso. In most cases, WA is projected to decrease towards the end of the twenty-first century by -0.418 mm/day. The largest decline in water availability is found to be over Ghana, northern Cote d'Ivoire, southern Mali and southern Burkina Faso.
Comparison of the water resources potential per capita, particularly that of groundwater resources, has indicated that the region has more resources compared to other parts of the world such as Europe and Asia. Moreover, the current utilization of both surface and groundwater resources for irrigated agriculture in the target region is much smaller than other regions in the developing world. This suggests that increasing the fraction of irrigated agricultural land is key for increasing productivity and improving food security over the region. The threat of global warming in reducing future water availability and increasing crop water

15 Sahel and West Africa Club, 2019, Security Implications of Climate Change in the Sahel Region: Policy considerations

16 Ickowicz, A.; Ancey, V.; Corniaux, C.; Duteurtre, G.; Poccard-Chappuis, R.; Touré, I.; Vall, E.; Wane, A. Crop-livestock production systems in the Sahel—Increasing resilience for adaptation to climate change and preserving food security. In Proceedings of the Building Resilience for Adaptation to Climate Change in the Agriculture Sector, Rome, Italy, 23–24 April 2012; pp. 261–294

demand, on the other hand, suggested a caution on the scale of irrigation schemes and management strategies.

The outcomes from the study represents a crucial input for the agricultural and water managers for introducing effective measures to ensure sustainability of irrigated farmlands. For instance, given the projected increase in irrigation requirements and reduction in the water availability, the following strategies can be proposed: i) use of technological adaptation, such as improvements in irrigation efficiency, as this might partly alleviate some of the problems; (ii) expansion of irrigation or cultivation of less water demanding crops sounds also a good adaptation strategy to reduce future crop failure frequency; (iii) promote strategies and techniques to climate proof agricultural production; (iv) use of cost-effective techniques to increase yields.

Analysis of ground water resources and prospects of irrigation use and potential
Several previous studies (e.g., Alan M. MacDonald et al., 2021; A. M. MacDonald et al., 2012) indicated that the target region has significant surface and ground water potential. The seven major trans-boundary river basins constitute the major surface water potential. While detailed information on ground water is lacking for the region, FAO (2003) statistics show that sub-Saharan Africa as a whole has more than 3 times the per capita ground water availability of China and nearly 6 times the availability of India. These groundwater resources have advantages as they have a slow response to climate variability, require less treatment (Siebert et al., 2010) and remain the ultimate source of freshwater when surface water is depleted during the dry season.

The potential and accessibility to groundwater over west Africa is enormous. The spatial distribution of groundwater productivity and storage amount clearly indicates a moderate to very high amount of groundwater productivity and storage for Senegal, Mali and Burkina Faso and lower value over the southern parts of Ghana and Côte d'Ivoire. Since groundwater is accessed and abstracted through drilling boreholes, the yield of the borehole will limit the rate at which groundwater can be abstracted. To sustain a community water supply fitted with a hand pump, a borehole must be able to supply greater than 0.1 l s−1, and preferably 0.3 l s−1 (A. M. MacDonald et al., 2012). Much higher borehole yields are required for intensive irrigated agriculture. For instance, commercial irrigation schemes typically demand boreholes supplying greater than 5 l s−1 whereas other farm systems which irrigate smaller areas do not require high yields.

It is interesting to note that the depth to groundwater mostly follows the amount of water storage. This implies that accessibility to groundwater is higher when the depth to groundwater is lower compared to regions where the depth to groundwater storage is high. The exception is over Senegal where the depth to the groundwater is not so deep despite having a large amount of groundwater storage compared to other nearby places e.g., project sites in Mali. The depth to groundwater follows a pattern that is opposite to the spatial distributions of rainfall. Areas lying from south of Mali to the south coast of West Africa possess shallow groundwater depth with values ranging from 0 - 50 meters below ground level.

Another critical point to consider is the recharge rate of the groundwater. In this aspect, the recharge rate is higher over the southern project sites, suggesting a quicker replenishment of the groundwater (Alan M. MacDonald et al., 2021). This implies that although the aquifer productivity in the southern part of the West African region is low, the recharge rate is, however, high due to the effect of rainfall. It is worth noting that the depth to the water table can change (i.e., rise or fall) and exhibit an annual cycle. During the rainy season when rainfall is plentiful, water on the surface infiltrates into the ground and the water table rises. On the contrary, when water-loving plants start to grow precipitation gives way due to transpiration in plants, therefore, the water table falls because of evapotranspiration.

It is important to note that groundwater type is affected by the intrinsic properties of the aquifer, such as, storage capacity, transmission capacity, and aquifer geometry. A deeper groundwater receiving recharge from extensive catchment areas is insensitive to short-term climatic variability, while shallow unconfined aquifers are more responsive to smaller-scale climate variability (Jalota et al., 2018). Deeper aquifers respond with delay to large-scale climate change only, not to short-term climate variability. Shallow groundwater systems, especially unconsolidated sediment or fractured bedrock aquifers are more responsive to smaller-scale climate variability (Kundzewicz & Döll, 2009). Groundwater storage in West Africa is unevenly distributed (Figure 20). The deeper water depths are found in locations situated in Mali, Senegal and parts of Burkina Faso . Water depth less than 1000 mm dominates project locations in Cote d'Ivoire and some sites in Ghana.

The study demonstrated that the estimated amount of productivity, recharge rate, storage and depth for each project site in the study area. Groundwater information at the project sites reveals that regions south of 10oN have low aquifer productivity (as low as 0.1 l/s) compared to sites in the north, where values >20 l/s can be obtained in Senegal The inverse relationship is demonstrated between the recharge rate and storage amount. This inverse relationship indicates that project sites located in Senegal have the highest potential to sustain community water supply and commercial irrigation schemes because the boreholes supply is greater than 20 l/s. Although the recharge rate is low, some locations in Mali and Burkina Faso have the potential to also sustain commercial irrigation schemes. Other sites with aquifer productivity less than 5 l/s can sustain farm systems which irrigate smaller areas because high yields are not necessarily required.

Given the availability of this huge surface- and ground-water resources, only less than 2 percent of its total renewable water resources is explored (Kadigi et al., 2012). About 4 per cent (6 million ha) of the region's total cultivated area is equipped for irrigation, which is far less from achieving the estimated 42.5 million ha irrigation potential (Kadigi et al., 2012). Report shows that about 20 percent of irrigation potential has currently been developed in the Sahel (World Bank, 2014). According to Giordano (2006) calculations, 1.5 % of rural households in sub-Saharan Africa use groundwater for crop production. In contrast, the figures for China and India may be in the order of 30 and 50% respectively. Several analysis highlights the low percentage (<10%) of agricultural land, equipped for irrigation by groundwater. There is also potential to increase the percentage of agricultural land equipped for irrigation by surface water. This is despite great potential for large dams that can be attained in the rivers Senegal and Niger (Barbier et al., 2009). Most of the existing irrigation investments in the Sahel are concentrated in North Nigeria, the Office du Niger in Mali and the Delta in Senegal. Hydraulic infrastructure such as dams is not well developed in West Africa. Yet the irrigation potential of major river basins including Niger, Senegal, Lake Chad, and Volta River basins remains largely undeveloped. Reasons for the underdevelopment can be explained by the lack of well-established institutions for irrigation, the prevalence of subsistence farming, and high investment costs.

The underutilization of the ground water resources and the need for improving food security over the region, may prompt an expansion of large-scale irrigation infrastructure. However, in addition to the adverse effects of climate change in reducing future water availability and projected increase in crop water demand, the following issues should be points of concern.

(i) Salinity: The risk of groundwater salinity should be considered in the development of long-term irrigation infrastructure. This is because the presence of excess salinity in soil water can decrease the plant's water availability and cause plant stress (Grattan et al., 2002; Irrigation Water Salinity and Crop Production, 2002). While there are several drivers of salinity in groundwater; climate change, excessive groundwater abstraction and irrigation are the main ones to consider. For instance, climate change could intensify the risks of seawater intrusion and evaporation. Too

much groundwater abstraction modifies the local subsurface hydrodynamic pressure field. Irrigation also tends to gradually increase the salinity levels in soil water, surface water systems and/or aquifers (Van Weert et al., 2009). To reduce the impact of salinization, the first and straightforward solution is to optimize the groundwater abstraction. Salinization could also be reduced either by decreasing the evaporation rate (by creating shades and reducing temperature). The salinity level of groundwater could also be improved by blending ground water with more fresh water prior to applying for irrigation. Finally, farmers can opt to grow crops by changing to more salt-tolerant crops.

(ii) Rate of recharge: This is a point of concern for deeper groundwater sites, which are located in the northern part of the domain such as Mali, Senegal and northern Burkina Faso. This is because deep groundwater types are characterized by low rate of recharge. This implies that any intense withdrawal of groundwater for large scale irrigation could lead to over abstraction and salinity, which could lead to unsustainable practice.

Therefore, any future irrigation infrastructure development should consider the above concerns and be equipped with improved water use efficiency technology to achieve sustainable water management.

Given these two competing factors (current underutilization of potential resources and future threat). Cautious expansion of irrigation, cultivation of less water demanding crops sounds like a good adaptation strategy to improve near term food security and reduce future crop failure frequency. Technological adaptation, such as improvements in irrigation efficiency is also another strategy that could partly alleviate some of the problems. If indeed technologically possible, this adaptation could effectively mitigate many adverse effects of climate change impacts by reducing groundwater pumping, irrigation water demand and decreasing the need for land retirement due to excessive soil salinization (Hopmans & Maurer, 2008).

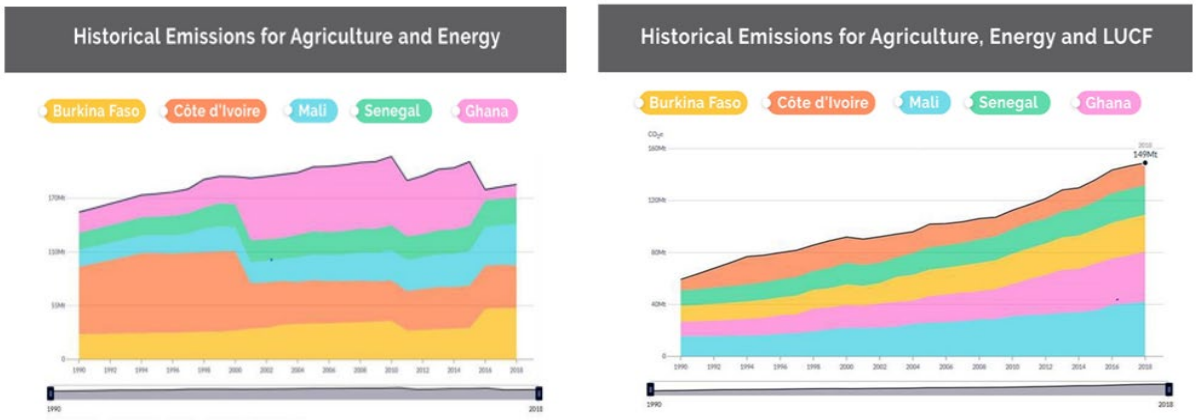
Future work could consider a number of details to explore the sensitivity of key agro-meteorological and hydrological estimates computed in this assessment. For instance, in the IR estimations, the calculation of effective precipitation can be computed differently which potentially yields a different estimation of IR and therefore future studies should explore these estimates to quantify the uncertainty arising from this. The crop coefficient (Kc) value used in the computation of crop water demand also assumes values close to unity which represents the values for the main crops cultivated in the region. Future assessments targeting different kinds of crops with smaller values of Kc need to consider changing the values of crop water demand and the corresponding irrigation requirements. From the water availability side, there is also uncertainty in future water supply under climate change, due to large variation in projected precipitation among climate models. It has to be noted that IR and water availability projections for planning purposes depend on changes in population growth and change in agricultural land use, therefore future studies should consider the population growth in the region and change in land use and land cover.

5. Greenhouse gas emissions profile

Two sectors, the AFOLU and energy sectors are responsible for most anthropogenic GHG emissions in the targeted countries. These emissions are primarily due to deforestation, livestock, soil and nutrient management practices. Clearing lands for agriculture, uncontrolled logging, wood for energy and cooking are key drivers for deforestation. Deforestation exposes soil to high temperatures, breaking down the organic matter, increasing evaporation and making soils vulnerable to erosion and further degradation. Overgrazing and land cover changes often lead to natural grassland ecosystem deterioration and degradation of catchments in arid and semi-arid regions. Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal are each responsible for less than

0.1 per cent of total global emissions. However, these countries' emissions pathways show the greatest and fastest increases in GHG emissions are driven by two sectors - a trend that is expected to continue due to the growing population and associated demand for food and energy in the coming decades (see Figure 7).

Figure 6 : AFOLU and Energy Emissions



Source: IGREENFIN programme development team based on CAIT Climate Data Explorer

Section III – Recommended adaptation & mitigation options

In the selected five countries of IGREENFIN I (Burkina Faso, Cote d'Ivoire, Ghana, Mali, Senegal), changes in precipitation amounts and patterns and rising temperatures are stressing key crops, livestock and forests, affecting production in many ways, both directly (e.g., less rainfall for crops) and indirectly (e.g., pests reproduce more quickly in dry conditions and heat)[17]. Against this backdrop, countries have identified the key crops and value chains within their Climate Smart Agriculture Investment Plans to boost crop resilience and enhance yields, helping them adapt to climate change and reduce climate-change causing GHGs as a co-benefit. The investments are presented as a broad package of potential green agricultural projects in select value chains to be supported both by the public and private sector in table 6. The proposed value chains will be further explored in detail during the implementation.

Table 6 : Prioritized Climate smart adaptation and mitigation techniques for select agricultural value chains in the five countries (Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal)

Selected value chains		Climate risks	Evidence of impacts	Adaptation and mitigation interventions	Adaptation and mitigation benefits
Sustainable livestock production	Cattle	Projected increases in temperatures, rainfall variability and frequency and length of droughts across the Sahel expected to reduce food and water availability for cattle, contribute to disease/pest outbreaks, affect reproductive cycle (reduce calving rates from 60-70% to 25-30%) and growth, and degrade pastureland further.	Livestock disease kills 20% of ruminants in developing countries. Desertification and land degradation have resulted in loss of pastureland. Higher temperatures found to reduce feed intake, milk production, fertility and lead to energy deficits. During major droughts in the past, farmers reported losing entire herds.	Adaptation: Investment in fodder banks; crop-livestock integration; improvements to grazing corridors; efficient watering technologies; vaccination, pest monitoring and control systems, intensification of cultivated pastures; resilient breeds. Mitigation: Frequent removal of manure for composting. Use of RETs to store vaccines.	Adaptation: Improved access to water, feed and disease control will contribute to greater resilience and productivity of livestock, which is key for millions of small livestock producers in target countries. Mitigation: emissions from cattle production reduced through improved management of manure and displacement of fossil fuel in the storage of vaccines.
	Chicken	Projected increases in temperatures, high humidity	Higher temperatures and humidity have been	Adaptation: Climate-smart livestock genotype; cross breeding with exotic	Adaptation: Improved housing, health, feed and

17 FAO 2017, http://www.fao.org/3/i6583e/i6583e.pdf

Selected value chains		Climate risks	Evidence of impacts	Adaptation and mitigation interventions	Adaptation and mitigation benefits
		and sunshine intensity have negative effects on poultry production, as they contribute to disease/pest outbreaks and affect production costs, the number of birds needed to raise to produce eggs and meat on the farm and feed grain availability (because high temperatures and low rainfall levels hinder grain harvest, their supply to the market and ultimately cost of poultry production)	found to increase incidence of disease and reduce feed intake, affecting egg production and feed grain availability. Increases in temperature raise the mortality rate of chickens raised for meat by 8.4%, eggs by 0.84%, and indigenous chickens by 0.32%.	birds; heat/drought/flood resilient and other climate resilient farming practices; Conserve & utilize climate resilient native poultry species; proper feed formulation; heat resilient housing; chicken waste processing into manure; extensive poultry management; vaccination, pest monitoring and control systems Mitigation: Frequent removal of manure for composting. Use of RETs to store vaccines.	disease control will contribute to greater resilience and productivity, a key protein and income source for millions of producers and their families in target countries. Mitigation: emissions from chicken production reduced through improved management of manure and displacement of fossil fuel in the storage of vaccines.
Sustainable horticulture and vegetable production	Tomato	High temperatures, excess water or drought reduce productivity levels. Heat also impacts farmers' ability to market and conserve tomatoes, which are highly perishable. Climate variability increases incidence of disease.	Studies show significant declines in yields due to heat and water stress. High temperatures affect plant growth and reproduction, with increased incidence of abortion of fruit. Lack of water results in formation of fewer flowers and affects pollen. Farmers reported poor yields due to climate change.	Adaptation: Drip irrigation; soil management techniques to address low fertility and salinity (organic fertilizers, mulch); higher-yield, disease resistant varieties. Mitigation: promotion of RETS for storage and processing facilities and efficient irrigation systems to displace fossil fuel use.	Adaptation: Increased production levels and plant resilience, new job opportunities and reduction in post-harvest losses; all contribute to raising smallholders' income and resilience. Better use and conservation of water resources. Mitigation: Adoption of RETs reduces use of fossil fuels and wood

Selected value chains		Climate risks	Evidence of impacts	Adaptation and mitigation interventions	Adaptation and mitigation benefits
					as energy source and thus, emissions
Restoring degraded land and agroforestry	Sustainable Mango (agroforestry model 1)	Negative impacts of water stress and extreme temperatures on flower induction, fruit set and pollen survival. CC scenarios predict a rapid decline in the number of induction days by end of century. Shorter flowering periods reduce productivity. Rainfall variability – especially if there is rain during flowering period – may also reduce yields.	Influence of climate change on yield, time of maturation and quality	Adaptation: Drip irrigation, organic fertilizer, improved pruning practices, integration of mango trees in agroforestry systems; intercropping with cereals Mitigation: Mango trees have a significant capacity for carbon sequestration, tend to use up more carbon than they emit. RETs to power mango processing equipment to reduce post-harvest losses.	Adaptation: Mango trees serve as ecological barrier against CC, contribute to soil and water conservation. Better production and harvesting techniques increase yields and farmers' incomes and contribute to job creation. Growing mangos in agroforestry systems with native trees can increase yields three-fold and prevent soil erosion Mitigation: Mango trees contribute to carbon sequestration. Improved soil management through agroforestry contributes to carbon sequestration, and the adoption of RETs reduces use of fossil fuels and wood as energy source and thus, emissions.
	Cashew production with native species	Increased temperature, rainfall and humidity can lead to higher	Higher temperatures, erratic rainfall and increases in humidity	Adaptation: Mulching to retain soil moisture, prevent weed growth and enhance	Adaptation: Improved productivity increase smallholders'

Selected value chains		Climate risks	Evidence of impacts	Adaptation and mitigation interventions	Adaptation and mitigation benefits
	(agroforestry model 2)	incidence of pests and disease, two major constraints to cashew production. Irregular rainfall, violent winds and prolonged drought can impact yields and quality. Though highly tolerant to drought, low rainfall during vegetative stage can prevent trees from obtaining enough water to sustain flowering.	increase the incidence of pests and disease. Irregular rainfall and temperature changes have been found to affect production.	soil structure; organic fertilizer; inclusion of cashew trees in agroforestry systems; drip irrigation. Investment in storage, conservation and processing techniques and infrastructure for reduced post-harvest losses and value addition. Mitigation: Cashew introduced to control soil erosion and for reforestation; ideal for carbon sequestration.	incomes and create jobs. Cashew trees contribute to soil and moisture conservation, prevention of erosion and slowing desertification. Mitigation: Improved soil management and agroforestry systems that combine cashew trees with native species contribute to carbon sequestration. Adoption of RETs reduces use of fossil fuels and wood as energy source and thus, emissions.
	Sustainable shea production (community forest model)	Favourable habitats of shea trees will decline by 13% (RCP8.5) by 2070 due to climate change. Higher risk of losing flowers and fruit due to heavy rainfall and winds; drought, flooding and wildfires increasing tree mortality and inhibit harvesting; decrease in water supply affecting growth and limiting	Higher temperatures and changes in rainfall patterns are already causing the trees to shift southward, with impacts on the trees' growth, regeneration and production levels.	Adaptation**:** climate resilient practices such as assisted natural regeneration and Zaï, sustainable forest management techniques Mitigation: Agroforestry landscape in which shea is naturally grown acts like a carbon sink, controls soil erosion and good for reforestation. Adoption of RETs to power shea processing and storage facilities.	Adaptation: Agroforestry parklands conserve natural resource base, improve soil fertility, enhance resilience and allow farmers to diversify production. Investments in forest management and shea processing capacity improve incomes and create jobs, especially for women.

Selected value chains		Climate risks	Evidence of impacts	Adaptation and mitigation interventions	Adaptation and mitigation benefits
		processing; more frequent and prolonged droughts leading to the abortion of fruit. Deforestation biggest threat.			Mitigation: shea value chain fixes 1.5 million tons of CO2 every year and every ton of shea kernel produced has a negative carbon footprint of 1.04 tons of CO2 (FAO-GSA, 2020). Valorisation of shea helps reduce deforestation and thus avoid emissions. Improved soil through combination of mixed native species with shea trees contributes to carbon sequestration. Adoption of RETs reduces use of fossil fuels and wood as energy source and thus, emissions.
Sustainable cereals-staple crops production	Sustainable rice production	Increasing climate variability (rainfall) and high temperatures disrupt growing seasons. Greater risk of prolonged drought, heat waves, floods, water shortages, strong winds and storms, pests and diseases, causing	Estimated reductions in rice yield range from 5-25% and up to 80%, in irrigated rice systems in the hot-dry season and around 40% in rainy season.	Adaptation: SRI; improved short-cycle rice varieties; efficient irrigation; management of soil salinity (namely drainage, flooding and organic matter addition). Mitigation: adoption of RETs to power processing facilities and irrigation; SRI involves alternate wetting and drying with minimal water application, thus reducing GHG emissions from flooded rice fields	Adaptation: More resilient and higher yielding rice production improves farmers' income and contributes to food security. More efficient water use. Mitigation: Reduced emissions from flooded rice fields thanks to SRI and

Selected value chains		Climate risks	Evidence of impacts	Adaptation and mitigation interventions	Adaptation and mitigation benefits
		substantial yield reductions or crop failure, which are higher for rainfed production. SLR increases risk of floods and salinization			adoption of RETs.
	Sustainable cassava production	Though resilient to climate change stressors, cassava production is vulnerable to pests and diseases.	Over a third of attainable cassava yield is lost every year to pests and disease, which could be exacerbated by higher temperatures (e.g., whitefly).	Adaptation: Efficient irrigation systems, intercropping with cover crops and trees (fruit and other), composting/organic fertilizer and pest control; sustainable land management techniques. Mitigation: Composting using biodigesters, minimal tilling and adoption of RETs to power processing, storage and irrigation.	Adaptation: Improved productivity through more effective water, soil and pest management increases farmers' incomes and resilience and contributes to food security. Mitigation: emission reductions due to biodigesters and use of RETs.
	Sustainable groundnut production	Though moderately drought resistant, excessive heat and prolonged drought limit yields. Rainfall variability is an important risk as germination is poor in drier soils, whereas excessive moisture increases plant mortality and incidence of disease. Average production expected to decrease 11%	Temperatures above 33˚C found to decrease growth by up to 84%. Higher temperatures will have most dramatic impact on yields, which are traditionally low due to unreliable rain, poor soils, pests and disease.	Adaptation: improved short-cycle varieties, organic fertilizer, intercropping, stone bunds, water efficient irrigation systems, storage and conservation techniques. Mitigation: As a nitrogen-fixing crop, groundnuts reduce GHG emission intensity and use of chemical fertilizers. Solar energy instead of fossil fuels to power drip irrigation systems and other equipment.	Adaptation: More resilient production and higher yields improve farmers' incomes and food security and create jobs in value chain. More efficient resource management (soil and water) contributes to conservation. Mitigation: As a nitrogen-fixing crop, has mitigation benefits, as it maintains soil health. Reduced

Selected value chains		Climate risks	Evidence of impacts	Adaptation and mitigation interventions	Adaptation and mitigation benefits
		over next 20 years.			emissions from use of RETs.
	Sustainable millet production	Though well-adapted to hot areas, temperature increases higher than 2°C are projected to decrease millet yields by 10% over next 20 years and 15-25% by 2080. Rain variability contributes to lower yields, primarily excess rain during flowering, which can cause crop failure.	Production predicted to decrease on average by 10% over next 20 years.	Adaptation: Climate resilient practices such as inter-cropping; soil fertility (compost) and water retention (Zai and half-moons) techniques; climate information systems. Mitigation: Use of millet crop leftovers to maintain and increase soil carbon levels; adoption of RETs for processing to reduce post-harvest losses and displace diesel to power drip irrigation.	Adaptation: More resilient production and higher yields increase farmers' incomes and contribute to food security. Improved soil and water management. Mitigation: Crop leftovers have a high carbon content, making them particularly significant for increasing soil carbon levels. Emissions avoided due to adoption of RETs instead of fossil fuels.

Below a snapshot of climate change impacts on the five countries' major commodities

Climate smart agriculture (CSA) is one sustainable approach to increase productivity, resilience and mitigation but requires understanding of how CSA is defined in different countries and designing projects to fit the varied contexts. CSA is an innovative paradigm shift approach that recognizes the importance of economic investments that account for climate change for agricultural productivity increase and sustainability. CSA promotes direct climate benefits to agriculture that supports adaptation, builds resilience and reduces emissions. CSA focuses on agriculture, but it is multisectoral and also includes commitments to enhancing livelihood benefits, ensuring food security and promoting sustainability. While CSA aims to create triple-wins across productivity, resilience and adaptation, it recognizes trade-offs among the three pillars based on the biophysical, agricultural and socioeconomic considerations.

The main CSA regional regulatory framework in the region is the West Africa CSA Alliance, which imbeds CSA within the ECOWAS Agricultural Policy (ECOWAP)/Comprehensive Africa Agricultural Development Program (CAADP) and its strategic priorities. Reportedly, national organizations have rapidly embraced CSA implementation. The following section presents a selection of CSA practices in Burkina Faso, Cote d'Ivoire, Mali, Ghana and Senegal. It will focus on value-chain solutions with high climate smartness scores according to expert evaluations. The average climate smartness score is calculated based on the practice's individual scores on eight climate smartness dimensions that relate to the CSA pillars: yield (productivity); income, water, soil, risks (adaptation); energy, carbon and nitrogen (mitigation).

Burkina Faso

Burkina Faso is developing this national CSAIP as part of the Adaptation of African Agriculture (AAA) Initiative. The CSAIP provided a set of 9 key CSA investments for Burkina Faso[18], which embody cutting edge and proven technologies and practices for climate smart agriculture. This CSAIP is clearly aligned with Burkina Faso's Nationally Determined Contributions, both for high level objectives and specific investment activities.

The five national investments that build capacity, financing, resilience, support mitigation and offer human health benefits are**:**

- **Sustainable On-Farm Biogas Production:** increase access to and knowledge of sustainable domestic energy sources in order to conserve wood resources, reduce greenhouse gas emissions, and reduce poverty, food insecurity, and health threats to rural communities.
- **Sustainable Intensification of Livestock Production:** foster climate resilience in Burkinabe livestock systems for improved food and nutritional security and economic outcomes.
- **Financial and Insurance Products:** foster smallholder ability to invest in CSA innovations through good access to robust financial services, including credit, loan, insurance and risk instruments, savings and payment services.
- **Forest, Agroforest, And Garden Production for Climate-Smart Diversification:** foster climate-resilient livelihoods and food sources for women and youth smallholders through home gardens, agroforestry, and non-timber forest product harvesting and value-addition
- **Building Capacity in Climate Smart Agriculture:** fully integrate national climate-smart priorities into Burkina Faso's agricultural research and extension programs, and build robust extension mechanisms for delivering timely, practical climate-smart information to farmers and other stakeholders through highly accessible channels.

Four climate-smart investments were prioritized to support adaptation of agricultural production systems by introducing a variety of climate-smart practices into the different investments.

- **Sustainable Management of Water Resources and Irrigation:** Fully leverage Burkina Faso's water resources in sustainable ways to improve productivity, food and nutritional security, climate resiliency, and ecological health in the Nord Soudanian region for 100,000 farmers and their families.
- **Developing Climate-Smart Organic Value Chains:** Develop a burgeoning niche market to create viable careers and shorten supply chains in peri-urban areas in the Nord and Sud Soudanian regions for 60,000 farmers and their families.
- **Developing Resilient Oil-Protein Value Chains:** strengthen the quality, yield efficiency, and value chains of oil-protein crops to sustainably meet domestic demands and support international market development in the Nord Sahelian, Nord & Sud Soudanian regions for 240,000 farmers and their families.
- **Integrated Soil Management for Agricultural Productivity & Environmental:** Provide producers and extension agents with location-tailored information on soil characteristics and best management practice recommendations, as well as the tools, products, partnerships, and policy environment to implement those recommendations for 200,000 farmers and their families in the North Sahel and North and South Sudan regions.

The following table presents the CSA potential of each investment: how it is important to understand how vulnerable the sector is to climate impacts, how the priority investment is

[18] World Bank and Ministry of Food and Agriculture . Climate-smart agriculture investment plan for Burkina Faso – Draft for Decision Meeting. Washington, DC: World Bank Group; 2020.

important, and what the future scenario looks like for that commodity or cropping system with and without the investments, and what the investments would accomplish.

Table 9: Proposed CSA for each investment

Climate Change	Project Importance	Scenario WITHOUT Investment	Scenario WITH investment	Investment objectives
Diversification through Forests & Gardens				
Medium resiliency	Livelihoods & food sources for women & youth thru garden, agroforestry, & non-timber forest products (NTFPs)	Low diversification increases smallholder vulnerability to economic & food insecurity under climate change; continued deforestation & environmental degradation; untapped international market opportunities	Smallholder food & economic resilience, particularly for women & youth; forest conservation & enhanced ecosystem services; national economic growth through value chain development of high-value export products.	• Food security • Resilience • Value chains • Sustainability • Mitigation • Livelihoods • Inclusivity
Sustainable management of water resources				
Medium resiliency	Protect & sustainably leverage water resources to improve climate resiliency.	Agriculture remains exposed to increasingly unpredictable precipitation. Crop & animal loss, food & economic insecurity. Conflict over scare resources. Watershed degradation.	Efficient water capture allows storage & management. Irrigation stabilizes crop & animal production, food supplies, & market prices. Reduced erosion & flooding, watershed protection.	• Food security • Resilience • Value chains • Transformation • Sustainability • Environmental quality
Foster climate-smart agriculture with financial services				
Foundational resilience through essential services	Enable smallholder investment in CSA through loan, insurance, & other basic services.	Smallholders have limited capacity to invest; cost of maintaining status quo increases with climate impacts; decreased food & economic security; downward poverty cycle	Credit & loan enable investment in system transformation; insurance & risk distribution instruments offer protection from loss, enabling farmers to take the risk of changing to new system	• Food security • Resilience • Value chains • Trade • Sustainability • Transformation • Mitigation
Building climate-smart capacity				
Foundational resilience	Establish sustainable systems for	Farmers make short-term decisions when	Robust research, extension, & information services	• Food security • Resilience • Value chains

Climate Change	Project Importance	Scenario WITHOUT Investment	Scenario WITH investment	Investment objectives
through essential services	developing & disseminating CSA innovation	facing uncertainty or high risk; perpetuates poverty cycle, degrades resources, & increases vulnerability.	support a suite of site-tailored solutions that drive resilience, productivity, environmental management	• Sustainability • Transformation • Mitigation
Develop value chains to meet demand for organic				
Highly vulnerable	Leverage untapped domestic & international markets for diversification	Low sectoral diversity, dearth of livelihood & income opportunities, particularly for youth & women	Diversification improves economic resilience by creating livelihoods all along several organic production value chains; environmental impacts reduced; increased peri-urban food access	• Food security • Resilience • Value chains • Sustainability • Livelihoods • Economic resilience
Developing resilient value chains for oil-protein crops				
Medium resiliency	Strengthen value chains to build livelihoods, reduce import dependency, & build export markets	Soybean yield plummets with climate change; soil health decline; income declines; reliance on imports	Sustainable productivity, reduced reliance on imports, improved national food security, export market development, new livelihood opportunities.	• Resilience • Value chains • Sustainability • Trade • Food security • Economic resilience
Agricultural productivity & environmental restoration through integrated soil management				
Foundational resilience through essential services	Provide location-tailored soil information, recommendations, & tools & policy to support implementation	Agriculture & extreme weather events degrade soils; productivity decreases; cost of production rises with increased fertilizer inputs; increased greenhouse gas (GHG) emissions exacerbate climate change; environmental degradation	Soils are resilient to climate stress; sustainable productivity; food & economic security; GHG storage; strong environmental services; optimum fertilizer usage	• Food security • Resilience • Sustainability • Transformation • Mitigation
Sustainable on-farm biogas				
Resilient under	Leverage farm waste	Continued deforestation, High	Reduce deforestation & GHG emissions;	• Sustainability • Mitigation

Climate Change	Project Importance	Scenario WITHOUT Investment	Scenario WITH investment	Investment objectives
climate change scenarios	to produce clean energy, support health & reduce GHGs	GHG emissions, unreliable & costly cooking fuel & fertilizer purchases, Indoor air pollution & related diseases affecting especially, women & children	Clean cooking fuel & fertilizer produced on-farm for free; improved crop yields; Improved health outcomes.	• Soil fertility • Health
Climate-resilient livestock				
Vulnerable to climate change	Create climate resiliency to ensure future food security & income	Reduced productivity as heat stress & mortality increase, feed sources decline. Increased pastoralist-smallholder conflict.	Improved health & productivity; food & income security; reduced farmer-pastoralist conflict; reduced GHG emission intensity; reduced environmental degradation	• Food security • Resilience • Mitigation

Source : World Bank and Ministry of Food and Agriculture. Climate-smart agriculture Investment plan for Burkina Faso – Draft for Decision Meeting. Washington, DC : World Bank Group ; 2020.

Cote d'Ivoire

The World Bank with support of the AAA Initiative and the technical assistance of the CGIAR Research Program on Climate Change Agriculture and Food Security (CCAFS) provided a set of 12 key CSA investments for Cote d'Ivoire that were developed with strong stakeholder engagement, expert input and scientific evidence, which is not intended to be comprehensive, but can further include additional investments when more funds are available. The CSA investment plans (CSAIP) of Côte d'Ivoire that were developed in the study are summarized in the table below:

Table 7: CSA Investment Plans (CSAIP) by zone

Northern savannah	Central zone	Southern forest zone	Nationally
Maize development	Cassava production	Abidjan market	Agrometeorological system
Mango value chain	Rainfed rice	Cassava production	Agricultural finance services
Livestock sector	Yam prod. & Processing	Cocoa	Soil fertility
Yam prod. & Processing			Agricultural extension

Source: *World Bank and Ministry of Food and Agriculture. Climate-smart agriculture investment plan for Cote d'Ivoire. Washington, DC: World Bank Group; 2020. Available at Cote d'Ivoire Climate-Smart Agriculture Investment Plan (worldbank.org)*

The CSAIP for Cote d'Ivoire's national-scale initiatives represent the fundamental components of an adaptive and climate-smart agricultural sector that are viewed as necessary at the national scale: agrometeorology, finance services, soil fertility and agricultural extension. These initiatives are foundational in supporting programs that are vital to ensuring that the agricultural sector becomes climate smart, by providing both the real-time information farmers need to make decisions (e.g., agroclimatic information and soil fertility monitoring) and the guidance, knowledge and financial support for needed investments in the sector (e.g., finance services, soil fertility and agricultural extension). For example, integrating CSA practices into the national extension system not only helps farms directly but helps ensure that there is a mechanism for transferring the information from the three national technology-based investments to farmers and other users These four national-scale investments, the beneficiaries, and the proposed development outcomes (PDOs) are shown Table 8.

Table 8: National-scale investments in climate-smart services

National investment	Beneficiaries (and their households)	Proposed Development Outcome (PDO)
Soil fertility	87,000 agricultural workers	lncrease agricultural producers' ability to practice CSA by providing producers and extension agents with location-tailored information on soil characteristics, best management practice recommendations and the tools, products, partnerships and policy env ironmen t to implement recommendations.
Agricultural financial services	980,000 agricultural workers	Sustainably increase productivity by improving agricultural producers' access to and ability to successfully leverage financial products and services, in order to lncrease their ability to manage climate-related risks.
Agrometeoro-logical system	312,000 agricultural workers	lncrease farm productivity and mitigate climate-related risks by providing timely, accurate agrometeorological information to producers, extension agents and agribusiness.
Agricultural extension services	235,800 agricultural workers	lmprove the quality and quantity of CSA-informed recommendations that farm advisors give producers in order to increase farm productivity and minimize climate-related risks.

There are eight climate-smart crop and livestock investments that were identified to support adaptation of agricultural production systems for important crops that will be harmed by climate change, while also supporting the expansion and development of climate-resilient crops and livestock. This dual perspective of including both adaptation of climate-sensitive crops and expansion of resilient crops provides a way for Ivorian farmers to adapt to climate change. The proposed crop and livestock investments all introduce climate-smart practices into the different investments. These site-specific investments are well supported by the four national-scale foundational investments (Table 9).

Table 9 : Crop and livestock climate-smart investments

Investment	Beneficiaries (and their households)	Proposed Development Outcome (PDO)
Cassava	90,000 producers in the lffou, Belier, Moronou and N'Zi districts	Increase the cassava sector's capacity to practice CSA by providing producers, processors and extension agents with technical assistance and increased access to improved varieties and up-to-date research.
Abidjan Food System	66,000 peri -urban agricultural workers in Grand Ponts region	Improve economic and nutritional self-sufficiency through CSA practices in the regions supplying Abidjan.
Cocoa	88,000 rural agricultural workers in the Moronou region	lncrease cocoa farm climate resilience to increase productivity and generate new income opportunities, particularly for women and youth.
Mango	5,000+ mango producers in the Hambol region	lncrease incomes in the lvorian mango sector via (i) greater productivity through CSA practices and (ii) reduced post-production losses through value-added processing
Maize	138,000 female agriculturalists in the Poro region	lncrease farm productivity and minimize climate risks by increasing the capacity of producers, cooperatives, extension agents and researchers in CSA maize research production

Ghana

Ghana is developing this national CSAIP as part of the Adaptation of African Agriculture (AAA) Initiative. The CSAIP provided a set of 9 key CSA investments for Ghana[19] which embody cutting edge and proven technologies and practices for climate smart agriculture. Table 10 shows the investments, their importance to Ghana, and assumptions of what would happen without the project investments.

Table 10: List of Prioritized CSAIP Investments

CSA Investment	CSA Investment Package	Commodities	Location
1. Knowledge systems and advisory services supporting CSA	Supporting evidence-based research, extension agents, and information and communication technology (ICT) advisory services	All crop commodities, fish, and livestock	National
2. Integrated water Resource management for rice	Irrigation facilities and water management for rice	Focused on rice, with possible expansion to other commodities	National

[19] World Bank and Ministry of Food and Agriculture . Climate-smart agriculture investment plan for Ghana. Washington, DC: World Bank Group; 2020. Available at Public Disclosure Authorized Agriculture Investment Plan ... (worldbank.org)

CSA Investment	CSA Investment Package	Commodities	Location
3. Cereal-legume integration	lmproving crop varieties (heat- and drought- tolerant, disease-resistant); soil fertility management	Maize, sorghum legume	Coastal savannah.
4. Climate-smart cocoa production	lmproving cocoa growing area suitability; planting new resilient cocoa strains (heat- and drought tolerant, disease-resistant); replacing old trees; cocoa IPM; integrated soi fertility management	Cocoa	Forest, transitional
5. Climate-smart poultry	lmproving poultry feed and manure management; enhancing genetic resources	Chicken, guinea fowl	Transitional ; savannah. forest
6. Climate-resilient ruminant and genetic resource conservation	lntroducing water harvesting technologies; irrigation for growing feed; establishing fodder banks, grazing, and watering pathways for livestock; improving breed varieties (heat stress – and disease-resistant)	Cattle, sheep and goat	Transitional . savannah; forest
7. Sustainable fisheries and aquaculture	lntroducing heat - and disease-resistant fish varieties; improving feed for aquaculture; culture-based fisheries	Tilapia, catfish, shrimps, mussels, and clams	Transitional ; coastal Savannah, forest
8. Diversified tree crop	Agroforestry; improving tree crop varieties (heat- and drought-tolerant, disease- resistant); integrated soil fertility management	Cashew, oil palm	Forest. transitional
9. Roots and tubers-livestock integration	lmproving crop varieties and livestock species (heat - and drought-tolerant, disease-resistant); integrated soil fertility management	Roots and tubers (cassava and yam)	Coastal savannah. transitional; savannah

Source: World Bank and Ministry of Food and Agriculture. Climate-smart agriculture investment plan for Ghana. Washington, DC: World Bank Group; 2020. Available at Public Disclosure Authorized Agriculture Investment Plan ... (worldbank.org)

Table 11 shows the proposed investments, how vulnerable a sector or commodity is to climate impacts, why the proposed investment matters, and likely future scenarios with and without the investments. Of the nine investments, cereal-legume integration addresses the commodity most vulnerable to climate change. Investments in cocoa, poultry, ruminants, fisheries and aquaculture, and tree crops all address commodities' vulnerability to climate change. Investments in roots and tubers livestock are targeted to mixed vulnerability, as roots and tubers are generally resilient to climate change. The two national-scale investments for knowledge and advisory services and water management (for rice) support Ghana's efforts toward building a resilient production system.

Table 11: Proposed Investments

Climate impact	Project Importance	Scenario WITHOUT Investment	Scenario WITH Investment
Knowledge Systems and advisory services supporting CSA			
Resilient	Foundational: leverage all CSA objectives to transform knowledge and extension by creating two- way information flow to identify emerging problems	Farmers make short-term decisions when facing uncertainty or high risk, perpetuating the poverty cycle, degrading resources, and increasing vulnerability. Local knowledge is less helpful with sudden shocks from climate or other factors.	Strong flow of good information on CSA suite of interventions supporting improved practices and productivity. Awareness and demand are driven by project. Project supports OneHealth, allows early action for pests, drought, and soon.
Water harvesting technologies and irrigation management focused on rice			
Resilient	Shows links for managing water and crop production(rice)	Rice imports increase while prices increase, globally; environmental resources continue to be degraded while water scarcity increases; crop failure.	Efficient water capture and management allows Ghana to use rice resilience to meet its own demand and possibly to export rice.
Cereal-legume integration			
Highly vulnerable	Optimize existing-cereale legume farm practices to increase yields and improve soils	ln 10 years, maize yields drop 8- 11%; millet and sorghum drop 2- 3%; soil degradation reaches critical levels, forcing people to move and clear land, increasing emissions.	Cereals are resilient; productivity increases; groundnut exports are supported; there is a 40% yield boost to 20,0000 farm families; diversified on-farm crops increase resilience to shocks.
Climate-smart cocoa production			
Vulnerable	Transform a well-established sector with CSA practices to reverse declining yields	Old trees and climate impacts lead to yield declines; continued deforestation exacerbates climate impacts, causing additional yield declines.	Sector is transformed by climate-resilient practices that reduce encroachment on forest areas and boost yields.
Climate-smart poultry			
Vulnerable	Make sector climate resilient; create jobs; lower costs and sale prices; reduce imports; improve phytosanitary conditions and monitoring	Climate-related diseases and heat, long with feed cost, accelerate sector shutdown; Ghana becomes reliant on imports; native stock ignored, potential for avian disease vectors	Resilient domestic poultry sector provides jobs, income, protein and reduces import demand. High demand for local poultry products is met with supply. Mitigation benefits achieved. Value chains increased.
Climate-resilient ruminant and genetic resource conservation			

Climate impact	Project Importance	Scenario WITHOUT Investment	Scenario WITH Investment
Vulnerable	Make sector climate resilient; create jobs; lower costs and sale prices; reduce imports. improve phytosanitary conditions and monitoring	Reduced productivity as feed sources decline while heat stress and mortality increase. Pastoralist- smallholder conflict increases as does reliance on bushmeat.	Crop-livestock integration and resilient breeds with improved health boosts productivity for income and consumption, enabling climate resilience; established water sources and corridors reduce conflict.
Sustainable fisheries and aquaculture			
Vulnerable	Make a highly profitable sector sustainable and climate-resilient, build value chains to create jobs and grow sector	climate shocks affect the sector; overharvesting and poor resource management impact productivity; prices increase; protein intake suffers. Jobs and value chains decline.	A burgeoning sector is built on climate-resilient and sustainable feeds, breeds, and practices to ensure long-term profitability and well-developed value chains. Export market, jobs, and economic growth are enabled.
Diversified tree crop			
Vulnerable	Leverage agroforestry practices in profitable export sectors to ensure Continued food production and reduce forest encroachment	A 3-4% drop in oil palm yields; forest and soil health decline as does income; forest clearing; a significant decline in food production leads to increased prices, food insecurity, and reliance on imports	Resilient agroforestry practices ensure long-term productivity of export tree crops and reduce forest loss; enhanced ecosystem services mitigate climate change impacts; food production and security maintained or improved
Roots and tubers-livestock integration			
Mixed	lntegrate two key farming systems to foster resiliency, increase productivity, reduce costs in both, and monitor livestock health	Climate impacts further reduce feed availability and increase mortality; overgrazing exacerbates soil degradation; low cropand livestock productivity creates poverty trap; smallholder-pastoralist conflict is increased.	Resilient varieties, new feed resources, and relevant value chains bring climate resiliency and increase productivity, resulting in increased incomes, new jobs, productivity, and relevant sectoral growth.

Mali

Given that Mali's agricultural development strategy is centered on the "agropoles" concept there is need to ensure that investments in these growth poles integrate climate-smart practices to support long term resilience and productivity as well as low emissions development in the agriculture sector. A detailed assessment of the climate-smartness of planned agropole investments could assist in this regard. The World Bank provided a set of 12 key CSA investments for Mali that would support overall food production/food security improvements by zone.

Table 10: CSAIP investment priority by zone

Northern savannah	Central zone	Southern forest zone	Nationally
Maize development	Cassava production	Abidjan market	Agrometeorological system
Mango value chain	Rainfed rice	Cassava production	Agricultural finance services
Livestock sector	Yam prod. & Processing	Cocoa	Soil fertility
Yam prod. & Processing			Agricultural extension

Source: World Bank and Ministry of Food and Agriculture. Climate-smart agriculture investment plan for Mali. Washington, DC: World Bank Group; 2020. Available at Mali Climate-Smart Agriculture Investment Plan (worldbank.org)

The CSAIP for Mali's national-scale initiatives represent the fundamental components of an adaptive and climate-smart agricultural sector: remote sensing monitoring capability, CSA inclusion in national agricultural extension services, agroclimatic information systems, and monitoring soil fertility. These initiatives are foundational in understanding and monitoring of the agricultural sector by supporting programs in remote sensing, agroclimatic information, and soil fertility monitoring. These three programs, all based in proven technologies, have the potential to provide vital, real-time guidance to both decision-makers and to farmers themselves. Furthermore, the remote sensing and agroclimatic systems can support a range of other development objectives. For example, understanding potential weather-related impacts (e.g., heavy rainfall), is useful to minimize impacts on everything from people to infrastructure. Integrating CSA practices into the national extension system not only helps farms directly but helps ensure that there is a mechanism for transferring the information from the three national technology-based investments to farmers and other users (Table 12).

Table 11 : **Nationally wide investments in climate-smart services**

National investment	Beneficiaries (and their households)	Proposed Development Outcome (PDO)
Soil fertility	87,000 agricultural workers	Increase agricultural producers' ability to practice CSA by providing producers and extension agents with location-tailored information on soil characteristics, best management practice recommendations and the tools, products, partnerships and policy environment to implement recommendations.
Agricultural financial services	980,000 agricultural workers	Sustainably increase productivity by improving agricultural producers' access to and ability to successfully leverage financial products and services, in order to Increase their ability to manage climate-related risks.
Agrometeoro-logical system	312,000 agricultural workers	Increase farm productivity and mitigate climate-related risks by providing timely, accurate agrometeorological information to producers, extension agents and agribusiness.
Agricultural extension services	235,800 agricultural workers	Improve the quality and quantity of CSA-informed recommendations that farm advisors give producers in order to increase farm productivity and minimize climate-related risks.

There are eight climate-smart crop and livestock investments that were identified in the CSAIP for Mali to support adaptation of agricultural production systems for important crops that will be affected by climate change, while also supporting the expansion and development of climate-resilient crops and livestock. This dual perspective of including both adaptation of climate-sensitive crops and expansion of resilient crops provides a way for Malian farmers to adapt to climate change. The proposed crop and livestock investments all introduce climate-smart

practices into the different investments. All of these site-specific investments are well supported by the four national-scale foundational investments. Note that although cotton is important commercially, it was not selected by Malian stakeholders, who instead emphasized food security (Table 13).

Table 12 : Crop and livestock climate-smart investments

Investment	Beneficiaries (and their households)	Proposed Development Outcome (PDO)
Cassava	90,000 producers in the Iffou, Belier, Moronou and N'Zi districts	Increase the cassava sector's capacity to practice CSA by providing producers, processors and extension agents with technical assistance and increased access to improved varieties and up-to-date research.
Abidjan Food System	66,000 peri-urban agricultural workers in Grand Ponts region	Improve economic and nutritional self-sufficiency through CSA practices in the regions supplying Abidjan.
Cocoa	88,000 rural agricultural workers in the Moronou region	Increase cocoa farm climate resilience to increase productivity and generate new income opportunities, particularly for women and youth.
Livestock	80,100 smallholders in the Hambol region	Increase the productivity and climate resilience of the livestock sector through CSA practices, infrastructure development and scientific research.
Mango	5,000+ mango producers in the Hambol region	Increase incomes in the Ivorian mango sector via (i) greater productivity through CSA practices and (ii) reduced post-production losses through value-added processing.
Maize	138,000 female agriculturalists in the Poro region	Increase farm productivity and minimize climate risks by increasing the capacity of producers, cooperatives, extension agents and researchers in CSA maize research, production, processing and marketing.
Rice	68,640 rainfed rice producers in the Cavally region	Increase rice productivity and stabilize producer revenues by scaling CSA practices applicable to the African context in order to achieve national rice self-sufficiency.
Yam	70,000 rural agricultural workers in the Gbeke region	Increase farm productivity and minimize climate risks by increasing CSA yam production and strengthening yam markets for improved economic and nutritional resilience.

Senegal

In Senegal, examples of CSA practices exist, particularly among farmers who have been exposed to government, development and NGO programs. These include use of high-quality certified seeds and short-cycle varieties, crop diversification, good agriculture practices (fire control, weeding), intercropping with cowpeas and groundnuts, agroforestry, assisted natural regeneration, use of stone bunds for water management, application of organic fertilizer, mulching and composting and use of Neem as a biological pesticide, particularly in the horticulture and arboriculture sectors. Livestock management practices include intensification and sedentarization of livestock and changing herd species for small ruminants. Pastoralism and especially nomadic transhumance is a common adaptation strategy practiced in the Sahel to cope with the climatic stresses and limited resources in the region20. Increasingly, farmers are organizing themselves into associations to pool resources and form savings groups. Farmers are also gaining access to and using climate information to make decisions such as the Senegalese National Meteorological Agency (ANACIM), farmers are now benefiting from climate information to support their day-to-day agriculture decisions.

The climate index insurance for groundnuts, maize, millet and rice has been developed to protect farmers from risks associated with drought or variable precipitation. The National Agricultural Insurance Company of Senegal (CNAAS, its French acronym) is in charge of underwriting crop

20 Diouf B; Lo HM; Dieye B; Sane O; Sarr OF (Eds.) 2014. Pour une agriculture intelligente face au changement climatique au Sénégal: Recueil de bonnes pratiques d'adaptation et d'atténuation. Document de travail No 85. Copenhagen, Denmark: Programme de Recherche du CGIAR sur le Changement Climatique, l'Agriculture et la Sécurité Alimentaire (CCAFS).

and livestock insurance and is working with a number of partners to distribute insurance products to smallholder farmers. The government currently provides a 50per cent subsidy on agriculture insurance, making it more financially accessible to smallholder farmers.

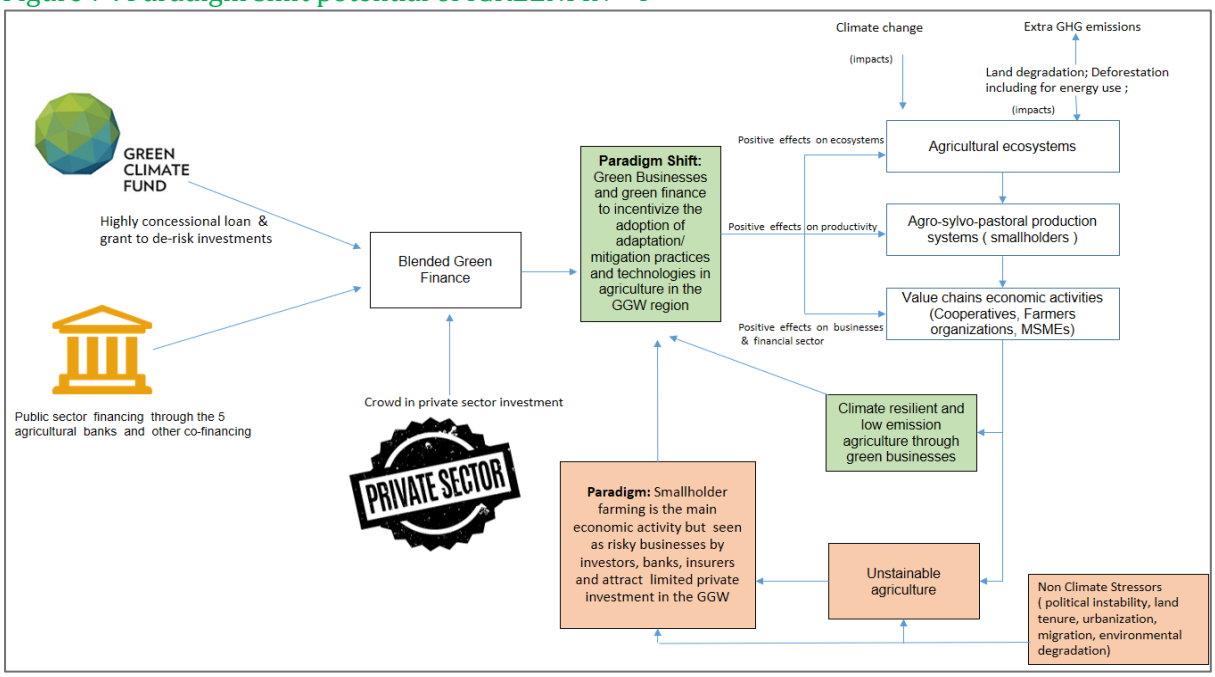
Practices in the following graphics have been selected for each production system key for food security identified in Senegal. A practice can have a negative/ positive/ zero impact on a selected CSA indicator, with 10 (+/-) indicating a 100per cent change (positive/ negative) and 0 indicating no change.

Section IV - Transformational and paradigm shift potential

1. Paradigm shift potential of the IGREENFIN I

To tackle the financial needs of smallholder agriculture, the IGREENFIN program is designed to support the strengthening of rural communities' resilience and adaptive capacity by enabling them to access concessional credit lines for green agricultural investments offered by local national agricultural banks (LNABs). IGREENFIN will foster ecosystem-based approaches for climate change adaptation and the adoption of low-carbon technologies by removing financial and technical barriers faced mainly by smallholder farmers, farmers' organizations (FO), cooperatives, micro, small and medium-sized enterprises (MSMEs), and renewable energy technologies (RET) operators, as well as those financial institutions (commercial banks and MFIs) must overcome to enable their access. It will also build the capacities of all relevant actors along agricultural value chains to foster green finance and alignment of financing flows with NDCs' targets. All interventions under the IGREENFIN regional program will complement IFAD baseline investments, which are more development-oriented, by promoting inclusive green finance for low emission and climate-resilient agriculture. This study assesses the feasibility of the IGREENFIN in the five countries of the Phase I and that of the umbrella program.

Figure 7 : Paradigm shift potential of IGREENFIN – I



2. Paradigm shift potential and theory of change of the regional support programme

Several GCF projects and programmes are already being implemented in the GGW countries and new projects are being elaborated by several entities, including GCF's National and Regional Direct Access Entities as well as International Accredited Entities. These projects contribute to achieving the objectives of the Great Green Wall through the implementation of specific activities that focus on one or more of the five pillars (value chain development, landscape restoration, climate-smart infrastructure, capacity building and institutional development). Still, in the absence of an overarching framework, these GCF projects and programmes are being implemented in isolation, resulting in missed opportunities for improved delivery of the GCF mandate. The GGW Regional Support Programme will address:

- Lack of analysis and sharing of lessons and experiences across GCF projects in GGW countries.
- Duplication of activities by AEs on due to limited awareness of AEs and project staff of similar topics or activities being implemented in similar countries activities being implemented by GCF and other projects including GEF.
- Limited evidence-based knowledge generated and tailored to specific audience to inform GCF project development.
- Increased costs for AEs, countries and the GCF due to limited exchanges of knowledge on GCF project implementation and available studies (e.g., climate analysis, gender assessments etc.)
- Limited coordination at country level to strategically plan the allocation of GCF, GEF and other resources that can contribute to achieve the GGW objectives resulting in a duplication of projects and activities. NDAs are not necessarily aware of the lessons learnt, best practices or innovation from other countries or other GCF projects, which could help them in better programming their respective Country Work Plan to the GCF, projects, iteration of their NDCs or NAPs.
- Innovative solutions, in particular digital solutions to address climate change in value chains and landscape restoration, developed by GCF projects, GEF projects and other stakeholders are not widely available and spread across the GCF project portfolio.
- While innovation and digital solutions are increasingly recognized as a strategic path to address climate change impacts, the ecosystem to support innovation and digital solutions developers is in its very early stage of development with missed opportunities for replication and scaling up.

To address the challenges mentioned above, the Regional Support Programme will improve access to best practices, encourage learning and fostering innovation, digital transformation across Great Green Wall countries to increase the collective impact of individual GCF projects. The Regional Support Programme added contribution is that its entire structure and all its actions are geared towards building the knowledge and systems necessary to identify transformational pathways for the GGW area. The Regional Support Programme will not replace the knowledge management and innovation activities of each GCF project nor take over the responsibilities of the corresponding AEs. It aims at creating bridges through a structured framework to ensure that project specific information, knowledge and learning is properly captured and disseminated across GCF projects, AEs but also GEF projects and other entities contributing to tackling climate change in the Great Green Wall. The GGW UP will be uniquely placed as a facilitator between individual GCF projects to promote the scale up existing innovation through GCF projects in the GGW and to increase uptake of innovations and digital solutions developed by other stakeholders in current and future GCF projects. The GGW UP will promote and amplify action on the ground to bring action to scale and generating spillover effects that positively affecting other GGW initiatives and undertakings.

Section V - Financial context

1. Overview of Financial sources and mechanisms for climate resilient and low emission agriculture

1. **In identifying the practices of relevant actors focused on financing climate change adaptation in West Africa, the study identified and mapped relevant players that are currently offering specialized products and services to smallholders in agriculture in the five West African and GGW countries within the IGREENFIN 1 framework.** These include governments, regional/multilateral development banks, local development public banks (LDPBs), especially agricultural banks or any national financial institutions specializing in agriculture, private sector and microfinance institutions. Furthermore, information for each country is included in order to provide some context on the local financial sector.

2. **A significant limitation of this mapping is that it is skewed towards relevant actors with a strong Web presence and publication requirements, which are typically larger actors.** Other smaller institutions could be more active in financing smallholder in agriculture. Going forward, IFAD intends to carry out a detailed survey of relevant financial institutions to gather more insights and map their current involvement with smallholder in climate resilient and low emission agriculture across West Africa. Such a questionnaire-based mapping should last about six months given typical lags in response time.

3. According to our mapping results, the **private sector (local commercial banks, branches of foreign banks, insurance companies etc.)** offer tailored financial products to smallholder in agriculture. Private commercial banks provide about 70 % and 58 % of funding to formal micro and SMEs, respectively[21]. According to the Climate Policy Initiative (CPI-2020), private sector financing by corporates and commercial financial institutions amounted to USD539 million per year were mostly directed to finance climate resilient infrastructure projects, such as solar photovoltaic or wind farm projects. While there is no shortage of commercial banks in the five target countries in IGREENFIN 1 (14 in Burkina Faso; 15 in Côte d'Ivoire; 23, Ghana; 14, Mali 14, and 19 in Senegal), they offer little, if any, financing to smallholder farmers and their organizations. The bulk of the limited private financing for agriculture from commercial banks is for larger farming operations and agro-industrial businesses, and often mainly for the most organized, export-oriented value chains, such as cotton and cacao, among others.

4. **Microfinance institutions (MFI)** also play an important role in offering financial services in the region and often liberate low-income households such as smallholder farms, FOs, MSMEs and cooperatives from moneylenders with outrageous interest rates that often reach 100per cent annually. While there are some bigger, more organized MFIs, the large majority of them do not have the necessary resources to offer long-term loans to farmer, the amounts granted are often much lower than what farmers need, their branches are concentrated in urban areas and their interests are high, among other issues. That said, with capacity-building and organizational support, their real contribution to the development of the agricultural sector could be much greater.

5. **Regional development banks** play an important role in agriculture finance in West Africa, especially Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal by filling financial gaps though funds for specific programmes in the public sector, directly with local companies or through local banks acting as intermediates because of their better access to the domestic market. For

[21] Stein, Peer; Ardic, Oya Pinar; Hommes, Martin. 2013. Closing the Credit Gap for Formal and Informal Micro, Small, and Medium Enterprises. International Finance Corporation, Washington, DC. © International Finance Corporation. https://openknowledge.worldbank.org/handle/10986/21728 License: CC BY-NC-ND 3.0 IGO.

example, the West African Development Bank (BOAD) is the common development finance institution of the member countries of the West African Monetary Union (WAMU or UEMOA) which are Burkina Faso, Côte d'Ivoire, Mali and Senegal. Its Strategic Plan 2021-2025, or "Plan Djoliba", aims to allocate 25 per cent of annual funding to climate projects by 2025 and explicitly identifies investments in renewable energies and climate smart agriculture, including for family farms, as key intervention areas. **In terms of multilateral development banks (MDB),** according to the tenth edition of the Joint Report on MDB's Climate Finance[22], MDBs committed US$ 8,975 million to Sub-Saharan Africa in climate finance (mitigation and adaptation) in 2020 or 23.6% of total MDB commitments for low-income and middle-income economies. The net total climate co-finance [23] committed during 2020 alongside MDB resources was US$ 43,489 million to low-income and middle-income economies (US$ 18,795 million for adaptation and US$ 24,694 for mitigation). Together, MDB climate finance and climate co-finance totaled US$ 68.17 million. Table 9 presents the five west African countries covered by at least one MDBs for climate finance, in accordance with the World Bank's classification list dated June 2020.

Table 9: Climate finance by selected country (in US$ million)

		Total climate finance in reporting year (US$ million)		
Country	**Income level of borrowing /recipient country**	**2016**	**2018**	**2020**
Burkina Faso	Low-income	7	130	134
Cote d'Ivoire	Lower-middle income	73	346	453
Ghana	Lower-middle income	72	63	89
Mali	Low-income	9	104	102
Senegal	Lower-middle income	16	272	265

Source: 2020 Joint Report on Multilateral Development Banks' Climate Finance

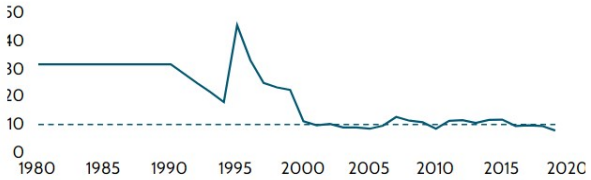
6. **Governments** are also important sources of financing for climate resilient, low emission agriculture for farmers, FOs, MSMEs and cooperatives in West Africa. African governments have made food security a priority through the Comprehensive Africa Agriculture Development Programme (CAADP), which recognizes the role of smallholder agriculture in reducing poverty and hunger. In the context of CAADP, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal have committed to allocating at least 10 per cent of the national budget to the agricultural sector, with the aim of achieving at least six per cent agricultural growth annually. However, Figures 5 shows that the annual share of total public expenditure allocated to agriculture ranged from 2.85 per cent to 15.14 per cent in 2000-2020 in Burkina Faso, Côte d'Ivoire, Mali, Ghana and Senegal. This figure also reveals a downward trend in these countries' spending on agriculture since 2015, especially in Burkina Faso, which went from an average of 20 per cent in 1991–1999 to 9.94per cent in 2014-2019. This decrease could be explained by the countries' orientation towards other sectors such as secondary or tertiary, which may be perceived as much more promising.

Figures 5: Government agriculture expenditure (% of total expenditure) per selected country

[22] The MDBs are the African Development Bank (AfDB), the Asian Development Bank (ADB), the Asian Infrastructure Investment Bank (AIIB), the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB), the Inter-American Development Bank Group (IDBG), the Islamic Development Bank (IsDB) and the World Bank Group (WBG). 2020's report summarises information on climate finance tracking from the New Development Bank. Sources of MDB climate finance are split between the MDBs' own accounts and the external resources channelled through and managed by the MDBs.

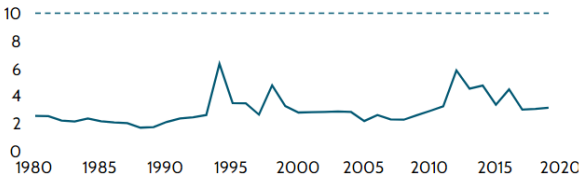
[23] External resources include trust-funded operations, such as those funded by bilateral agencies and dedicated climate finance funds such as the Climate Investment Funds (CIF), Green Climate Fund (GCF) and climate-related funds under the Global Environment Facility (GEF), EU blending facilities and others.

(a) Burkina Faso



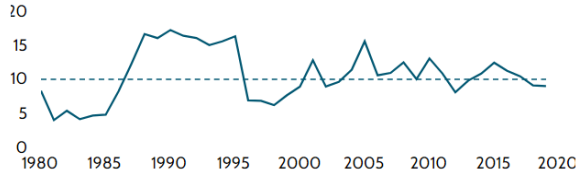
9.94
2014-2019

(b) Cote d'Ivoire



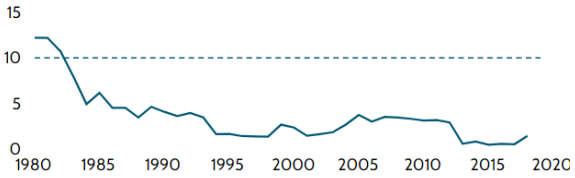
3.68
2014-2019

(c) Mali



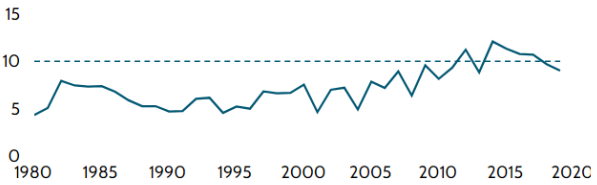
10.51
2014-2019

(d) Ghana



0.77
2013-2018

(e) Senegal



10.59
2014-2019

Source: ReSAKSS [24]

7. Another important government source of finance are state owned banks or other government agencies such **local development public banks (LDPBs), especially agricultural banks** or any **national financial institutions specializing in agriculture**, whose regulations are usually defined by central banks (i.e., the Central Bank of West African States (BCEAO), which share the common West African CFA franc currency and comprise the UEMOA and the central

[24] ReSAKSS

Bank of Ghana (BoG), formed in 1957 in developing financial inclusion policy and is a member of the Alliance for Financial Inclusion). For SMEs, these provide around 30 % of the funds, while for micro enterprises, the figure is around 21 %[25]. For example, the Banque Agricole du Faso, Banque Nationale d'Investissement of Côte d'Ivoire, the ARB Apex Bank Limited of Ghana, Banque Nationale de Développement Agricole of Mali and the Banque Agricole of Senegal are state-owned banks acting as major financers in their countries. A more detailed overview of the five agricultural banks is available in the IGREENFIN 1's Annex on the banks' pipeline.

2. Types of products and services available

The types of products and services offered by the financial institutions (FIs) analyzed in this market scoping can be categorized into financial in the form of premium loans and deposit accounts and non-financial in the form of training and empowerment workshops. Financial literacy programmes for smallholders, premium savings accounts and discounted rate loans appear to be among the most popular services and products offered by FIs. Following is a list of main financial and non-financial services/products identified during our investigations:

- Smallholder empowerment initiatives:
  - Providing business information, networking opportunities, business workshops.
  - Partnership in investment.
  - Financial literacy programmes.
  - Mentoring programmes.
- Loans for smallholder in agriculture with interest rates between 10% (interest rates for all UEMOA agricultural banks) and around 20 for commercial banks and MFIs, which is much higher than international standards, etc.
- Short-term and long-term lines of credit with high interest rates, low tenors and short grace periods.
- Premium savings accounts, usually with minimum charges and slightly higher interest rates.
- Partnerships with organizations to provide loans and credits to underserved or unserved smallholders.
- Various kinds of SME loans.
- Investment in electronic banking to increase financial inclusion in general.
- Open specialized branches for smallholders.

The types of products and services offered by governments focus on subsidies and support on the more organized export-oriented value chains, leaving other high potential value chains underfunded and poorly organized. In Mali, for example, "the 'high-priority/low-value' cotton sector is overshadowing 'high-priority/high value' sectors, such as livestock, fish, rice, mango and sesame, among others, which deters banks from investing is sectors other than cotton"[26]. Governments in the region generally offer support for farmers in the form of payment of indemnities, reductions in social security contributions and exemption of taxes during periods of crisis in the sector or subsidizing private insurance schemes or purchases of inputs. They can also create credit guarantee funds or support credit guarantee schemes offered by private institutions through counter guarantees. For instance, the Nigerian Agricultural Credit Guarantee Scheme Fund is among the longest-standing agricultural guarantee funds in the world.

[25] "Stein, Peer; Ardic, Oya Pinar; Hommes, Martin. 2013. Closing the Credit Gap for Formal and Informal Micro, Small, and Medium Enterprises. International Finance Corporation, Washington, DC. © International Finance Corporation. https://openknowledge.worldbank.org/handle/10986/21728 License: CC BY-NC-ND 3.0 IGO."
[26] WB, 2015

The type of products/instrument offered by development banks and donors for low-income and middle-income economies are described below along with their 2020 estimates (Table10)[27]. Other instruments include advisory services and bonds. Some MDBs report eligible bonds under the category of investment loans.

Table 10: Estimates for low-income and middle-income economies offered by development banks and donors

Products/instrument	Amount in USD million*
Equity	478
Grant	3,300
Guarantee	1,561
Line of credit	455
Investment loan	26,345
Policy-based financing	4,395
Results-based financing	983
Other instruments	491

3. Major financial constraints for agriculture sector development and resilience

Access to credit is crucial to building resilience and improving productivity, but it remains a key constraint for smallholder farmers, farmers' organizations, cooperatives and MSMEs in the targeted countries, particularly in COVID-19 recovery efforts and for rural women and youth who rarely benefit from financial services. Despite its crucial role, financial markets (both insurance and credit markets) in the Sahel region are often underdeveloped, with over 80% of the population being financially excluded. The inherent risks in smallholder farming discourage the private sector, especially the banking sector, from investing in agriculture. Most banks including LNABs in the target area still face numerous internal obstacles including:

a. the perception of small-scale agriculture as too risky, fostering reluctance to lend farmers money and the practice of charging them higher interest rates.
b. a lack of awareness on the potential benefits of investing in climate adaptation and mitigation.
c. an overestimation of risks due to a lack of technical knowledge, and
d. a lack of access to appropriate capital for on-lending.

Other limiting factors are:

e. high transaction costs when dealing with frequent small loans, and unclear and unfavorable land tenure and property rights.
f. the broader business and legal environment that may differentially affect women and men in businesses.
g. personal characteristics of the entrepreneurs (such as differences in educational attainment and skills).
h. characteristics of the firm (size, area of specialization, location, formal/informal sector, with the majority of smallholders operating informally), and
i. constraints within financial institutions, primarily the lack of familiarity with rural entrepreneurs and biased views.

These constraints limit the ability of the selected countries to leverage more private resources to implement the objectives of the GGW. In a post COVID-19 context, contributing to the elimination

[27] 2020 Joint Report on Multilateral Development Banks' Climate Finance

of these technical and financial barriers would allow these institutions to finance transformational change towards climate compatible investments at a time when local financial institutions, FOs, cooperatives, MSMEs and governments are recovering from the impacts of the pandemic.

Section VI: Credits and other financial services offerings

Literature review and consultations with the five country agricultural banks within the IGREENFIN 1 framework, indicate that to date, local banks in general are risk adverse and have had a generally limited appetite for agricultural credits given the availability of alternative investments, especially government securities, except where they have well-established banking relationships with participants within the sector. In addition, an analysis of the supply of finance in the GWW countries illustrates that credit from both microfinance institutions and the banking sector to the whole agricultural sector currently accounts for roughly two per cent of total credit offered by regulated financial systems[28]. The 2017 International Finance Corporation (IFC) research on the MSME finance gap estimated that there was, on average, 21 per cent of microenterprises in developing countries that were fully credit constrained, 19 per cent were partially credit constrained and 60 per cent were credit unconstrained. Sub-Saharan Africa had the second largest proportion of financially constrained microenterprises – both fully and partially constrained (52 percent)[29].

Further analysis from the IFC (2017) study showed that countries in the low-income group such as Burkina Faso, Mali and Senegal had the largest proportion of fully or partially-constrained MSMEs – 67 per cent (3 million MSMEs) – in comparison to countries in the high-income group that had the highest proportion of unconstrained MSMEs: 81 per cent (4.2 million MSMEs), with only 19 per cent of financially constrained enterprises (1 million). [30] Similarly, in countries in the lower-middle-income group such as Côte d'Ivoire and Ghana, 15 per cent (8.9 million) of MSMEs were fully constrained, 33 per cent (19.5 million) were partially constrained and 52 per cent (30.2 million), unconstrained (table 15). These figures indicate that greater market opportunities exist for financial institutions in the low and lower-middle-income countries. However, financial products are often only available to large-scale farming operations with soundtrack records and therefore do not meet the specific needs of FOs, MSMEs and cooperatives in these five countries.

Table 13 : Distribution of MSMEs by Financial Constraint Level (per cent)

Country Income Group	Fully Constrained	Partly Constrained	Unconstrained
Low income	42	25	33
Lower-middle income	15	33	52
Upper-middle income	26	9	65
High income	7	13	81
Total	22	18	60

Source: IFC data and analysis, 2017

To unlock such potential, there is a need to carefully detail the barriers that may hold back CSA including mitigation development in West Africa and the area of the GGW. High risks associated with subsistence agriculture in rural areas have left the agricultural sector with limited investment and capacity for job creation for youth and women in the region. When credit is available, the interest rate is more than 10 per cent and the loan repayment periods are short and thus, unaffordable for smallholder farmers. This challenge has been further aggravated by the

28 Terfa Abraham, 2019
29 IFC,2017
30 MSME Report.pdf (smefinanceforum.org). See the IFC proposed methodology for details. Also, the lack of data in the study imposed the need to make stronger assumptions than would be necessary if data availability was not an issue. As access to financing for MSMEs continues to be an issue of critical importance, there is an ongoing need to improve data collection efforts for MSME financing in developing countries such as Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal.

predicted economic recession caused by the COVID-19 outbreak. The agriculture finance markets are constrained by a variety of factors which include: (i) inadequate or ineffective policies; (ii) high transaction costs to reach remote rural populations; (iii) covariance of production, market and price risks; (iv) absence of adequate instruments to manage risks; (v) low levels of demand due to fragmentation and incipient development of value chains, and (vi) lack of expertise of financial institutions in managing agricultural loan portfolios.

In addition, local currency finance providers in countries that are not part of the UEMOA zone in West Africa have very limited appetite for investing in climate resilient, low emission agriculture such as in Ghana, other than through traditional on-balance sheet corporate lending to established players, due to a lack of understanding of the market, including the role of receivables as collateral and other new emerging (leasing) business models.

The agricultural sector across the GGW countries continues to be marked by low productivity due to structural issues such as low soil fertility, lack of technology and capacity, failure to adopt land reform and high vulnerability to agricultural and climate related risks as described in table 1631. These risks include: (i) high dependence on rainwater, which is the sole water source for a large majority of smallholder farmers and is limited to a short wet season in the targeted countries; (ii) high inter-annual climate variability that drives large year-to-year changes in rainfall and temperature; (iii) recurrence of natural disasters and extreme weather events, including floods and droughts, locust outbreaks, livestock and crop diseases and pests, which all reduce productivity levels; (iv) fluctuations in the agricultural market for both inputs and outputs; and (v) limited disaster management policies in support of agriculture.

Combined, these risks result in lower yields, loss of productive assets, income and productivity, increased costs and changes in taxes and market access32. These affect smallholder farmers, FOs, MSMEs and cooperatives' already weak ability to build up their assets and provide collateral for loans. Smallholder farmers in the region, particularly women, often lack the title to their land or the value of the land may be too low, or in the case of Mali, the land title market is non-existent. Financial and climate shocks, combined with the lack of access to external financing over time restricts the ability of FO, MSMEs and cooperatives to expand, diversify and modernize their agriculture activities and therefore increase their climate resilience and business opportunities.

The risk factors inherent in agriculture mentioned above are also factors that discourage public and private banks from offering credit for small-scale climate-resilient agriculture, including for the adoption of solar energy systems to power agriculture chains in the targeted countries in IGREENFIN 1.

31 Zougmoré et al., 2016
32 IFAD, 2018

Table 14 : Summary of Key risks faced by smallholder farmers, FO, MSMEs and Cooperatives in West Africa

Type of risk	Factors	Effects
Production	Climatic phenomena (e.g., droughts, floods and cyclones), pests and epidemics and damage from animals, storms or fires	Lower yields, but can also affect yield quality
Infrastructure and technologies	Lack of cost-competitive and suitable technologies for agricultural activities for smallholders, poor availability and innovation on sector-specific financial instruments and services	Lower yields, loss of productive assets or income
Climate	Rainfall and temperature variability, drought, floods, extreme weather events	Lower yields, loss of productive assets or income
Biological	Pest, disease, infestation	Lower yields, loss of income
Market-related	Low prices, market volatility, variation of supply and demand caused by changes in local and global supply and demand.	Lower yields, producers are concerned about falling prices (which reduces their income), consumers are worried about rising prices (which increases their spending)
Financial	Subsidies from government is not financially sustainable, low capacity of rural populations to pay for agricultural inputs, especially after climatic shocks	Lower yields, loss of income
Foreign exchange rate	The currency of Burkina Faso, Côte d'Ivoire, Mali and Senegal, the West African CFA franc (XOF), is pegged to the euro at a fixed rate. Most of the trade is with Europe and other countries with XOF as their currency, which eliminates much of the risk. Ghana currency (cedis): significant volatility and risks of both lending and borrowing in the sector	Low access to credit lines, loss of productive assets or income
Labour/health (especially in the context of COVID-19)	Illness, death, injury especially youth, women and elders	Loss of productivity, increased costs
Policy and political	Regulatory changes, political instability, disruption of markets	Change in costs, taxes and market access

Source: Adapted from IFAD PARM risks management

The COVID-19 pandemic is having devastating impacts on the lives of West African farmers, as it aggravates the risks identified above and adds new ones to the list. When the pandemic hit, Burkina Faso, Côte d'Ivoire, Mali and Senegal were classified as "high-risk" countries on the

INFORM COVID-19 Risk Index[33]; Ghana fared slightly better, classifying in the "medium risk" category. In Côte d'Ivoire, for instance, data shows that the incomes of the poorest decreased by 30 percent. Consequently, the number of households considered "extremely poor" has increased nearly four-fold[34]. In the agricultural sector, the COVID-19 crisis impacted small producers across the majority of agricultural value chains and led to a significant reduction of activities in the agro-industrial sector[35]. This is because: (i) containment measures are inducing disruptions of input supply chains and the availability of services and marketing channels; (ii) social distancing is impacting field work; (iii) border closures are impacting opportunities for trade in agricultural products with neighbouring countries and reducing the movement of agricultural labour, and (iv) curfews and closures of restaurants are constraining the sale of food products. The COVID-19 pandemic is also adversely affecting MSMEs involved in input and output supply, making it difficult to sustain the linkages between them and smallholder farmers and increasing pressure on agribusinesses.

Faced with a decrease in incomes, vulnerable farmers are engaging in harmful coping strategies – such as the selling of productive assets or reducing investment in human capital, especially for girls [36] – with potential long-term consequences for the prospects and resilience of their households. The AGRA food security monitor[37] observed that the food security situation has deteriorated in the region: very high levels of hunger were found in Burkina Faso and Mali, among other countries, as more than 50per cent of the population did not have sufficient food for consumption during the month. In a study conducted in June-July 2020 in Côte d'Ivoire, over 70 per cent of respondents that they had depleted savings in order to continue buying food, 61 per cent reported that drops in income had prevented them from buying their usual amount of food, and over 40 per cent reported lowering their portion sizes or reducing the number of meals they eat[38]. Similar situations can undoubtedly be found in other parts of West Africa. Therefore, not only is the pandemic having devastating impacts on farmers' lives and health, but it is also forcing them to deplete their asset base, which will increase the risk of default and make it even more difficult for them to obtain loans.

Demand for financing climate resilient and low emission agriculture

Currently, there is no regional sizing of the demand and supply for lending to climate finance needed for small-scale climate resilient and low emission agriculture. Nevertheless, a joint report by Dalberg and KfW estimated that there is an annual USD 100 billion agricultural small- and medium-sized enterprises (SMEs) lending gap in sub-Saharan Africa alone[39]. This gap cuts across all sizes of agricultural enterprises, but is especially prevalent for micro-SMEs, as well as mezzanine and equity investments to SMEs.

33 Inter-Agency Standing Committee Reference Group on Risk, Early Warning and Preparedness and the European Commission, INFORM COVID Risk Index, April 2020

34 https://www.undp.org/content/undp/en/home/news-centre/news/2020/Cote_dIvoire_pandemic_prompts_surge_in_extreme_poverty.html

35 Agence CI PME, ONU Femmes. Évaluation de l'impact de la COVID-19 sur les activités de PME Ivoiriennes. Avril 2020

36 Ministère du Plan et du Développement and UNDP. Mesure de l'impact socio-économique du COVID-19 sur les conditions de vie des ménages en Côte d'Ivoire, May 2020

37 Africa Food Trade and Resilience Initiative. Food Security Monitor, Edition#8, October 2020

38 Innovations for Poverty Action in partnership with the Côte d'Ivoire Ministry of Employment, Côte d'Ivoire Ministry of Education: RECOVR Côte D'Ivoire: Tracking the Effects of the COVID-19 Pandemic, June-July 2020

39 Dalberg collected quantitative data on each participating lender's agriculture lending portfolio from 2010-2019 in up to three areas: – Loan-level time series data: schedule of loan disbursements and repayments, including fees, interest, and credit losses (write-offs) – Portfolio breakdown of loan characteristics: borrower and loan details such as country, value chain, product type, tenor, etc. – Operating cost data: annual cost data by region and business unit where possible, including compensation, legal and professional fees, back-office resources, and other overheads. Quantitative data was complemented with surveys and structured interviews with 31 lenders, seeking to understand main hurdles faced by lenders in the agri-SME lending segment. Source: Dalberg and KfW, Africa Agricultural Finance Market Landscape, 2018.

Additionally, a study by Shakhovskoy et al, 2019 estimated the sizing numbers of the demand in agricultural and non-agricultural finance to be around 61 million of farmers in sub-Saharan Africa and 9 million pastoralists[40]. Overall, the study estimated that financial needs of smallholder producers in sub-Saharan Africa countries are estimated at about USD 240 billion annually, including USD 55 billion for sub-Saharan Africa[41]. This gives an indication of the magnitude of the climate investments required in small-scale climate resilient, low emission agriculture. Despite the scale of these needs, the cumulative climate finance for agriculture, forestry and land use cumulatively received an average of USD 20 billion per year in 2017 and 2018, which is equivalent to 3 per cent of the total global climate finance for the period[42]. While full comparison with other sectors is difficult due to data gaps specific to agriculture, the study showed that climate finance for energy efficiency and renewable energy generation averaged USD 370 billion per year for the same period (equivalent to 64 per cent of the total), while low-GHG transport received an average of USD 140 billion (or 24 per cent of the total climate finance tracked)[43]. In contrast, agriculture, forestry and other land use at the global scale are responsible for nearly a quarter of greenhouse gas emissions, which further confirms that climate finance targeting these sectors is underserving the needs[44].

According to the Climate Policy Initiative (CPI-2020), supported by IFAD, out of the total tracked climate finance of USD 20 billion for agriculture, forestry, and land use, only USD 8.1 billion targets small-scale farmers, agri-entrepreneurs and value chain actors serving them. This is equivalent to approximately 40 per cent of the total climate funds committed to the agriculture, forestry, and land use sectors. An additional USD 1.72 billion of climate finance benefits small-scale agriculture actors through renewable energy generation, sustainable transport in rural areas and water management (Figure B.1). The total climate finance targeting small-scale agriculture is therefore close to USD 10 billion. It represents 1.7per cent of the total climate finance tracked and it covers only a small fraction of the general needs of small-scale agriculture actors.

The majority of commitments in climate finance in small-scale agriculture in this CPI (2020) analysis were provided by the public sector (95per cent), including governmental donors, multilateral development finance institutions and bilateral development financial institutions each contributing 39per cent, 32per cent and 16per cent respectively[45]. While the remaining amounts were tracked from the private sector, it should be noted that the majority of private sector climate finance is untracked due to data limitations. Out of the total climate finance tracked, a total of USD10 billion was channeled to bring benefits to small-scale agriculture actors such as FOs, MSMEs and cooperatives, which is the equivalent of only 1.7 per cent of the total climate finance tracked (Figure 17)[46]. Grants are the predominant financial instrument used for 50per cent of finance committed, followed by concessional debt (33per cent), and non-concessional debt (16per cent). Such a prevalence of grants is to be expected as financial access in the agricultural sector in developing countries is still limited compared to other sectors. Further,

40 Please see Appendix 1 for a full explanation of sizing methodology and assumptions relevant to this section. Source: Shakhovskoy et al, 2019. "Pathways to Prosperity. Rural and Agricultural Finance State of the Sector Report." ISF, Mastercard Foundation, Rural & Agricultural Finance Learning Lab. https://pathways.raflearning.org/

41Shakhovskoy et al, 2019. "Pathways to Prosperity. Rural and Agricultural Finance State of the Sector Report." ISF, Mastercard Foundation, Rural & Agricultural Finance Learning Lab. https://pathways.raflearning.org/

42 Data collection primarily focused on deep dive of climate finance under agriculture, land use and forestry sector. For more information, read the ANNEX IV DATA COLLECTION METHODOLOGY AND GEOGRAPHICAL SPLIT, available at https://www.climatepolicyinitiative.org/publication/climate-finance-small-scale-agriculture/.

43 Chiriac et al., 2020. Examining the Climate Finance Gap in Small Scale Agriculture. CPI.
Available at Examining-the-Climate-Finance-Gap-in-Small-Scale-Agriculture.pdf (climatepolicyinitiative.org)

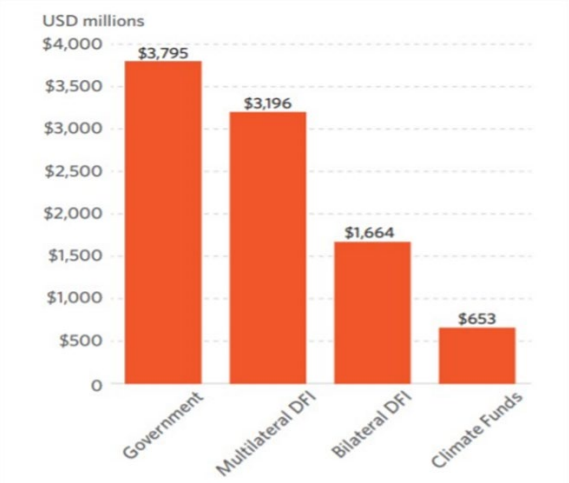
44 IPCC, 2014

45 Chiriac et al., 2020. Examining the Climate Finance Gap in Small Scale Agriculture. CPI.

46 Chiriac et al., 2020. Examining the Climate Finance Gap in Small Scale Agriculture. CPI.
Available at Examining-the-Climate-Finance-Gap-in-Small-Scale-Agriculture.pdf (climatepolicyinitiative.org)

small-scale producers encounter major barriers to access loans due to lack of collaterals and limited land tenure rights.

Table 15 *: Annual commitment by public sector, in USD million*



Source: CPI analysis, 2020

The CPI (2020) analysis also estimated that nearly half (49per cent) of the tracked small-scale agriculture climate finance was for climate adaptation projects, while projects tackling both mitigation and adaptation objectives received 29per cent of the total. Mitigation only projects were targeted by 21per cent of the finance47. The high percentage directed towards adaptation is aligned with the increased vulnerability of small-scale agricultural actors to climate change. In comparison, 93per cent of the total climate finance is targeting mitigation activities, with renewable energy generation being the leading sector (at 63% of mitigation finance) 48 . Increased temperatures, rainfall variability, and extreme weather events have direct effects on agricultural productivity, incomes, and food security in rural communities49.

Low GHG emission and climate resilient infrastructure received the largest share of funds (36per cent), followed by investments to improve agricultural production at farm level (14per cent), and improvement of livelihoods of rural communities in general (also 14per cent)50. The lack of and poor state of transport infrastructure is indeed a major barrier for finance to agriculture, thus justifying a large share of investments. Technical assistance to governments and capacity building for target groups received similar shares, around 10per cent of the total each. These types of activities have the potential to tackle many of the technical and political barriers identified, therefore funding towards them needs to be raised in order to achieve transformational impacts.

Private sector financing by corporates and commercial financial institutions amounted to USD539 million per year were mostly directed to finance climate resilient infrastructure projects, such as solar photovoltaic or wind farm projects. Some commercial finance institutions also provided microcredit for rural population and smallholder farmers to adopt climate smart agricultural practices such as Ghana's concessionary-rate loans under its "One District, One Factory" initiative. Indeed, One District One Factory Program is addressing the challenge of slow

47 Chiriac et al., 2020. Examining the Climate Finance Gap in Small Scale Agriculture. CPI.
. Available at Examining-the-Climate-Finance-Gap-in-Small-Scale-Agriculture.pdf (climatepolicyinitiative.org)
48 Buchner et al, 2019
49 Referring to section E and F on climate change and its impact.
50 Chiriac et al., 2020. Examining the Climate Finance Gap in Small Scale Agriculture. CPI.
. Available at Examining-the-Climate-Finance-Gap-in-Small-Scale-Agriculture.pdf (climatepolicyinitiative.org)

economic growth at the district level through a massive nationwide industrialization drive, which is equipping and empowering communities to utilize their local resources in manufacturing products that are in high demand both locally and internationally. This is to allow the country to reap the well-known rewards of industrialization, such as gains in efficiency in every facet of life in our society, increase the agricultural and manufacturing output, a reduction in the reliance on imports and increase in the production of consumer goods and food availability. The program is expected to facilitate the creation of between 7,000 to 15,000 jobs per district and between 1.5 million and 3.2 million jobs nationwide by end of 2021. Currently 45 factories are currently operating under this initiative and 136 are in various phases of constructions.

The CPI (2020) analysis also added that 41per cent of funds were targeting rural communities in general. This seems to be aligned with the fact that many projects might adopt a holistic approach to rural development whereby they target general wellbeing of rural communities. Finance benefitting individual small-scale producers and cooperatives constitute 31per cent of the total for small-scale agriculture. It indicates the strong focus of climate finance on agricultural production at farm level, which should address the knowledge barriers limiting the adoption by farmers of climate-smart agricultural practices. Only 10per cent of the funds were found to target value chain actors and formal financial institutions. As many of the barriers identified are of commercial nature, climate finance is insufficiently benefitting businesses and financial institutions which are essential for small-scale producers to improve yields and to access markets and finance[51].

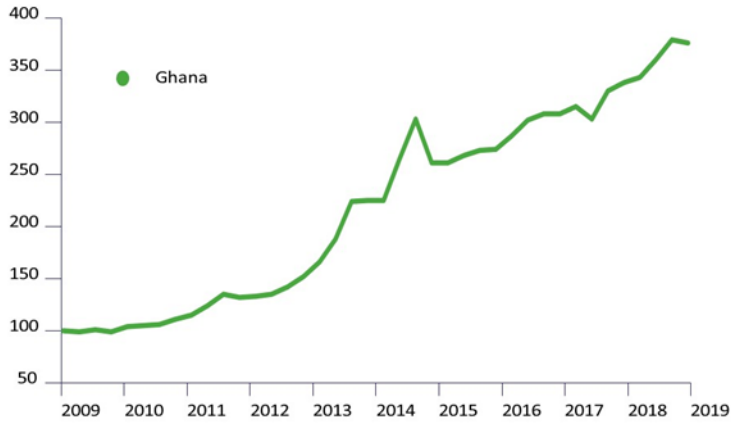
Despite significant progress in the rural agricultural finance sector (see the next section on existing financial institutions for access to credit by country), financial service providers are still unable to meet 73 per cent of the short-term agriculture-related needs of smallholder farmers in sub-Saharan Africa– a percentage that rises to 99 per cent for long-term needs; the funding gap is estimated at USD 17 billion and USD 19 billion for short and long-term needs, respectively[52]. To go beyond production for subsistence and truly become resilient to climate change, farmers urgently require access to resources that they can invest in raising their productivity levels and thus, profitability. There is a need for new models for understanding the rural agricultural finance market that lays out the different transition pathways rural households may take as they pursue increased resilience and agency through various livelihoods strategies. The ISF Advisors and the Mastercard Foundation Rural and Agricultural Finance Learning Lab (2019) suggested that these pathways coalesce around four centers of gravity: 1) farming as a business; 2) rural services; 3) rural labor; and 4) urban migration[53]. By mapping out the likely transition points for rural households, financial service providers will be able to create a strategy for engagement that delivers the right services at the right time.

There is also a demand for local currency finance in non-UEMOA countries such as Ghana**.** Local currency financing enhances the ability to manage currency exposures and better match project cash flows of sovereign and subnational entities in West Africa. Subject to market availability, FOs, MSMES and cooperatives may access local currency financing at loan approval or through conversion of disbursements or outstanding loan balances of dollar denominated loans. Figure C.3 illustrates how the exchange rates of the Ghanaian currency has moved against the US dollar since 2010, which shows that the Ghanaian Cedi has experienced a significant loss in value, particularly in 2010 when it lost 73 per cent. There is a need for credit lines that help financial service providers supporting climate resilient, low emission agriculture to raise local currency financing from local/regional banks and manage portfolio risk of grants and loans in the Ghanaian

51 Chiriac et al., 2020. Examining the Climate Finance Gap in Small Scale Agriculture. CPI.
Available at Examining-the-Climate-Finance-Gap-in-Small-Scale-Agriculture.pdf (climatepolicyinitiative.org)
52 Shakhovskoy et al. (2019)
53 ISF Advisors and the Mastercard Foundation Rural and Agricultural Finance Learning Lab. 2019. "Pathways to Prosperity: Rural and Agricultural Finance State of the Sector Report." Washington, D.C.

Cedi. FX rate risks do not apply to the euro-pegged CFA franc of the rest of the targeted countries (Burkina Faso, Côte d'Ivoire, Mali and Senegal), whose currency is seen as an anchor of financial stability within the West African Economic and Monetary Union (known by its French acronym, UEMOA)[54].

Figure 8: Exchange rate movements of selected Ghanaian currency against the US dollar (December 2009=100)



Source: Bloomberg, CEPA analysis.

1. National financial sector and current financing for climate resilient and low emission agriculture

Burkina Faso.

The financial sector in Burkina Faso is dominated by the private sector and is relatively well-capitalized with sufficient liquidity in line with the BCEAO norms55. The banking sector consists of 14 banks, of which the three largest ones – Coris Bank, EcoBank and Bank of Africa – are pan-African and together, hold 55 per cent of total assets. Other banks include privately-owned domestic banks and two small state-owned banks. The banks are adequately capitalized: the average capital adequacy ratio (CAR) is 13.75 per cent vis-à-vis the BCEAO norm of eight per cent, and the liquidity ratio was 88 percent, higher than BCEAO's norm of 75 percent. The microfinance sector consists of 133 MFIs, with 130 of these being cooperatives.

The microfinance sector is highly concentrated, with one MFI – Réseau des Caisses Populaires du Burkina, or RCPB – representing more than 73 per cent of the clients and 70 per cent of the deposits. While large MFIs appear to be in good health, a majority of medium and small MFIs are struggling to operate, with some having negative equity and/or negative returns. The digital financial services (DFS) sector is still in its infancy, although it is growing rapidly.
Around 39 per cent of Burkinabe individuals are unable to access financial services. According to the most recent data, just approximately 15 per cent of these individuals have a bank account, and a considerably lower percentage of those who do have a bank account actually use it for standard banking transactions like saving or borrowing. In the 2016 Finscope report, which assesses the level of financial inclusion in sub-Saharan African countries, Burkina Faso is ranked 13th out of 21 countries.

54 https://www.imf.org/external/pubs/ft/fabric/backgrnd.htm
55 IFC,2019

The existence of structural impediments such as low incomes, service costs, distance from the source of service and onerous documentation requirements help explain these low rates. Furthermore, access to finance is becoming increasingly differentiated depending on education and salaries, as well as the fact that women are less likely than men to have a bank account. Because official bank credit is scarce, informal arrangements such as borrowing from family and friends continue to be common. Only informal procedures are used by 21 per cent of respondents polled in the Finscope. Similarly, despite the enormous number of mobile phone customers (estimated at over 12 million in 2015), mobile banking usage is still quite low.

Furthermore, financial literacy is also low, and Finscope (2017) shows that over 75 per cent of the population do not ask for financial advice or rely on their families. While micro and digital finance institutions are trying to fill the financing gap for SMEs, these products do not always meet customers' needs. In addition, financial sector processes and risk culture are not conducive to improving financial inclusion for firms and individuals. When bank financing is available for SMEs, it is usually small (covering only about 16 per cent of the total investment), with high interest rates (anywhere from 7.75 to 15 percent) and of short duration (maximum of two years), with stringent collateral requirements that are difficult for SMEs to meet. In addition, the absence of a functioning digital collateral registry impedes access to credit. Though Burkina Faso recently launched a new credit bureau, it covers only 1.1 per cent of the adult population. In comparison, coverage in Côte d'Ivoire is about 9.6 per cent of its adult population[56].

In Burkina Faso, the finance needs of agricultural households, agricultural firms and young farmers must be distinguished. Short-term financing needs of farm households are: (i) funding of the agricultural campaign (inputs: seeds, fertilizers, pesticides; labour: soil preparation, transplanting, weeding, harvesting…); (ii) financing of fattening (pig, sheep, goat, cow) and (iii) financing storage and processing. Longer terms agricultural financing needs of agricultural households relate to equipment financing (production intensification: harnessed cultivation, motor pumps, modest mechanization, etc.); marketing of production (transport) or storage (buildings); infrastructure financing including storage warehouses, wells, boreholes and hydro-agricultural initiatives; access to land and its security.

For agricultural businesses, their needs vary according to their form. For instance, large family farms, cotton producers, need loans for long term financing of the mechanization equipment necessary to develop their land. Young farmers have access to a number of funds and tools managed by the Ministry in charge of Youth designed to provide them the means to start a viable business (FAIJ: Fonds d'Appui aux Initiatives des Jeunes, FAFPA: Fonds d'Appui à la Formation Professionnelle et à l'Apprentisage).

Regarding supply in agricultural financing, banks' lending to the private sector is oriented toward large corporations in commerce, services, public infrastructure and extractives, which account for about 80 per cent of total bank assets. The share of loans to the agriculture sector remains low (3,9 per cent of total bank assets). This offer can take the shape of MFI refinancing or direct intervention, such as the fattening loan, if the banks do not have other agricultural-related products. A few large producers (with an almost agribusiness profile) are among the clients for fattening loans, but the bulk are small farms. However, the lack of guarantees remains a major obstacle. Considering this, banks continue to consider warrantee as an option, but only under particular conditions such as good producer organization in the intervention areas, presence of outlets for the sale of stored agricultural products and provision of reliable infrastructure/depots.

Limited access to finance is especially detrimental to the development of agriculture and agribusinesses. Potential supply-side constraints for access to finance are the fact that interest

56 IFC,2019

rates are as high as 15 per cent, well out of reach collateral requirements and the limited access to bank branches (only one bank per square km).

The level of profitability of banks also remains low compared with other UEMOA countries, such as Côte d'Ivoire, Senegal and Mali. For MFIs, the portfolio quality, as measured by the portfolio at risk indicators, has declined and is 4.95 percent, above the three per cent norm mandated by the BCEAO57. Profitability of MFIs remains low and the liquidity ratio is at the threshold. Most MFIs do not meet the coverage ratio of medium and long-term financing with stable resources. Furthermore, regulatory oversight of the microfinance segment is weak, with the responsible regulatory teams being understaffed and having limited capacity. Micro and digital financial institutions are attempting to bridge the funding gap for SMEs; however, their products may not always match their consumers' demands. So far, microfinance has concentrated on the development of short-term financing.

To reinforce the sector's importance, the Government launched the Program for Economic Growth in the Agricultural Sector (PCESA) from the Agro-Industry Fund. According to the technical adviser to the Minister of Agriculture, Hydro-Agricultural Development and Mechanization, Ismaël Nandian Ouédraogo, since the beginning of the program, the Kingdom of Denmark has worked with all partners to facilitate access to financing for businesses in partnership with financial institutions (Ecobank, Coris Bank and Sofigib) which have granted 363 loans, 35per cent of which are managed by women's businesses, at a total cost of about 21 billion CFA francs Over the same period, 105 SMEs/SMIs benefited from advisory support, 123 green projects were financed for a total cost of about CFAF 7.8 billion. In three years the Agro-Industry Fund has helped about fifty agribusinesses in their development through facilitating access to finance and increasing turnover. While reaffirming its willingness to continue this type of initiative in its 2021-2027 programming, the European Union welcomes the key role of facilitators in the support and access to finance.

According to the Smallholder Finance Product Explorer, Burkina Faso has four types of smallholder finance loans offered by one institution, the First Agency of Microfinance58. The four types of loans include the animal fattening loan, which is cash loan to support activities undertaken during the fattening period for livestock; the trading loan supporting small-scale commerce; the horticulture loan supporting activities related to vegetable cultivation and the agricultural loan supporting agricultural production or storage.59

Cote d'Ivoire

Côte d'Ivoire has one of the most developed financial sectors in the Economic Community of West African States (ECOWAS) region. Twenty-six banks manage about 80 percent of the financial sector assets, with the remaining controlled mostly by insurance companies (Figure C.2)60. Côte d'Ivoire's insurance sector is the largest in the WAEMU region in term of asset size but covers only a small part of the population. The microfinance sector, which is recovering from the socio-political conflict of the late 2000s, is small (2 percent of financial sector assets). Commercial banks primarily lend to large businesses and for short-term needs such as the purchase and sale of export crops. Their business model, network and capabilities prevent them from lending to small manufacturers or trade groups. There is a limited range of options for other services, such as investment credit, crop insurance and risk capital. In Cote d'Ivoire, the financial sector players

57 IFC,2019

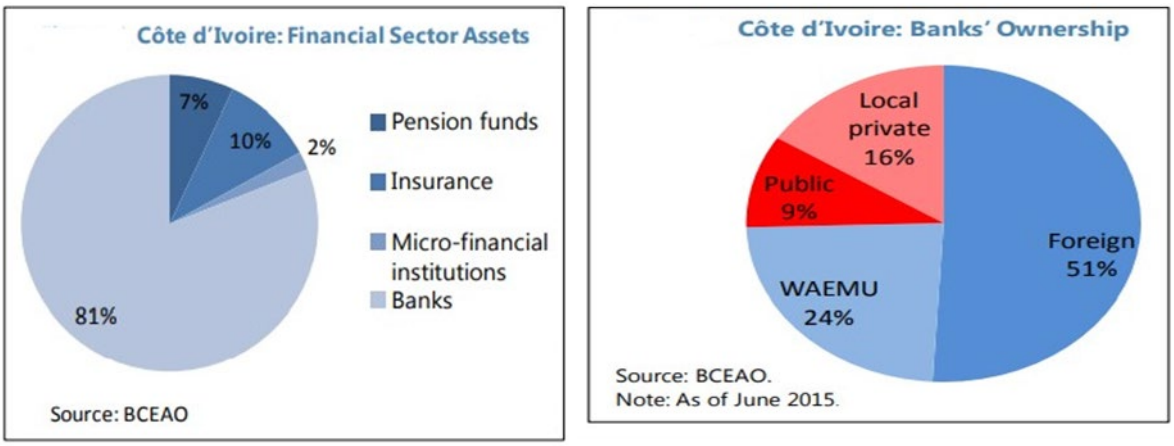
58 https://sfpedata.oneacrefund.org/resource/?customOrder=country&order=ASC

59 In terms of financial figures, the data shows only the portfolio size and, for some of the instruments, annualized total amount lent or disbursed over a 12-month period, without however indicating the exact year of the transactions. The dataset does not contain any information on environmental impact, links to climate adaptation or mitigation, type of agricultural practices promoted.

60 IMF, 2016. CÔTE D'IVOIRE SELECTED ISSUES

involved in agricultural financing include mostly banks, which hold most of the financial sector assets.

Figure 9 : Financial sector overview in Cote d'Ivoire



A number of projects that foster the development of knowledge and evidence on the effectiveness of climate-smart agriculture in improving food security, mitigating climate change and improving the adaptive capacities of production systems and populations in Côte d'Ivoire have received support from various donors and financing schemes. For instance, DFID and IDRC through the Climate Change Adaptation in Africa (CCAA) program funded an ecosystem system approach to managing water in the context of climate change in some West African countries including Côte d'Ivoire. This was deemed as a climate-smart drought intervention for communities whose conditions were also aggravated by floods.

In addition, IFAD has since 1984 invested hugely in several aspects of the agricultural sector of Côte d'Ivoire which also includes the development and promotion of CSA innovations. For instance, IFAD provided USD 41.9 million to the Western Extension Support to Agricultural Production and Marketing Project (for implementation between 2014 to 2020) which will deliver on CSA goals - improved food security for 30 000 households by increasing smallholder farmers' access to services, technologies and markets while strengthening the resilience of their production systems to climate change.

On behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), GIZ is also helping to improve climate change adaptation in Côte d'Ivoire through a number of complementary projects such as the climate change adaptation and population stabilization program and the support for the improvement and intensification of agricultural production project which mainstream CSA principles in improving food security and enhancing the value chains for cocoa, cashew nuts and cotton.

In terms of access to UNFCCC funding mechanisms, the country has accessed approximately USD37 million worth of funding from the Global Environment Fund (GEF) for 23 national projects focused on areas such as biodiversity and forest management; sustainable production and processing of cassava; and coastal areas management among others. The country has also been a part of 41 regional or global projects to the value of USD290 million.

At the national level, there are very few institutions financing CSA in Côte d'Ivoire. National opportunities for funding agriculture in Cote d'Ivoire include the finance support from the government (through the National Development Program and the National Investment Plan) and private sector. This highlights the primary barriers to accessing financial services for agricultural producers in Cote d'Ivoire which are: a still inadequate rural branch network (59 per cent of the

4,050 access points are in Abidjan…); the reluctance and lack of capacity of banks to deal with credit to agriculture, which is seen as a high risk with no possibility of guarantees; the low credibility and reliability of most cooperatives as credit retailers; and the high real interest rates on loans (MFIs charge up to 30 per cent p.a.), which is incompatible with the financing of most investments. Even though microfinance institutions serve low-income households with short-term loans and operating capital, and they are spreading into rural areas, particularly those with cocoa farms, the majority of the institutions, on the other hand, do not provide loans for productive activities or investments, and many are financially poor and unable to provide good services to their members.

Other initiatives include, the World Cocoa Foundation's financial growth, which is offering input loan. As part of WCF's USD 40 million Cocoa Livelihoods Programme (CLP) in Ghana and Côte d'Ivoire, the World Cocoa Foundation investing USD 800,000 in a Financial Growth Fund to increase farmers' access to financial services, providing them with the necessary working capital to purchase inputs[61].

Ghana

Ghana has 23 commercial banks (CB), 144 rural and community banks (RCB), 25 savings and loan companies (SLC), 132 microfinance companies (MC), 31 microcredit companies (MCC), 12 financial NGOs (FNGO) and numerous money lenders and susu collectors. Village Savings and Loan Associations (VSLAs) are widespread. Despite the diversity of financial institutions (FI), only 37 per cent of the rural population has access to accounts in formal FIs. The banking system provides only five per cent of the total loans and advances to the agricultural sector. Smallholders are reluctant to borrow due to the high interest rates (30-36 per cent flat offered by RCBs), lengthy procedures for borrowing and the fear of default due to crop losses accompanied by lost revenue. FIs are averse to agricultural lending because of the high risks and limited awareness of available "de-risking" instruments such as insurance, guarantees and warehousing. However, the Bank of Ghana has announced a reduction in the policy rate from 15.5 per cent to 14.0 per cent and has lowered the reserve requirements from 10 per cent to 8 per cent to increase credit availability and affordability amongst other monetary measures to reduce the impact of coronavirus.

In Ghana, the financial sector players involved in agricultural financing include banks, rural banks, savings and loans companies and microfinance institutions. According to Global Findex Database for 2017, and between 2014 and 2017, the share of adults having accounts with a financial institution or through a mobile money service rose from 62 per cent to 69 percent. In developing economies in general, the share rose from 54 per cent to 63 percent, making Ghana's level of financial inclusion slightly higher than the average for developing countries[62].

In terms of climate financing, Ghana Investment Plan for the Forest Investment Program (FIP) financing of over $75 million is supporting projects that unite public and private sectors with indigenous peoples and local communities in restoring degraded forest landscapes, improving forest management, and reducing pressure on forests. Efforts include promoting sustainable cocoa and agriculture practices, securing tree tenure, and facilitating institutional capacity building and policy reforms[63]. Another $40 million from the Scaling up Renewable Energy Program in Ghana (SREP) is helping to create an enabling environment for renewable energy scale-up, focusing on renewable energy mini-grids and stand-alone solar photovoltaic (PV) systems, solar PV-based net metering with storage, and utility-scale solar PV and wind power

61 RAFLearning Data
62 The Global Findex Database 2017
63 fip_5_ghana.pdf (climateinvestmentfunds.org)

generation. The SREP endorsed an investment plan as a basis for the further development of the projects and programs foreseen in the plan64.

Globally, the private business sector is the major source of investment for climate change mitigation in Ghana. Private sector partners include industry/technology companies, commercial banks and private funds (thematic green, venture capital, pension, social, etc.), whether local, regional or global. At the local level, banks such as ECOBANK Ghana Limited, Agricultural Development Bank and Standard Chartered Bank are already active in lending support for mitigation activities. For example, the Forestry Commission is in partnership with ECOBANK to fund afforestation projects on concessionary terms65. Ghana Country Private Sector Diagnostics (CPSD) identifies that the private sector could notably support: (i) agribusinesses in high-value export markets; (ii) the upscaling of financing for promising SMEs in the 'missing middle'; and (iii) the provision of goods and services for smallholders (seeds, fertilizers, storage, transport, machineries, extension etc.).

Public sector partners include international development banks, public agencies and bilateral/ multilateral institutions and their programmes. Examples include the Swedish International Development Agency, Canadian International Development Agency, United States Agency for International Development, World Bank, African Development Bank, European Investment Bank, European Investment Fund, European Bank for Reconstruction and Development, United Nations Development Programme, United Nations Environment Programme and IFC. Funding opportunities include Climate Investment Funds, CDM, Bio Carbon Fund, the Green Climate Fund and Prototype Carbon Fund, among others. In addition, EPA and the Energy Commission have established funds and MESTI is in the process of establishing an Ecological Fund. Resources from all these funds can be explored for climate change financing66.

New opportunities to strengthen agricultural marketing and increase agricultural lending include: (i) the Ghana Incentive-based Risk Sharing System for Agricultural Lending (GIRSAL) which started as a USD 72 million credit guarantee facility to secure up to 80 per cent of agrarian sector loans; (ii) the Ghana Commodities Exchange (GCX) which provides commodity storage and trading services to farmers through a network of certified warehouses directly or indirectly (through brokers) linked to producer Cis, and (iii) the Ghana Agricultural Insurance Pool (GAIP) which offers crop insurance products to farmers and intends to increase its smallholder outreach.

The Government also intervened in an agriculture modernization program aimed at improving production efficiency, achieving food security and profitability for farmers, and significantly increasing agricultural productivity as the basis for industrialization, job creation and export. Government has increased subsidies on retail prices of seeds, fertilizers and other agrochemicals, and it is focusing on developing irrigation schemes, facilitating the provision of community owned and managed small-scale irrigation facilities across the country, especially in northern Ghana, through the "One Village, One Dam Policy", and improving the extension officer to farmer ratio. Planting for Food and Jobs (PFJ) works through the following modules: Food Crop Production; Planting for Export and Rural Development (PERD); Rearing for Food and Jobs (RFJ); Greenhouse Technology Development as well as Mechanization for Food and Jobs. Ghana has led by example through creating a conducive environment for private and public sector engagement in the planning and implementation of climate actions. For instance, Ghana developed a Nationally Appropriate Mitigation Actions (NAMAs) investor guide to attract the private sector for low carbon development67.

64 srep_13_4_srep_investment_plan_for_ghana_0.pdf (climateinvestmentfunds.org)
65 UNDP, 2014
66 UNDP, 2014
67 https://www.pef.org.gh/documents/Ghana%20NAMA%20Investor%20Guide_final_web.pdf

Other initiatives financing climate resilient and low emission agriculture for smallholders in Ghana are the following[68]:

- The input financing from the Success for People institution, which is a pre- harvest loan through direct supply of input in terms of maize, rice and soya's seed, fertilizers and other agriculture inputs to smallholder farmers. The same institution also offers a warehouse receipt financing which is a commodity-backed collateral loan for farmers to store their produce (maize, rice and soya) after harvest in a Ghana Commodity Exchange (GCX) approved warehouse to borrow up to 50per cent of the face value of stored produce. When produce is sold, payments are made directly to SFP/Financial Institution directly before produce are released to buyer by warehouse manage.
- An agricultural loan from Bonzali Rural Bank, which is an agricultural loan with interest rate of 32per cent. The loan's duration is 8 months, enabling a two-time repayment system with group solidarity, landed property or salary guarantors as security.
- VisionFund Ghana Microcredit Limited also offers an agricultural loan to farmers for cultivation of food crops, animals' husbandry, purchase seeds and farming inputs.
- A micro enterprise loans from the Global Impact Foundation FNGO, which are loans given to clients in farming and farm services such as, Maize, Yam, Beans, Vegetables and other farm value chain products like chemicals and implements sale.
- A horticultural loan (including a maize loan) and cocoa loan from the Opportunity savings and Loans Ghana, which are an in-kind input supply loan, supporting horticultural production and supporting cocoa value chain, respectively. In some cases, the institution may have cash component to assist with cost of farm support labor.
- A smallholder farmers production loan scheme from SeendFingo, which is a small amount of loans (USD 60) that are disbursed to small holder farmers to cultivate maize, soya beans, cassava, yam millet, rice and cowpea. SeedFingo also provides a women solidarity loan scheme, which are small loans that are disbursed to women who are into agricultural processing such as rice, groundnuts, sheanuts and soya beans as a group. Repayments are done weekly at group meeting grounds for a period of sixteen weeks thus a cycle. There is a grace period of one week.
- A cash agroproduction loan and an in-kin agroproduction loan from Grameen Ghana, which is a cash loan for agricultural production.

Mali

Owing to more effective regulation of the sector at the UEMOA level, Mali has seen several international and regional players enter the banking market, fostering competition with the local public banks created in the years following independence. The percentage of foreign-owned banks in Mali has nearly doubled since the early 2000s. The Banque Nationale de Développement Agricole (BNDA) is the lead financier of agriculture and rural development in Mali.[69]

Mali also has an extensive network of micro-finance institutions or SFD. However, of the 126 SFDs registered in the country, only 35 are operational. The vast majority of this sector's resources are concentrated in the four largest institutions – Kafo Jiginew, Soro Yiriwaso, RMCR and Nyesigiso – which distribute 77 per cent of credit (WFP, 2017). The sector is still struggling to fully recover from the major crisis that began in 2009 and led to the closure of numerous MFIs (both large and small), the loss of millions of FCFA in people's savings and as a result, generalized mistrust towards the sector. Significant effort has been made by GoM and its development partners, including the IFAD Rural Microfinance Programme (FMR), to restructure and resolve the issues in the sector, such as the adoption of stricter regulations, a national microfinance development

68 Source: MIX & One Acre Fund Smallholder Finance Product Explorer Dataset. Available at:https://sfpedata.oneacrefund.org/resource/visionfund-ghana-micro-credit-limited/

69 BNDA, 2019).

policy and action plan (2016-2020) and support for refinancing, among others. While progress has been made, the situation of dozens of MFI still needs to be regularized. An important source of financing for SMEs, MFIs account for only 4.4 per cent of all bank loans in the country.

Credit markets in Mali, while comparable to UEMOA averages, are historically thin compared to sub-Saharan Africa in the aggregate. Mali is ranked 142 of 190 on the World Bank Doing Business index's credit access metric. Various sources of debt capital exist within the country, but Malian private sector firms' access to credit is dominated by the banking sector[70].

Classification of lending institutions into the banking sector is somewhat broad and may include guarantee funds and leasing companies as well as MFIs, but nearly all lending in Mali is done by traditional depository banks. In 2016, depository banks had USD3.17 billion of private sector exposures on their balance sheets. Banks tend to have highly concentrated portfolios of assets on their balance sheets favouring medium and large enterprises, with small businesses and individual entrepreneurs receiving a relatively small proportion of credit. In 2016, the three largest banks in the country held 50.7 per cent market share by assets.

Financing for agriculture, particularly smallholder farmers, is extremely limited in Mali. In 2014, only 5.5 per cent of private sector loans were for agricultural production, most of which went to cotton production. When commercial banks offer credit to the sector, it is typically for large agro-industries, input suppliers and agri-food processing companies and rarely finance producer organizations (POs) or farmers directly.

In both 2018 and 2019, the BNDA, the main supplier of farm credit, dedicated 53 per cent of its credit portfolio to loans to the rural sector (including input suppliers, agro-industrial enterprises and farmers) (BNDA 2019). While BNDA makes direct loans to agricultural borrowers, these accounted for an average of only 3.6 per cent of all credit extended to the sector between 2013 and 2017. Much more commonly, BNDA extends working capital facilities of various structures to large agribusinesses, input suppliers and agro-processing companies, which accounted for the remaining 96.4 per cent of agricultural exposures on average over this period[71]. The majority of its loans are short-term, and interests hover around 10-12 per cent per annum. It offers cooperatives and SMEs short-term loans (maximum of two years) for agricultural inputs, advances on harvest and paddy stocks, grain storage marketing and medium (1-5 years) and long-term loans for equipment, production materials and infrastructure. It also has a special line of credit that offers women's groups short and medium-term credit[72]. While the BNDA has a corporate social policy with guidelines to ensure clients are following environmental and social standards, it does not yet offer specific lines of credit for climate-resilient agriculture.

Mali's extensive network of microfinance institutions play an important role in providing financial services to microenterprises and farmers. They generally offer loans for small equipment, inventory credit, leasing products and short-term production and marketing needs. Numerous smaller MFIs exist but have little resources and are generally unable to respond to farmers' demand for credit for longer-term credit. The existing main microfinance institutions are[73]:

The Faso Jigi: cooperative finance which is of the largest producer cooperatives in Mali with 18 years of experience. It is active in the Ségou region and has 5,900 members. The cooperative offers

70 USAID, 2018
71 USAID, 2018
72 BNDA, 2019
73 Rural & Agricultural Finance Smallholder Financial Solutions. Available at https://data.raflearning.org/#/dataset?dataset_id=%2321:4

its members several services for collective actions: inputs purchase, storage and marketing. Linked with financial institutions (MFIs and one bank), Faso-Jigi provides to its members agricultural loans for crop and post-harvest needs as well as equipment loans (for production and processing). The cooperative has set up a security fund for default from farmers due to natural disaster. The total funding from financial institutions that go through the cooperative per year is approximately USD 4.4 million.

The Kafo Jiginew which is a financial cooperative, the largest MFI in Mali with 27 years of experience. Kafo has offered financial services to smallholder farmers but in 2007, Kafo completely revised its business model (internal organization, and loan policy) for serving smallholder farmers in order to better meet their needs. The range of products was diversified. One of very few successful movements of savings and credit cooperatives of small farmers, built on principles of self-help and self-reliance, comprising some 180 coops with 224,000 members (30per cent female).

Poor access to financial services is a major hindrance to the uptake of climate resilient, low emission agricultural practices by smallholders. Risk factors beyond their control - such as erratic weather, irregular seasons, unclear land tenure and lack of on-farm collateral systems - result in the rejection of 70 per cent of Malian farmers' loan applications (CSAIP). The main demand-side constraints are:

1. Farmers lack the necessary capacity to prepare sound, bankable business proposals and often do not own assets that could be offered as collateral. Land titles in rural areas are rare and are not attractive collateral due to the lack of liquidity of the land title market[74]. These factors affect women farmers more: less than only five per cent had access to seasonal loans in 2015[75].
2. Interest rates charged by banks and MFIs on loans are prohibitive for most smallholder farmers. They are often higher than the average rate of return on agricultural businesses.
3. Farmers have limited access to long-term funding, which prevents them from investing in infrastructure and equipment.
4. Banks are mostly concentrated in urban areas.

The main supply-side constraints are:

1. Financial institutions' limited knowledge and understanding of the farming sector and the lack of quality data on the sector make it difficult for banks to accurately analyse risks, contributing to the perception of smallholder farming as a high-risk investment.
2. Clientele in rural areas is highly dispersed and as a result, establishing branches in such areas is often too costly. Mobile phone banking apps and services are emerging as an alternative to overcome this obstacle.
3. Banks do not have long-term deposits or other funding liabilities to finance larger term loan portfolios. The financing gap for equipment is estimated at around CFA Franc 2 to 3 billion.
4. Risk management tools such as micro and macro-insurance schemes are still scarce in Mali. In 2014, Assurance Allianz through Planet Guarantee insured 20,000 smallholder producers in maize sector and has expanded since. OKO Finance offers weather-indexed insurance products to farmers.

The recently approved GCF IFAD Africa Integrated Climate Risk Management Programme will work with existing stakeholders in Mali's insurance market to scale up micro agricultural

74 WFP, 2017
75 FAO, 2018

insurance schemes for smallholder farmers and FOs while promoting the adoption of best climate resilient agricultural practices.

At national level, costs for implementing the National Climate Change Strategy (SNCC) over the period 2012-2017 amount to USD 250 million, while adaptation and mitigation activities in the agricultural sector - as outlined in the country's INDC - expected to cost another USD 20.6 billion by 2030, indicating a need to tap into new public and private financing opportunities to help achieve the desired targets[76].

Major funders of climate-smart agriculture related work in Mali include IFAD's Inclusive Finance in Agricultural Value Chains (INCLUSIF) will build on the experience of the Rural Microfinance Programme (PMR) to improve the financial inclusion of rural communities by promoting financing for smallholder adoption of climate resilient agriculture practices and techniques. INCLUSIF uses the Refinancing mechanism (MEREF-SFD) that has currently two counters to meet the financing needs of the different categories of beneficiaries of the project: in particular a refinancing window for microfinance institutions (SFDs) as indirect beneficiaries of the project, and a financial facility for the establishment of grants to direct beneficiaries. As of September 30, 2020, the plans of 13 FOs had obtained subsidies for a total amount of 294.22 million FCFA through the window of financial facilities. Regarding the refinancing window, as of September 30, 2020, a cumulative amount of FCFA 1,834 million had been made available in the form of DAT refinancing for the benefit of 09 partner SFDs[77].

The GEF is another funder of CSA, for which the country has accessed funds for projects related to improved hydrometeorological information and integration of climate change adaptation into the agricultural sector (USD 2.2 million project implemented by FAO). There is also reversing deforestation through reforestation (The GGWl for the Sahara and The Sahel project, also supported by the World Bank and the European Union), supporting agroforestry and sustainable land management among others. Mali's first project to the GCF focuses on putting in place a hydro-meteorological (hydromet) system to improve food security, protect livelihoods and inform infrastructure development. The project has a budget of USD 27.3 million with the GCF providing USD 22.8 million of this and the World Bank and the Government of Mali providing USD 2.5 million and USD 2 million respectively. Key challenges noted for scaling up the implementation of activities indicated in Mali's NDC include the availability of long-term large-scale finance as well as availability of technologies.

Bilateral donors such as the United States Agency for International Development (USAID), have also contributed to various food security and resilience related projects. Climate finance is channeled through the Mali Climate Fund (MCF), a mechanism set up in 2012 to mobilize and anchor bilateral, multilateral, public and private financing and align these to the SNCC. The MCF is expected to improve coordination of budgets and technical interventions on the field, incentivizing innovative partnerships and investments in key areas: improved research capacity to assess vulnerability to climate change, improved water supply for multiple uses, enhanced food production and promotion of CSA practices, livelihoods diversification and promotion of renewable energy. UNDP acts as the administrator and distributor of the funds, while the secretariat is ensured by AEDD. A Steering Committee formed of representatives of the stakeholder groups (government, donors, civil society) takes decisions over resource allocation and re-distribution[78].

76 République du Mali (RdM). 2015. Contribution Prévue Déterminée au niveau National. UNFCCC. Available at: http:// www4.unfccc.int; UNDP. 2013. Mali Climate Fund factsheet. UNDP. Available at: http://mptf.undp.org/document/download/12430.

77 c0b708b4-b247-f061-5fda-be5a291bcfaf (ifad.org)

78 UNDP. 2013. Mali Climate Fund factsheet. UNDP. Available at: http://mptf.undp.org/document/download/12430.

Up to 2015, the MCF had mobilized USD 7.29 million from the Governments of Norway and Sweden, targeted towards agriculture, livestock and fisheries (USD 1.6 million, with a 39 percent execution rate) and water management. Political instability, heavy bureaucracy and insufficient human resources for managing fund-related processes have significantly stalled the functioning of the MCF79.

Senegal

National opportunities for funding agriculture in Senegal include support from the government (MAER, MEPA), local private financial institutions such as CNCAS, National Bank for Economic Development (BNDE) and Locafrique, cooperatives, NGOs and, to some extent, the private sector80.

The main governmental funding mechanisms available include FNRAA and FNDASP, which are primarily accessed by the country's research institutions (i.e., ISRA). Through the FNRAA, a number of projects have been funded that have climate resilient and low emission agriculture characteristics including: the improvement of agriculture production through the application of bio-products and promotion of the use of vetiver – a perennial bunchgrass to combat erosion and improve soil fertility in the Niayes zone. The government executed a program for seed reconstitution from 2013 to 2015, and ISRA was responsible for producing first-level seeds of groundnut, cowpea and cereals to meet the national needs. Through MEPA, support comes from FONSTAB, which is a mechanism to implement the LOASP and linked to the FNDASP. It promotes the commercialization of the livestock sector through investments in machinery, processing, packaging and marketing.

Senegal fares poorly compared to sub-Saharan Africa or the world average in key indicators of access to finance for private firms. Less than one of four companies, or about 22.6 percent, have a bank loan or line of credit. That number is close to the average in the sub-Saharan Africa region, even though real interest rates are not high, at 3.4 per cent to 4 per cent over the period from 2015 to 2017. When they do manage to get a loan or line of credit, firms must still pledge significant assets to secure their loans. For example, three of four firms, or 78.9 percent, were asked for some form of guarantee when applying for a loan[81].

The value of the guarantee required is very high on average at 271.7 per cent of the value of the loan; extreme for small firms, at 428.7 percent, but much smaller for large firms, at 160.7 percent. This wide range of guarantees across firm size, coupled with a collateral-based lending culture, reflects the increased risk perceived by banks to lend to smaller clients. Lending conditions are also difficult because of the type of guarantees required by banks, with land and real estate being the preferred forms of guarantee in about half, or 53.1 percent, of the time. This is an additional hurdle, as securing this type of collateral is extremely difficult for smaller firms and may be nearly impossible for young firms and start-ups82.

MSMEs are among the most credit constrained. They represent about 99.8 per cent of the total number of "economic entities" and about 70 per cent of the labor force, according to the latest census by the Agence Nationale de Statistique et de la Démographie (National Agency of Statistics and Demography of Senegal). Yet, evidence shows that they only get about eight per cent of the total financing from financial institutions. These restrictions are echoed by survey results that

79 MEA. 2017. Deuxième rapport annuel consolidé des activités du Fonds D'Affectation Spéciale du Mali pour le Climat (Fonds Climat Mali). Multi-Partner Trust Fund Office, Programme des Nations Unies pour le Développement (PNUD). Available at: http://mptf.undp.org

80 FAO, ICRISAT, CIAT, CCAFS. 2016.

81 World Bank, 2017. An Investment Climate Assessment for Senegal, Rapport N° AUS7348, Washington, D.C. : World Bank.

82 World Bank, 2017

show that MSMEs are more constrained than large firms. An estimated 43 per cent of medium firms and 59 per cent of small firms claim that access to finance is their biggest issue, generating a large financing gap of about USD0.9 billion83. Among MSMEs, those led by women or based in rural areas have even lower access. Constraints to improved access to finance include limited competition among financial services providers, weak financial infrastructure, weak financial sector policies as well as inherent weaknesses among MSMEs. The lack of capacity for MSMEs remains a major constraint to access to funding:

1. Existing data show that MSMEs have more difficulty obtaining financing than larger companies. Thus, many companies with financing needs avoid applying either because they are unable to provide the guarantees required for a loan (28.2 per cent of all companies did not request a loan but were in need of funds), they perceived a heavy and complex screening process (27.6 percent) and they considered interest rates high (15.8 percent)84.
2. Furthermore, the capacity limitations of Senegalese MSMEs and lack of financial education of their leaders is a challenge. The absence of reliable financial statements, procedures for results and performance monitoring and the inability to provide the required documentation and/or prepare an appropriate business plan are factors that disqualify many MSMEs from traditional finance.

CNCAS is the main credit provider to smallholder farmers across the country accounting for 50–60per cent of microfinance products 85 . They support individual farmers and farmers associations in obtaining credit to finance agricultural inputs and post-harvest activities. The credit union works through certified seed distributors to ensure that farmers taking out credit obtain high-quality seeds (to reduce risk of lending). The organization is also working to strengthen the value chain, particularly in rice cultivation and harvesting by promoting the establishment of warehouses for farmers to stockpile their rice to protect its quality until the sale. Very few other financial institutions provide farmers with loans for planting activities and tend to focus more towards developing the agribusiness sector, which includes mainly post-harvest activities.

On the other end of the credit value chain, the Senegalese microfinance sector has been very active, with 2.6 million clients and a total asset base of USD 528.3 million as of year-end 2016 (+9.4 per cent year on year) (IFC, 2020). Unlike in most countries, microfinance institutions in Senegal can collect deposits for a total of USD 456.4 million, which creates some competition with the banking sector. However, despite past expansion, microfinance remains rather small and its capacity to satisfy the needs of even the smallest firms is limited86. Senegal's financial infrastructure still faces significant limits in key areas, including credit information limited in coverage but is improving, insolvency regime remaining constrained, capital markets remaining small and dominated by government issuances with corporate bond markets absent and the uncertainty on secured transactions, preventing a proper functioning of the country's credit markets87.

Alleviating the issue of access to finance in Senegal and closing the financing gap will require three kinds of solutions: fostering greater competition, improving financial sector infrastructure; and improving public interventions designed to address market failures and crowd in the private sector88.

83 IFC,2020
84 WB, 2017
85 CSE. 2010. Rapport sur l'état de l'environnement. Centre de Suivi Ecologique (CSE). Available at: http://bit.ly/1SzO98i
86 IFC,2020
87 IFC,2020
88 IFC, 2020

The productivity of many Senegalese agriculture producers is still limited by two major constraints: they cannot obtain credit to invest in more productive operations or purchase crop insurance to manage risk and protect their investments. While 46 per cent of rural adults borrowed money in 2017, only 5.7 per cent borrowed from a formal financial institution. The key constraints to lending for agricultural activities are well-known: it is costly and risky to lend to farmers involved in rainfed agriculture, financial institutions lack knowledge of agriculture finance, microfinance institutions have exhibited weak performance and governance issues, and public interventions have been inefficient (involving crowding out effects). The Government subsidizes loans issued to smallholders (with little evidence on efficient targeting), administered by state-owned Banque Agricole, by covering the difference between market interest rates (about 13 per cent) and the capped interest rate for farmers (7.5 per cent). The government also supports access to agricultural insurance through the Compagnie Nationale d'Assurance Agricole du Sénégal (CNAAS) under a 50 percent subsidy on premiums. Despite these efforts, wide access to suitable agricultural insurance products remains constrained[89].

International technical and financial support for climate initiatives comes from several sources. Senegal was one of the first countries in 2010 to access the UNFCCC Adaptation Fund to finance a project on coastal protection by the name of "Adaptation to Coastal Erosion in Vulnerable Areas," which was developed based on the PANA. They will also be one of the first countries to receive funding through the Green Climate Fund for a project to restore salinized lands and to increase the climate resilience of the coastal region's population.

With support from the World Bank and the Global Environmental Facility (GEF), the Government of Senegal created the Project for Inclusive Development and Sustainable Agribusiness in Senegal (PDIDAS), which provides smallholder farmers with access to funds to make investments necessary to improve agriculture productivity. Some of the eligible investments include training, inputs (seeds, fertilizer), agroforestry, transformation and commercialization of products. While there are many bilateral and multilateral institutions supporting the implementation of projects related to agriculture development and food security, there are a limited number that are explicitly addressing climate change adaptation. Nonetheless, these resources have been used to make progress in strengthening farmers' access to high-quality inputs, financial mechanisms and training and investments in reinforcing the various components of the value chain for key crops in the country. The table 16 below presents a snapshot of interest rates generally offered by different financial intermediaries in the targeted countries.

89 WB, 2020

Table 16 : Overview of interest rate applied by various actors in the IGREENFIN countries

Country	Interest rates per banking sector					
	Commercial Banks		Microfinance institutions	Agricultural Banks	Central Bank	
Burkina Faso[1]	7,44% in 2018	Interest rate applied by Commercial Banks	Lending interest rate on credit from banks to prime borrowers i.e., to the lowest risk borrowers in the private sector	Maximum interest rate 5%	4%	Burkina Faso is a member of the Economic and Monetary Community of West Africa (UEMOA). In UEMOA, interest rates decisions are taken by the Central Bank of West African States' Monetary Policy Committee. The Central Bank of West African States' official rate is the key interest rate.
Ghana[2]	6,30% in 2021	Lending interest rate on credit from banks to prime borrowers i.e., to the lowest risk borrowers in the private sector	20%	20%	14.5%	The Bank of Ghana kept its monetary policy rate at an eight-year low of 14.5% during its March 2021 meeting, to continue supporting the domestic economy from the pandemic crisis while it assesses the impact of new tax measures announced this month and higher utility costs on inflation.
Ivory Coast[3]	5,14% in 2017	Lending interest rate	All in rate at 24%- CAP	between 10% and 13% for short term and 9% to 11% for mid-term and long-term	4%	Cote d'Ivoire is a member of the Economic and Monetary Community of West Africa (UEMOA). In UEMOA, interest rates decisions are taken by the Central Bank of West African States' Monetary Policy Committee. The Central Bank of
	6,33% in 2018	Interest rate applied by Commercial Banks				

Country	Interest rates per banking sector					
	Commercial Banks		Microfinance institutions	Agricultural Banks	Central Bank	
						West African States' official rate is the key interest rate.
Mali [4]	7,86% in 2018	Interest rate applied by Commercial Banks	17,8% in rural area	4%	4%	Mali is a member of the Economic and Monetary Community of West Africa (UEMOA). In UEMOA, interest rates decisions are taken by the Central Bank of West African States' Monetary Policy Committee. The Central Bank of West African States' official rate is the key interest rate
Sénégal [5]	Bank of Africa: 9-13% for a 2 to 6 years loan Banque Régionale de Solidarité: 12-14% Société Générale de Banque in Sénégal: 5-10% depending on the type of credit Alliance du crédit et d'épargne pour la production: 13,5% Crédit mutuel du Sénégal: 10-13%	Interest rate applied by Commercial Banks	12% (PAMECAS-2013)	Average interest rate 10%	4%	Senegal is a member of the Economic and Monetary Community of West Africa (UEMOA). In UEMOA, interest rates decisions are taken by the Central Bank of West African States' Monetary Policy Committee. The Central Bank of West African States' official rate is the key interest rate.

[1] Rapport_Annuel_2018_Situation_Inclusion_Financiere.pdf (bceao.int), https://burkinafaso.opendataforafrica.org/drkelmb/interest-rates, https://tradingeconomics.com/burkina-faso/interest-rate , https://www.diva-portal.org/smash/get/diva2:207141/FULLTEXT01.pdf
http://www.commodafrica.com/10-02-2021-lancement-du-fonds-de-developpement-de-la-banque-agricole-du-faso
[2] https://tradingeconomics.com/ghana/bank-lending-rate, https://tradingeconomics.com/ghana/interest-rate, https://www.mftransparency.org/wp-content/uploads/2012/05/MFT-RPT-102-EN-Country-Survey-Ghana.pdf

[3] Ivory Coast Lending Interest Rate (ycharts.com) , Rapport_Annuel_2018_Situation_Inclusion_Financiere.pdf (bceao.int), https://tradingeconomics.com/ivory-coast/interest-rate , https://www.convergences.org/en/ensuring-the-profitability-of-microfinance-in-cote-divoire-a-case-study-from-the-advans-group/
http://finclusion.org/uploads/file/ivory-coast-report_final.pdf
[4] Rapport_Annuel_2018_Situation_Inclusion_Financiere.pdf (bceao.int), https://tradingeconomics.com/mali/indicators ,
https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/ADB-BD-IF-98-87-EN-ESPS-003677830.PDF
http://planipolis.iiep.unesco.org/sites/planipolis/files/ressources/mali_2008_rndh.pdf
[5] Rapport_Annuel_2018_Situation_Inclusion_Financiere.pdf (bceao.int),
https://digitalcollections.sit.edu/cgi/viewcontent.cgi?article=2706&context=isp_collection ,
https://tradingeconomics.com/mali/indicators , https://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_4/colloques/23371.pdf

2. Eligible Local National Agricultural Banks (LNABs) and applicable terms

Five local national agriculture banks (LNABs) that have been subject to financial management capacity assessment will be the primary recipients of the GCF loan proceeds. These eligible banks for the implementation of the GCF loan proceeds (Component 1) are :

	Name	Acronym	Category
1	The Agricultural Bank of Burkina Faso,	BADF Burkina Faso	Universal Bank
2	The National Investment Bank of Côte d'Ivoire	BNI Cote d'Ivoire	Investment Bank
3	The ARB Apex Bank Limited of Ghana	Apex Bank Ghana	Mini-central bank for the Rural & Community Banks (RCBs)
4	The Agricultural Bank of Mali,	BNDA Mali	Universal Bank
5	The Agricultural Bank of Senegal.	LBA Senegal	Universal Bank

IFAD has worked together with these banks to set up the terms and conditions under which the GCF loans proceed will be administrated. The process first considers the formation of the interest rate by the banks for their business-as-usual activities and then evaluate how GCF concessionality will be applied for the IGREENFIN low emissions and climate resilient products.

Current interest rate calculation and pricing regime by the five (5) LNABS

WAEMU countries: Burkina Faso, Côte d'Ivoire, Mali and Senegal

Table 17 compiles interest rates communicated to IFAD by all LNABs on 2-3 September 2021. These exclude subsidized rates or rates supported by COVID-19 measures. The LNABS' interest rates have been determined based on the key determinants that inform the calculation of their interest rate for business-as-usual activity, discounted by the effect of the zero percent interest rate provided by GCF. This way, IGREENFIN ensures that the concessionality provided by GCF is retroceded down to the end-users and beneficiaries of the programme.

Table 17 : West African Monetary Union countries LNABS' interest rates

Determinants	Burkina	Côte d'Ivoire	Mali	Senegal
1. Cost of the resource	6.3%	6.54%	1.86%	2.0%
2. Management Fee	2.0%	2.30%	2.98%	3.5%
3. Cost of the risk	1.7%	3.5%	1.79%	3.0%
4. Margin	2.0%	0.46%	2.0%	4.0%
Interest rate (2021)	**12.0%**	**12.8%**	**8.63%**	**12.5%**

Table 18 : Non-WAEMU country: Ghana interest rates

Determinants	Ghana
Cost of the resource (Bank of Ghana Policy Rate @ March 2021)	14.5%
Weighted annualized interest @ June 2020	**16.98%**
Treasury bill rate @ June 2020	**16.89%**
Margin	2.52%
The interest rate that Apex bank offers its rural community banks shareholders	**19.50%**
The interest rate that community banks shareholders offer to final beneficiaries	**20.5 %**

Determination of the concessional interest rates to be applied to final beneficiaries

The final interest rate established by averaging the interest rate of the GCF loan with that of the LNABs is presented below. The blended interest rate applicable to final beneficiaries cannot be changed by the LNABs during the program's implementation, regardless of the quarterly review of the LNABs' interest rates using 50 % GCF and 50% LNABs' resources.

Table 19 : Example of average interest rate for IGREENFIN I

Country	Interest Rate in Local Currency Interest Rate in US$			
	GCF-IGREENFIN I	Agricultural Banks Fund	Commercial Banks Fund or MFIs	Average final interest rate to end-users
Burkina Faso	0%	12.0%	5%	**5%**
Côte d'Ivoire	0%	12.5%	4%	**4%**
Ghana	0%	20.5%	9.5%	**9.5%**
Mali	0%	8.63%	4%	**4%**
Senegal	0%	12.5%	4%	**4%**

LNABs interest as communicated on 2-3 September 2021

All details on each Bank's blended interest rate methodology and method of calculation are presented below. Considering the confidential nature of this information, this section shall be redacted from any public documentation to be submitted to the GCF.

BURKINA FASO - AGRICULTURAL BANK OF FASO (BADF)

1. **The current cost structure of the Bank's resources**

The average interest rate applicable to loans is currently about 12%, broken down as follows:

Determinants	Average cost
The average cost of resources	6,30%
Management fees	2,00%
Cost of risk	1,70%
Margin	2,00%
Average credit rate	**12,00%**

2. **Proposed rate applicable to IGREENFIN credits**

a. Determination of the average rate of resources:

Determinants	Average cost
The average cost of BADF resources (20% of financing)	6,30%
Average cost of IFAD resources (80% of funding)	0,000%
The average cost of all resources	**1,26%**

b. The basis for calculating the interest rate applicable to IGREENFIN financing:

Determinants	Average cost
The average cost of all resources	1,260%
Management fees	1,240%
Cost of risk	1,000%
Margin	1,500%
Average credit rate	**5,00%**

To obtain the prime rate of 5%, the BADF agreed to reduce about 2% on its management fees, the cost of risk, and its margins. This reduction was made based on the following non-exhaustive elements:

- Capacity building of bank staff and training of the various beneficiaries in credit management through the "grant" component of the program,
- The subscription to agricultural insurance by the beneficiaries,
- Etc.

This project is of interest to the BADF in more than one way. Indeed, it will allow the Bank to increase its volume of financing for the rural world. The low level of long-term resources and their high cost does not allow the Bank to offer loans at rates adapted to the agricultural sector's targeted clients. This Project could lead other institutions to commit to or intensify their financial interventions in the field of adaptation and resilience to climate change.

IVORY COAST – NATIONAL INVESTMENT BANK (NBI)

The methodological approach for the determination of interest rates is essentially based on the following variables:

The cost of resources

1. The cost of operation
2. The cost of risk
3. The bank base rate (TBB)

The methodological approach for the determination of interest rates is essentially based on the following variables:

1. The cost of resources
2. The cost of operation
3. The cost of risk
4. The bank base rate (TBR)

$$T_x = f(T_B, CNR,\ C_f,\ Marge\ )$$

$$T_x = (T_B + C_f + Marge) * (1 + CNR)$$

T_B: Base rate, determined by market spleen (yield curve) or resource cost

C_f : Operating cost
CNR : Net Cost of Risk

Given the particularity of BNI, with the majority of the Bank resources coming from the Government of Cote d'Ivoire, weighted average capital costs stands around 2%, more precisely at 1.47%. The operating cost, measured by the operating coefficient, is well controlled by the Bank and stands around 59% for an appetite threshold of 60%. The Bank's CNR is also in line with the good momentum of portfolio consolidation and stands at -0.37% for an appetite threshold of 0.20%. It is lower than the level observed on the Ivorian banking place, which is 1%.

In this case, the financing will be granted to a category of clients assimilated to the SMEs in our portfolio. To this end, the components of the determination of the interest rate for this target are:

- Net cost of risk: 12.80%
- Cost of resources: 3.5%
- Operating cost + margin: 2.30%

Thus, the exit interest rate is 6.54% ((3.5%+2.30%) *(1+12.8%) = 6.54%).
Considering a mix of resources, i.e., a contribution of resources from the Bank whose average cost is 1.47%, the exit interest rate will be 4.25% ((1.47%+0%) +2.30%)*(1+12.8%) = 4.25%. Rounded to 4%.
It should be noted that the maximum interest rate applied to SME customers is 12.5%.

GHANA - ARB APEX BANK LIMITED

The cost, margin, and interest rates presented in the two tables below have been thoroughly discussed and iterated in several discussions with the APEX and different IFAD departments and experts. Those discussions led to three different methodologies[1] to estimate an acceptable level of cost and margin for the different stakeholders. At the end of the process, those methodologies converged to similar results – most importantly a cost to the final beneficiary of approximately 9.5%, considering acceptable margins for the APEX and the RCBs.

- **Legal and Fiscal:** APEX acts as the investment manager of the fund (Fund Manager). APEX is therefore legally responsible for its legal and fiscal aspects.
- **Economic:**
-
    - The funds are disbursed in various trenches upon completion of milestones (performance-based disbursements).
    - As shown in Table 1 below, the funds on-lent to the selected financial institutions are expected to have an interest rate that will be the average between the funds provided by PROSPER (GCF IGREENFIN 1 resources at approx. 0% to 1% and IFAD resources at 2%) and the average cost of other funds for APEX (approx. 12%) – thus taking the average cost of the fund to approximately to 2%.

Table 1: the composition of the fund

Fund lines	Interest rate	Amount	Cost of fund Total	The average cost of fund[2]
1. GCF highly concessional loc for climate mitigation (aka, Functional line of credit for climate mitigation)	0%	$6.9 m	0m	2%
2. GCF highly concessional loc for climate adaptation (aka, Functional line of credit for energy for agriculture)	1%	$13.9 m	0.139m	
3. Contribution from the APEX's own resources. the PFIs (RCBs plus other qualified FIs)	12%[3]	$1.25 m from Apex $1.25 m from other PFIs	0.3m	
4. Other investors (private capital)/ other co-financiers (development partners), as possible[4]	4%	$1m	0.04m	
5. IFAD concessional loc to complement (fill the demand-supply gap)	2%	$14m	0.28m	
Total	NA	38.3m	0.759m	

Table 2 below shows how the interest rate would evolve based on the average cost of funds and the margin of the APEX and the RCBs, the costs of a guarantee instrument, and the cost of insurance.
It is assumed in this case that APEX would have a margin of approximately 2% on its loan. After that, the margin of the retail FIs (RCBs plus other qualified FIs) could be approximately 4.5% and would therefore need to be added to the interest rate applied to the retailers. In addition, it is expected that the APEX will subscribe to a guarantee instrument from GIRSAL, where the IFAD will also contribute up to 0.5%. In addition, customers may include in their business plan to subscribe to crop insurance (provided for example by the risk management instrument of the Ghana Agricultural Insurance Pool - GAIP) – this may be subsidized separately as part of the PROSPER project. This will take the interest rate charged to the customer to approximately 9.5% - which is significantly cheaper than the market rate offered by RCBs and other FIs to their agricultural customers.

Table 2: Estimates of the cost of the final beneficiaries

Elements	Average Weighted Annualized Cost of Funds	Cost of fund APEX	Average Weighted Annualized Cost of Funds (including the cost of fund APEX)	GIRSAL / APEX Credit Guarantee Premium[5]	IFAD Contribution on GAIP Insurance	Interest Rate for On-Lending to RCBs and S&Ls	The margin of the RCBs	The interest rate applied to the clients (farmers)
Cost	2.0%	2.0 %	4.0%	0.5%	0.5%	5.0%	4.5%	9.5%
Reference	a	b	1=a+b	2	3	4=1+2+3	5	6=4+5

MALI - NATIONAL BANK FOR AGRICULTURAL DEVELOPMENT (BNDA)

Table 1: Calculation of the BNDA bank base rate

Determinants	**31-Dec-19**	**31-Dec-20**	**30-Jun-21**
GNP	38 067	43 535	43 506
Average gross productive uses (a)	430 626	435 173	475 461
Interest Accounts Payable Resources (b)	7 129	7 552	8 848
Average effective resource rate (b/a)	*1,66%*	*1,74%*	*1,86%*
Overhead (c,)	20 432	23 378	23 662
Intermediation rate (c/a,)	*4,74%*	*5,37%*	*4,98%*
TBB (b/a+c/a)	**6,40%**	**7,11%**	**6,84%**
Net change in provisions (d)	6 900	8 132	8 500
Cost of risk (d/a)	1,60%	1,87%	1,79%
Cost of jobs (TBB+d/a)	**8,00%**	**8,98%**	**8,63%**

Table 2: Calculation of the exit rate of IGREEFIN files

Determinants	**% rate**
Average effective resource rate (b/a)	*0,00%*
intermediation cost	*2,00%*
TBB	**2,00%**
Cost of risk	2,00%
Cost of jobs	***4,00%***
Margin rate	***0,79%***
Proposed exit rate	***4,79%***

- *Since the IGREENFIN credit line is sold at a zero rate, resources' cost is 0%.*
- *The BNDA has decided to make an effort on the intermediation and risk costs which now amount to 2% each. These two costs constitute the cost of jobs (4%)*

These two costs are added a margin rate of 0.79%, resulting in an exit rate of 4.79% for the IGREENFIN portfolio.

SENEGAL – THE AGRICULTURAL BANK (LBA)

Out-of-resource IGREENFIN (LBA) exit rates
The determinants of interest rates revolve around the following points:

- The cost of the resource estimated at 2% (the ratio of commissions and interest charges paid / the average outstanding resources)
- Management or approach fees valued at 3.5% (the ratio of overheads / average outstanding jobs)
- The cost of risk estimated at 3% (the ratio of net staffing (doubtful – provisions) / average outstanding jobs)
- The expected margin rate on the activity is 4%

This calculation brings us back to an exit rate of 12.5%

1. Exit rates with IGREEFIN resources

Considering the zero cost of the IGREENFIN resource, it will cover the three compartments: the cost of risk, management fees, and margin. Thus, the pricing of the exit rate to beneficiaries will depend on the level of fees paid by the lessor for the management of resources, the modalities of disbursements, and repayment.
In addition, the use of agricultural insurance reduces the cost of risk.
All these factors combined allow us to offer an exit rate to beneficiaries of around 4%

[1] The tables 1 and 2 present a first simple methodology for project design high level estimates. There is also a second methodology used in the private sector to provide funding facilities in the context of public / private partnership. A third methodology has been used by APEX, in their standard planning internal templates.
[2] for the blended fund managed by the APEX
[3] The rate of 12% has been defined based on the rate that the APEX and the RCBs get when buying government bonds of Ghana.
[4] In the initial phases of the project other investment partners will be approached to see if they could also invest in the project. Given the low interest rate that is required under this project by the final beneficiaries (below 10%), it will be important to approach development funds that have access to highly subsidized private funds, and/or ensure that the volume of fund they on lend remains marginal in the blend (1m for example) – to avoid increasing the price to the final beneficiary. The project will consider approaching in this context the Ghana's Securities and Exchange Commission, which is developing a Green Bonds Market and its risk management instruments.
[5] Cost for risk guarantee instrument GIRSAL.

Section VII – Market scoping – Evidence of existing demand and market growth potential

This section summarizes the findings of a market scoping study commissioned by the IFAD to inform the design of the IGREENFIN programme focusing on the five countries of the Phase I.: It assesses the access to agriculture finance landscape for smallholder farmers in the 5 countries. Through virtual meetings and IFAD baseline investments field missions, small holder farmers and agri-preneurs as well as representatives of cooperatives, farmer's organizations and MSMEs were interviewed in each of the five countries to understand their opportunities and challenges in accessing finance and business growth from a demand perspective. Similarly, national agricultural banks, commercial banks and non-bank financial institutions were interviewed to understand both demand side and the supply-side constraints in providing finance for smallholder farmers. Furthermore, a financing gap analysis and banking mapping were completed to obtain a broader picture of the agricultural finance landscape in the region as well the energy sector to invest in when it comes to low emission agriculture.

The findings reveal that the landscape for Smallholder farmers' access to finance in West African and countries within the Great Green Wall remains very limited. When finance is available, the lending terms are not attractive to smallholder farmers (high interest rate, short repayment. The financial institutions perceive women/youth and businesses as risky due to their low number of assets and smaller business size and the impact of climate change. In addition, banks' poor understanding of smallholder farmers results in demands for high-value collateral and the charging of high interest rates. For instance, in Cote d'Ivoire, the collateral requirement was seen as the biggest issue hampering access to finance, followed by high interest rates, resulting in low profit margins. Additionally, smallholder's farmers lack confidence in formal institutions and thus are not willing to ask for a loan. The smallholder farmers' educational attainment and their financial literacy are usually lower; consequently, they are not aware of the development funds or financial products available including highly green concessional climate fund that could better serve them. In general, there is a sound financial system, and many agricultural programmes are available, but smallholder farmers particularly youth and women still face numerous challenges in accessing those funds to adopt climate resilient and low emission agriculture. In addition to limited access to domestic and international market information, market regulations, socio-cultural norms further hamper their competitiveness and business growth.

Going forward, IFAD wish to consider further enhance the prospects for successful programme design and implementation. The vision for IGREENFIN is rightfully ambitious and innovative but IGREENFIN needs to treat smallholder farmers in agri business as a heterogeneous group of actors with different backgrounds, skills, literacy levels, ages, firm sizes, and, therefore, different needs. To be successful, IGREENFIN needs to take a country-by-country approach, use cooperatives, MSMEs, Farmers Organizations as entry points and leverage existing best practices in promoting access to finance particularly the first initial green finance. IGREENFIN will not be successful in isolation given the magnitude of the issue and the model should be seen as a catalyst for market forces and the private sector to take over once there is solid proof of concept and solid pipeline of projects financed under IGREENFIN. A clear implementation plan and growth strategy are integral parts of the programme's long-term financial sustainability framework and are essential to communicating a long-term partnership vision to participating financial institutions under the Great Green Wall Umbrella Programme. A short-term (at most one year) flagship programme should be launched. This will ensure this IFAD potential climate finance brand is picking up in a timely fashion if the approach is working or if adjustments are necessary.

Section VIII - Initial pipeline

During the design of IGREENFIN I, various meetings (virtual and on site) were organized to collect each bank potential pipeline to invest in with IGREENFIN I loan proceeds. Each bank prepared a demonstrations pipeline extracted from its 2021 and 2022 demand portfolio. Part of the portfolio submitted to the banks was selected and a demonstration pipeline was prepared and finalized during a technical meeting organized by IFAD with key all banks on 2 and 3 September 2021 in Abidjan. The demonstration pipeline provides models which required to be completed using IGREENFIN I investments criteria for activities that can be financed by loan proceeds. At implementation stage, the technical assistance facility will support banks and their clients to finalize the pipeline in line with GCF investment criteria's for IGREENFIN I. The summary of demonstration pipelines is summarized below for each country and group per value chain. The pipeline for the first 12 months represents a total demand for low emissions and climate resilient credits for a minimum amount of more than USD 22 million. This represents an indicative pipeline testifying the demand for the IGREENFIN credits offerings.

USD

Table 20 : Demonstrated Pipeline per country

Cote d'Ivoire	Ghana	Burkina Faso	Mali	Sénégal	Total
4532040	6697019.86	2963200	6864000	1074800	**22,131,060**
20%	30%	13%	31%	5%	**100%**

The pipeline composition is dominated by MSME but comprise a wide varieties of actors consistent with the eligibility of the beneficiaries targeted by IGREENFIN.

Table 21 : IGREEFIN I – Year 1 synthetic pipeline composition

Association	**3**	**3%**
Cooperative	16	15%
Farmers Organisations	10	9%
Economic groups	16	15%
Micro-entreprise	7	6%
MSMEs	41	38%
Individuals	9	8%
Women groups	4	4%
Youth groups	2	2%
	108	100%

Section IX - Business model and Bankability

The Economic and financial analysis performed for the preparation of this programme demonstrated that GCF involvement is critical for the successful implementation of the IGREENFIN business model. The GCF concessionality is necessary to make investments economically viable while creating needed awareness to address climate impacts that affect severely the agricultural sector in the five countries. Moreover, the investments to be promoted through IGREENFIN loans deployed through the national agriculture banks will improve climate resilience, they will also pave the way for the adoption of sustainable practices in the sector, limiting both the carbon footprint and environmental impacts that is generally associated with current agriculture practices. Support can be tailored to different types of beneficiaries, using a differentiated approach. The following sections present results aggregated by beneficiary and by country, to determine the extent to which the investments implemented will be more or less profitable for targeted beneficiaries in each country. These results may then inform the approach used to offer targeted support to farmers. For example, there is an expectation that the provision of more advantageous financing conditions benefits farmers' organizations, who normally face the highest financing risk.

Ten Value Chains (VCs) have been analyzed, considering the implementation of one or more Climate Resilient and Low Emission Agriculture practices and technologies. A synthetic portfolio composition prepared together with the agricultural banks from each country has also been analyzed to understand socio-economic impacts associated to investments in a package of solutions that will address more effectively the challenges posed by climate change to these farmers. This analysis should be interpreted as indicative of the likely impact of the project. It reflects results associated to the specific package assessed and may in fact differ from the actual impacts of implementation over the next 6 years if different practices/ technologies are chosen and implemented. The analysis has been performed for each value chain being supported and the aggregated results for the entire program provided. The analysis of each investment considers the lifetime of the intervention (ranging between 1 and 20 years depending on the type of investment analyzed). The analysis also considered the discount rates owing to GCF contribution. Further, the results consider the full lifetime of investments, which often goes well beyond the duration of the project (6 years). As a result, both revenues and externalities extend beyond the formal duration of the involvement of GCF and other partners in the project.

Overall, the results are positive, indicating that the investments will generate value for farmers. Further, it is possible to note the size of the positive externalities generated, which is comparable (generally slightly lower) to the revenues generated by the project. This highlights the importance to consider the societal impacts of investment in climate adaptation, in addition to the direct economic benefits these generate.

Concerning specific types of investments, six over ten (6/10) value chains show both positive IRR and BCR (for both assessments, 1ha/1head and programme), which means that they are profitable investments in all the assessed countries: VC2, VC3, VC6, VC7, VC9, and VC10. The remaining VCs are at times not economically viable with the assumptions used about impacts on productivity and related revenue creation, and costs of implementation. The following tables present a variety of results, for all the VCs and for all the countries analyzed.

9.1. Burkina Faso

	Portfolio composition		
	FOs	MSME	Cooperatives
VC1			
VC2			
VC3			29.63%
VC4			
VC5			25.93%
VC6	0.40%		
VC7		100.00%	44.44%
VC8	98.94%		
VC9	0.66%		
VC10			

A - Portfolio composition in Burkina Faso

	NPV	S-NPV	BCR	S-BCR	IRR	S-IRR
FOs	$1,947.57	$2,070.47	1.43	1.45	43%	46%
MSME	$0.64	$0.64	1.09	1.09	19%	19%
Cooperatives	$622.21	$763.02	1.86	1.96	29%	31%

B- 1ha/1head – beneficiaries in Burkina Faso

	S-NPV	NPV	S- IRR (lifetime)	IRR (lifetime)	S-Benefit to cost ratio (lifetime) / discounted	Benefit to cost ratio (lifetime) / discounted
FOs	$825,355	$761,709	26%	24%	1.26	1.22
MSME	$4,235,979	$4,235,979	82%	82%	2.54	2.54
Cooperatives	$3,360,493	$3,181,530	57%	55%	2.35	2.22

C- Programme – beneficiaries in Burkina Faso

Table A shows the portfolio composition in Burkina Faso. FOs and MSME will receive funding for mainly one VC each, VC8 and VC7 respectively. This is why the results shown in Tables B and C, beneficiaries are similar, if not identical, to those VCs. On the other hand, the portfolio of cooperatives is a mix between VC3, VC5, and VC7.

9.2. Ghana

Table X : Portfolio composition in Ghana

	Portfolio composition		
	FOs	MSME	Cooperatives
VC1	8.73%		
VC2	15.87%		
VC3			
VC4			
VC5	23.81%		
VC6	19.84%		
VC7		100.00%	
VC8	17.86%		
VC9	13.89%		
VC10			

Table Y 1ha/1head – beneficiaries in Ghana

	NPV	S-NPV	BCR	S-BCR	IRR	S-IRR
FOs	$769	$1,047	1.70	1.89	79%	112%
MSME	$0	$0	1.06	1.06	19%	19%
Cooperatives	$-	$-	0.00	-	0%	0%

Table Z – Programme beneficiaries in Ghana

	S-NPV	NPV	S- IRR (lifetime)	IRR (lifetime)	S-Benefit to cost ratio (lifetime) / discounted	Benefit to cost ratio (lifetime) / discounted
FOs	$1,873,193	$1,363,477	48%	35%	1.59	1.27
MSME	$4,011,263	$4,011,263	81%	81%	2.09	2.09
Cooperatives	$-	$-	0%	0%	0.00	0.00

Table X shows the portfolio composition in Ghana. In this case, cooperatives are not considered. Like in Burkina Faso, also in this country MSME will receive investments only for VC7. The portfolio of FOs is a mix of six different VCs, showing positive results in both the 1ha/1head assessment (Table Y) in the programme assessment (Table Z)

9.3. Ivory Coast

Table U: Portfolio composition in Ivory Coast

	Portfolio composition		
	FOs	MSME	Cooperatives
VC1	29.76%	55.56%	
VC2	8.47%		33.33%
VC3			
VC4			
VC5	29.76%		
VC6			
VC7			
VC8	0.28%		33.33%
VC9			
VC10	31.74%	44.44%	33.33%

Table V: 1ha/1head – beneficiaries in Ivory Coast

	NPV	S-NPV	BCR	S-BCR	IRR	S-IRR
FOs	$2,031	$2,523	1.83	2.11	42%	80%
MSME	$2,482	$3,055	2.07	2.53	52%	118%
Cooperatives	$3,528	$3,647	2.22	2.28	75%	81%

Table W: Programme– beneficiaries in Ivory Coast

	S-NPV	NPV	S- IRR (lifetime)	IRR (lifetime)	S-Benefit to cost ratio (lifetime) / discounted	Benefit to cost ratio (lifetime) / discounted
FOs	$3,268,932	$2,320,223	42%	26%	2.06	1.71
MSME	$4,497,177	$2,983,608	57%	31%	2.51	1.97
Cooperatives	$4,016,909	$3,800,270	50%	47%	2.19	2.11

Table U shows the portfolio composition in Ivory Coast. Each beneficiary shows a portfolio with a different mix of VCs, from cooperatives, where investments in three value chains are split equally, to FOs, where VC8 represents only 0.28% of the total investment, while VC10 accounts for almost one-third of it. Nevertheless, the financial and economic indicators shown in both Table V and Table W are similar among these countries.

9.4. Mali

Table K: Portofolio composition in Mali

	Portfolio composition		
	FOs	MSME	Cooperatives
VC1			
VC2			
VC3	33.33%	29.39%	11.11%
VC4		23.51%	55.56%
VC5		19.84%	
VC6	33.33%	3.67%	22.22%
VC7		13.96%	
VC8	33.33%	5.95%	
VC9		3.67%	
VC10			11.11%

Table L: 1ha/1head– beneficiaries in Mali

	NPV	S-NPV	BCR	S-BCR	IRR	S-IRR
FOs	$801	$897	2.69	2.82	40%	44%
MSME	$783	$943	1.95	2.05	31%	38%
Cooperatives	$1,138	$1,173	2.19	2.25	34%	35%

Table M: – Programme beneficiaries in Mali

	S-NPV	NPV	S- IRR (lifetime)	IRR (lifetime)	S-Benefit to cost ratio (lifetime) / discounted	Benefit to cost ratio (lifetime) / discounted
FOs	$3,203,483	$2,954,075	36%	33%	2.40	2.23
MSME	$3,505,687	$3,279,398	53%	49%	2.38	2.24
Cooperatives	$4,724,912	$4,604,149	69%	68%	2.86	2.78

Table K shows the portfolio composition in Mali. The portfolio of each beneficiary is a mix of different VCs. The NPV, IRR, and BCR shown in both Table K and Table L indicate that these portfolios in Mali will generate positive outcomes for all the interested beneficiaries.

9.5. Senegal

Table E: Portfolio composition in Senegal

	Portfolio composition		
	FOs	MSME	Cooperatives
VC1		43.76%	
VC2			
VC3		22.45%	36.14%
VC4			
VC5		2.75%	
VC6		11.68%	53.49%
VC7			
VC8			
VC9			
VC10		19.35%	10.37%

Table F: 1ha/1head – beneficiaries in Senegal

	NPV	S-NPV	BCR	S-BCR	IRR	S-IRR
FOs	$ -	$ -	0.00	-	0%	0%
MSME	$ 1,055	$ 1,464	2.10	2.48	39%	90%
Cooperatives	$ 1,546	$ 1,584	3.32	3.38	58%	59%

Table G: Programme– beneficiaries in Senegal

	S-NPV	NPV	S- IRR (lifetime)	IRR (lifetime)	S-Benefit to cost ratio (lifetime) / discounted	Benefit to cost ratio (lifetime) / discounted
FOs	$-	$-	0%	0%	0.00	0.00
MSME	$4,109,927	$2,828,317	49%	27%	2.29	1.82
Cooperatives	$6,481,245	$6,100,512	54%	52%	2.96	2.79

Table E shows the portfolio composition in Senegal. In this case, FOs are not considered, while the portfolio compositions of both MSME and cooperatives generate positive IRR, BCR and NPV, as indicated in both Table F and Table G.

Section X – Socio economic value creation

IGREENFIN I and the Regional Support Programme have identified and adopted the following UN SDGs and mapped each of the target sectors to them: No poverty (SDG 1); Zero hunger (SDG 2); Gender equality (SDG 5); Clean water and sanitation (SDG 6); Affordable and clean energy (SDG 7); Decent work and economic growth (SDG 8); Climate action (SDG 13); Life on land (SDG 15), and Partnerships for the Goals (SDG 17).

Environmental co-benefits: The programme is designed to help secure multiple environmental benefits for water, air, land and nature by promoting the adoption of best adaptation and mitigation practices and technology, which will enhance the sustainable management of natural resources, protect threatened dryland biodiversity and against erosion and desertification, and increase the potential for carbon sequestration. These benefits could also contribute to the increased resilience of the regions' ecosystems and human livelihoods to climate change and variability and the GGW's overall objectives (land restoration, job creation and CO2 emission reduction). The programme intends to reduce the use of energy from biomass, including firewood and agricultural residues, imported diesel fuel electricity and charcoal which are the main sources of electricity in the five countries by providing greater access to renewable energy. It is expected that CO2 emissions (14,741 million tCO2 eq) will be reduced during the programme's lifecycle thanks to agroforestry and SLM practices (this amount will further increase once the avoided emission from RET is integrated) and limits will be placed on the use of biomass and diesel for energy consumption through the adoption of RET. With the promotion of EbA and agroforestry techniques, more than 100,000 ha of degraded land will be restored and sustainably managed with improved ecosystem goods and services. The programme will build up each link in the selected agricultural value chains (including livestock and NTFPs) from production to markets, increasing the productivity for key commodities and farmers' incomes while safeguarding the environment. Through the adoption of climate resilient agriculture, the programme will reduce soil erosion and soil fertility loss, enhance soil moisture retention and maintain soil temperatures suitable for crop production.

Social co-benefits including health impacts: The activities proposed under this programme will generate multiple job opportunities for rural people, particularly for youth and women, promote inclusion and support coherent investment through farmers organizations, cooperatives and MSMEs. By promoting local low emission and climate resilient options, the programme will contribute to cost-saving health benefits thanks to cleaner air for local communities and access to clean energy, water and food, thus reducing food insecurity. As described in the gender action analysis and action plan, the programme will support women's participation in decision-making and greater access to financing and assets and improve their livelihoods. The targeted areas considered the most vulnerable and selected through IFAD baseline investments will be positively impacted by the programme.

Economic co-benefits: The economic benefits of this programme are linked to its high potential to reduce poverty through increased productivity of key crops and livestock production, as well as income generation activities (IGA), such as the production of and value addition to different fruit and NTFPs, including tamarind, Arabic gum, baobab leaves as well as fodder and seedlings sales. The GGW implementation status report indicated that revenues from IGA since 2007 have amounted to approximately US$90 million across all 11 GGWI countries, with Burkina Faso being more successful in creating IGA opportunities than the others. Revenues reported per country are as follow: Burkina Faso, US$6.8 million, and US$50,000 for Mali and Senegal each. A stable inflow of revenues from natural products and services is important in terms of exit strategies that contribute to the sustainability of the restoration projects over time. By promoting IGA and opportunities for

livelihood improvement, the programme will help better the living conditions in the five participating countries that are among the poorest and the most vulnerable to climate change in the world. The programme will contribute to create 703,600 jobs90. By doing so, the programme provides a unique opportunity to put an end to poverty traps.

Gender-sensitive development impacts: Women are increasingly and disproportionately affected by climate change. In the five participating countries, women play a central role in feeding their families and ensuring other basic needs (water, fuel for firewood, etc.). This responsibility has become harder to assume because of declining crop yields due to climate change (primarily higher temperatures and unpredictable rainfall patterns). The programme will increase opportunities for livelihood improvement and provide concrete benefits to smallholder farmers and pastoralists, both men and women. The implementation of targeted activities can potentially offer an array of advantages to local communities, such as greater yields, improved soil fertility, fodder availability, as well as shorter wood and water collection time for women, freeing up their time so they may engage in other productive tasks. Through its focus on gender mainstreaming and women's economic empowerment, this programme will support the reduction of entrenched gender inequalities in rights to land resources and access to technology and information that hamper women's capacity to manage current climate risks and adapt their livelihoods to long-term climate change trends.

The programme has set targets: 50 per cent of loans are to be granted to women-led MSMEs, cooperatives and FOs. The other 50 per cent will be dedicated to Men of which 50% will be youth-led MSMEs, cooperatives and FOs in which young women participate. Specific actions will be developed to strengthen the technical and managerial capacities of women aimed at providing them with appropriate tools for identifying and developing bankable business plans and improving their level of financial education. As stated in the gender action plan, gender-disaggregated data will be assessed against the appropriate indicator to measure women's enhanced access to loans. The project intends to close the gender gap, as women represent 60 to 70 per cent of the work force and do not have access to productive assets, finance and knowledge. At least 1/3 of the women will be included into the National Steering Committee to ensure that they influence the main strategic decisions.

90 The number of job created is calculated by adding the direct number of jobs created for each of the direct beneficiaries plus the average number of jobs created for the 1500 MSMEs and 2500 FOs or Cooperatives assuming that one MSME has on average 50 people and FOs about 70 people

Part II – Advancing the GGW Initiative under the Regional Support programme

1. Introduction

This part II analyses the different elements required to ensure the effective implementation of the GGW Initiative through the Regional Support programme.

2. Challenges and barriers to the Great Green Wall implementation

The report 'The Great Green Wall: Implementation Status and Way Ahead to 2030'[91] published by the UNCCD in September 2020 provides an overview of the main challenges encountered by the countries and implementation partners in the execution of GGW activities, which include:

1. **Weak environmental governance and donor fragmentation**: An overarching issue appearing in most GGW countries is weak governance in the field of environmental change, which is a main barrier to implementation. Institutional challenges include the lack of high-level political support for the environmental policy agenda from the governments of the GGW member states and weak organizational structures and processes for the implementation of environmental projects, development initiatives or programmes. As a result of the lack of structures and processes for handling environmental matters and developing policy frameworks, national GGW agencies have not yet been established.
2. **Limited coordination of knowledge management**: The lack of managed knowledge, information sharing and coordination mechanisms at the national and regional level leads to insufficient coordination and collaboration between GGW countries, project developers and donors. This is especially important for taking advantage of lessons learned, innovations and success stories, whose replication and scaling up could accelerate and ensure an efficient expansion of the GGW initiative's activities.
3. **Unstructured monitoring and evaluation (M&E) systems**: A fundamental barrier is the lack of a system to monitor and report on GGW activities on the ground. The problems identified between 2011 and 2017 clearly indicate a need for better overall follow-up and monitoring. M&E expertise is absent in general, which hampers the establishment of proper M&E systems at the project and national levels and across the GGW Initiative as a whole. It also results in shortcomings in documentation and hinders the sharing of lessons learned, which is key to avoid negative developments and capitalize on positive results achieved by the projects under the GGW.
4. **Access to finance in particular from the private sector**: An estimated US$2.6-4.3 billion is needed to restore the 100 million hectares of land in Sahel and achieve the GGW objectives. Mobilizing and absorbing finance requires adequate structures, processes, and capabilities to be in place within national governments, at the local level and among project developers/managers. Most GGW countries still face difficulties in establishing the required governance and project structures for attracting, accessing, managing, and reporting on large(r) finance flows. Exploring "untraditional" finance mechanisms by involving the private sector (IUCN Conference on Mobilizing Private Sector Investment in the GGW[92]) in land use and land restoration activities under the GGW initiative could be a great opportunity to complement the somewhat limited funding that has been mobilized so far. However, this remains a very challenging undertaking.
   There are various challenges related to developing bankable projects in such an extreme environment when targeting the land use sector, such as scale, land rights/ownership, community involvement and low(er) profitability expectations, among others. Apart from a few

[91] https://www.unccd.int/publications/great-green-wall-implementation-status-and-way-ahead-2030
[92] Mobilizing private sector investment in the GGW, Recommendations and Actions, IUCN Conference, 23-25 March 2021

larger, commercial forestry or agribusiness/food operations, most conventional restoration projects generate returns that are too low to attract private investors. Furthermore, it is difficult to ensure the continuity, long-term sustainability, and replication of these projects in the context of the Sahel and thus, they are considered riskier than other investments.

Pilot initiatives have established a range of restoration and sustainable land management approaches that have great potential to go to scale. However, there is a significant shortfall in resources and particularly in private investment in the region. Agriculture in the Sahel is insufficiently financed in general, despite this sector's contribution to employment, sustainable growth, and innovation. Renewable energy, such as solar, also has significant potential in terms of investment, job creation and private sector involvement. However, long-term finance is insufficient, as is the technical assistance needed to strengthen the monitoring of social and environmental impacts and building support for cooperatives for value-addition (including processing and marketing). Conflicts and issues related to governance, land tenure, climate impacts and limited data are some of the challenges faced by companies willing to invest in the agricultural value chains in the GGW countries. Promising opportunities include investing in agri-SMEs, global value chains and high value crops and new markets (such as food, carbon, and humanitarian relief markets).

Overcoming the barriers to investment in the GGW requires adequate information, awareness raising, implementation of relevant investment pilots, capacity-building (e.g., in mobilizing financing for the GGW) and addressing 'aggregators', such as land tenure and public policy.

3. Key lessons learned from the past GGW projects/programmes

Regional projects, programmes and programmatic approaches offer a number of lessons learned. The GGW Regional Support Programme will build on these lessons – particularly those from the World Bank SAWAP and the GEF7 Impact Program on Food Resilience - to maximize the overall impacts of individual projects.

Table 22 : Lessons learned and recommendations from regional approaches to programmes

Lessons learned	Recommendations
• Limiting the number of implementing agencies of regional support programmes helps reduce the complexity of reporting and bureaucracy. • It is key to ensure enough resources for knowledge management and M&E, both financial and human resources in support units and at country level. • When building M&E and knowledge management platforms, their sustainability and maintenance (hosted vs. managed by service provider) should be carefully considered.	• A consultative committee for regional multi-agency programmes is preferred to a steering committee to reduce the complexity of governance arrangements. • A common ground for defining knowledge management activities (languages, sub-region, thematic and size of projects, etc.) has proved to increase impact. • Countries are interested in designing an M&E system to harmonize indicators and methodologies and create a community of practice[1]. • All projects should include geo-referencing, mapping, and baseline data collection for all intervention sites[2].

• When working across a region with various languages, there is a need to allocate sufficient resources for translation of documents • Consistency of indicators across projects will allow for comparing/sharing	

[1] https://documents.worldbank.org/en/publication/documents-reports/documentdetail/343311608752196338/sustainable-land-management-in-the-sahel-lessons-from-the-sahel-and-west-africa-program-in-support-of-the-great-green-wall-sawap
[2] Ibid.

4. Closing the Gaps in the Great Green Wall

The Great Green Wall Accelerator

As indicated in the UNCCD report on the status[93] of the GGWI released in September 2021, if the current level of funding and pace of implementation continue, the GGWI's objectives and all the co-benefits of this flagship initiative will not be met. According to this report, it is estimated that a minimum investment of US$33 billion from national and international sources will be required to support countries in achieving the GGW objectives by 2030. With the shift in focus of the GGWI from tree-planting to more comprehensive rural development, including improving the production systems that underpin livelihoods of smallholder farmers and pastoralist communities to increase food security, create jobs and boost the local economy through sustainable land management, countries are now tackling systemic challenges in an integrated and holistic manner to ensure long-term sustainability in the entire Sahel region. The need for stronger support, coordination and engagement by development partners, international financing institutions and the private sector is not only critical for harnessing emerging technologies and innovations, but also for promoting policy options that unlock market opportunities and capital for scaling up interventions. Financial needs for impact at scale are estimated to average between US$40-130 million per country annually. More resources will thus have to be mobilized from a range of domestic and international sources, including multilateral development banks, special financing mechanisms such as the GEF, the Least Developed Countries Fund, and the GCF, as well as bilateral partners, civil society organizations and the private sector[94].

In September 2020, at the online meeting of the GGW Ministers organized by the UNCDD, the GGW countries invited the GCF and the other international entities to boost their support for the GGW initiative[95]. In response to this invitation, in January 2021, during the One Planet Submit, financial institutions committed to support the GGW objectives in the eleven GGW countries through the launch of a Great Green Wall that seeks to facilitate and strengthen the coordination and collaboration of donors and stakeholders involved in the GGWI and better monitor and measure the impact of their actions. The Accelerator will be coordinated through the Pan Africa Agency for the Great Green Wall (PAAGGW), with initial support from the United Nations Convention to Combat Desertification (UNCCD).

[93] https://www.unccd.int/publications/great-green-wall-implementation-status-and-way-ahead-2030
[94] https://www.thegef.org/sites/default/files/publications/gef_great_green_wall_initiative_august_2019_EN_0.pdf
[95] https://www.unccd.int/news-events/ministerial-declaration-great-green-wall

This Accelerator aims to address several of the barriers presented above by providing a common M&E framework to all donors who pledged additional support to the GGW objectives during the One Planet Submit. The Accelerator will also give greater visibility to the GGWI and mobilize additional financial resources from the private sector to accelerate the pace of implementation. The Accelerator is organized around five pillars:

(1). Investment in small and medium-sized farms and strengthening of value chains, local markets, organization of exports
(2). Sustainable management of ecosystems and land restoration
(3). Climate resilient infrastructures and access to renewable energy
(4). Favourable economic and institutional framework for effective governance, sustainability, stability and security
(5). Capacity-building

Pledges amounting to 14.3 billion euros in funding for the GGWI until 2025 were made by several multilateral and bilateral organizations at the Summit. The figure below shows the pledges made by each agency conditional to approval[96].

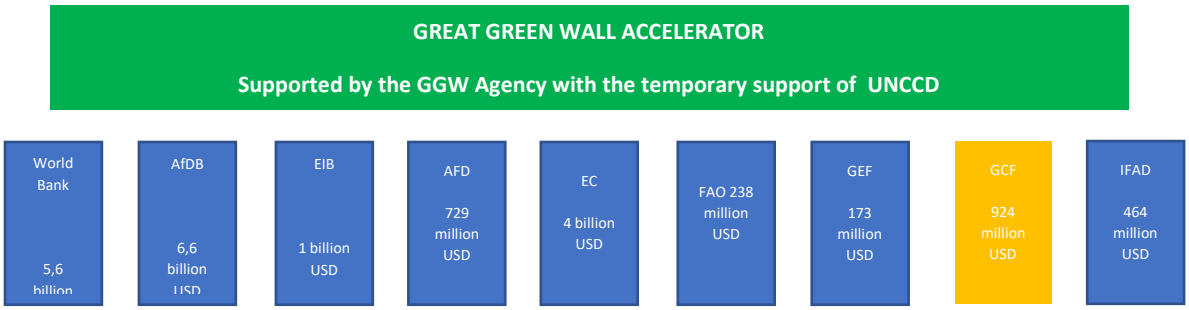


Figure 10 : Overview of the proposed contributions to the GGWI to be coordinated by the Accelerator

The GGW Accelerator The following pledges per pillar have been made to the GGW Accelerator:

[96] GCF contribution is conditional to GCF Board approval and GEF contribution is indicative as the final amount will only be known after the 8th replenishment and discussions with countries on the utilization of their STAR.

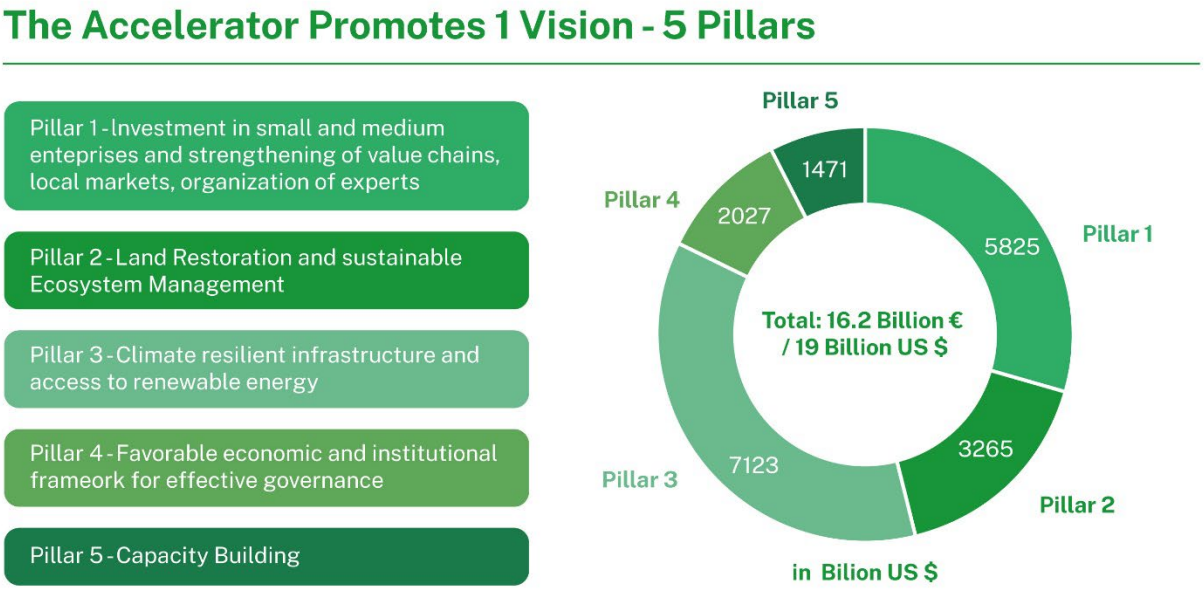


Figure 11 : GGW Accelerator main pillars

The Global Environmental Facility investments in the GGW

The Global Environment Facility has played a leading role in influencing a shift from the initial vision of a tree planting venture, to one that was focused on integrated management of natural resources for improving livelihoods and landscapes. In response to demands of countries in the region, the GEF has invested over US$800 million in grants and catalyzed an additional US$6 billion from national governments, development partners, and other multi-lateral for projects in the Sahel region. This financing has helped the GGW member countries to increasingly promote practices for improving crop and livestock productivity and restoring degraded parklands and strengthening resilience and adapting to climate change through a range of strategies[97]. Building on GEF experience with the integrated approach programs[98], the GEF 7 project "Harnessing the GGWI for a Sustainable and Resilient Sahel "is currently being implemented by UNEP to engage with all GGW stakeholders in fostering dialogue with countries, fleshing out a longer-term vision and serve as the vehicle to design a program with potential to mobilize larger investments in GEF-8. GEF-8 resources to support the GGW will be determined upon completion of the replenishment process and discussion with beneficiary countries on the use of their STAR allocations.

The GGW Regional Support Programme

In response to the call for pledges during the One Planet Summit in January 2021, the Green Climate Fund invited FIDA to develop a Regional Support Programme for the Great Green Wall. The objective of the regional programme is to enhance the collective impact of individual GCF projects and programmes which may otherwise be implemented in silos by facilitating knowledge exchange and innovation. The GCF will continue to set the strategic direction of its investments and to approve projects presented by Accredited Entities that contribute to the five

[97] GEF supported projects on the GGW from GEF-4 through GEF 6 cycles: https://www.thegef.org/sites/default/files/publications/gef_great_green_wall_initiative_august_2019_EN_0.pdf

[98] Relevant GGW related integrated approach programs include: TerrAfrica and the GEF4 Strategic Investment Program (SIP); GEF-5 Sahel and West Africa Program to Support the GGWI (SAWAP/BRICKS); GEF-6 IAP on Food Security (RFS); GEF-7 Food Systems, Land-Use and Restoration Impact Program (FOLUR); GEF7 Dryland Sustainable Landscapes Impact Program (DSL IP).

pillars defined by the GGW Accelerator. It will contribute to enhanced collaboration, increased efficiency, streamlining action and delivering increased impact between projects but will not play a coordination role in the project preparation and implementation nor in the strategic investments of the GCF in the GGW.

Long-term vision for collaboration between GCF and GEF

The Long-Term Vision on Complementarity, Coherence, and Collaboration between the Green Climate Fund (GCF) and the Global Environment Facility (GEF)[99] responds to the need to building on experiences gained from ongoing collaboration between the GCF and the GEF and responding to the needs of developing countries.

The Long-Term Vision on Complementarity, Coherence, and Collaboration between the Green Climate Fund (GCF) and the Global Environment Facility (GEF)

1. ***Coordinated support for major initiatives****:* To provide support in line with each Fund's strengths, as well as exploring mainstreaming gender as such collaborations are developed.
   - 1.1. ***Facilitation of national investment planning:*** Support, through existing programming processes and communicating of the long-term vision on complementarity, country-owned national planning and priority setting for programming to utilize opportunities across the GEF and GCF.
   - 1.2. ***Develop a list of activities or programs each fund will prioritize:*** The two funds will aim for better coordination and greater efficiency of project and program preparation by streamlining consultation processes with countries, optimizing number of missions and consultants involved, and identifying potential duplication of funding, among others.
   - 1.3. **Support collaborating financing platforms**: As part of the coordinated support for major initiatives (see objective 1 above), the two funds could support the establishment and deployment of collaborating financing platforms.
2. **Sharing information, lessons learned and knowledge**
   - **2.1. Information sharing, exchange and application of lessons learnt from portfolio to strengthen implementation of projects and programmes:** The Funds will review and apply relevant lessons learned across institutions in areas of project monitoring, indicators, and other relevant aspects of project implementation.
   - **2.2. Collaborate on development of methodologies and guidance to maximize climate impacts through strong project design:** The two funds agree to produce and use a set of guidance products and methodologies for designing projects and measuring their impact, to maximize emissions reduction and adaptation impacts**.**
3. **Communication and outreach**
   - **3.1. Communication and inclusion *of long-term vision on complementarity in respective fund's Programming :*** Relevant elements in this LTV will be included in the strategic documents in current and future replenishment and programming cycles.
   - **3.2. *Collaborate on communications, outreach, and sharing of lessons learned***: The two secretariats will enhance outreach and communication efforts, and on sharing of lessons learned from coordination and complementarity efforts.

Figure 13: summary of long – Term Vision Complementary, Coherence and Collaboration between the Green Climate Fund (GCF) and the Global Environment Facility (GEF)

Advancing the GGW vision will require an approach that is underpinned by holistic and systems thinking to maximize potential for harnessing synergies at scale. In this context, the GCF Umbrella Program provides an opportunity to implement this Long-term vision and enhance complementarity and collaboration at regional and country level through specific activities that foster facilitation of national investment planning for the GGW countries and sharing of information, lessons learned and knowledge.

[99] https://www.thegef.org/sites/default/files/council-meeting-documents/EN_GEF_C.60_08_Long-Term%20Vision%20on%20Complementarity%2C%20Coherence%20and%20Collaboration%20between%20the%20Green%20Climate%20Fund%20and%20the%20Global%20Environment%20Facility.pdf

5. Theory of Change of the GGW Regional Support Programme

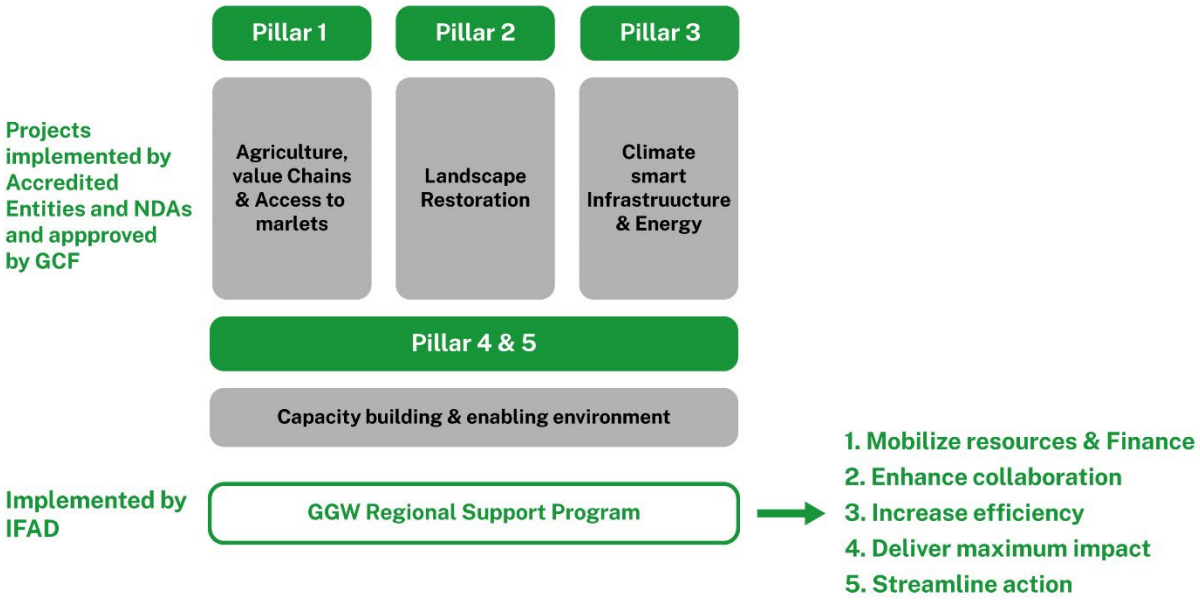
Several GCF projects and programmes are already being implemented in the GGW countries and new projects are being elaborated by Direct and International Accredited Entities. These projects contribute to achieving the objectives of the Great Green Wall through the implementation of specific activities that focus on one or more of the five pillars mentioned in section B1 (value chain development, landscape restoration, climate-smart infrastructure, capacity building and institutional development). However, in the absence on an overarching framework, these GCF projects and programmes are being implemented in isolation, resulting in missed opportunities for improved delivery of the GCF mandate. The GGW Umbrella Programme will address:

- Lack of analysis and sharing of lessons and experiences across GCF projects in GGW countries.
- Duplication of activities by AEs on due to limited awareness of AEs and project staff of similar topics or activities being implemented in similar countries activities being implemented by GCF and other projects including GEF.
- Limited evidence-based knowledge generated and tailored to specific audience to inform GCF project development.
- Increased costs for AEs, countries and the GCF due to limited exchanges of knowledge on GCF project implementation and available studies (e.g., climate analysis, gender assessments etc.)
- Limited coordination at country level to strategically plan the allocation of GCF, GEF and other resources that can contribute to achieve the GGW objectives resulting in a duplication of projects and activities. NDAs are not necessarily aware of the lessons learnt, best practices or innovation from other countries or other GCF projects, which could help them in better programming their respective Country Work Plan to the GCF, projects, iteration of their NDCs or NAPs.
- Innovative solutions, in particular digital solutions to address climate change in value chains and landscape restoration, developed by GCF projects, GEF projects and other stakeholders are not widely available and spread across the GCF project portfolio.
- While innovation and digital solutions are increasingly recognized as a strategic path to address climate change impacts, the ecosystem to support innovation and digital solutions developers is in its very early stage of development with missed opportunities for replication and scaling up.

To address the challenges mentioned above, the Regional Support Programme will improve access to best practices, encourage learning and fostering innovation, digital transformation across Great Green Wall countries to increase the collective impact of individual GCF projects. The Umbrella Programme added contribution is that its entire structure and all its actions are geared towards building the knowledge and systems necessary to identify transformational pathways for the GGW area. The Umbrella Programme will not replace the knowledge management and innovation activities of each GCF project nor take over the responsibilities of the corresponding AEs. It aims at creating bridges through a structured framework to ensure that project specific information, knowledge and learning is properly captured and disseminated across GCF projects, AEs but also GEF projects and other entities contributing to tackling climate change in the Great Green Wall. The GGW UP will be uniquely placed as a facilitator between individual GCF projects to promote the scale up existing innovation through GCF projects in the GGW[100] and to increase uptake of innovations and digital solutions developed by other stakeholders in current and future GCF projects. The GGW UP

[100] https://www.greenclimate.fund/news/innovation-imperative-gcf-tells-leaders-climate-summit

will promote and amplify action on the ground to bring action to scale and generating spillover effects that positively affecting other GGW initiatives and undertakings.



The Knowledge Management is central to the regional support programme. It will promote and support an enhanced culture of knowledge sharing whose benefits include:

- **Easy access to information and resources** for GCF NDAs, GGW, GEF and AF focal points, AEs and especially DAEs. With information easily available, these actors and entities will be better equipped to support countries in implementing their NDCs and NAPS through present and future GCF projects.
- **Increased pace of learning uptake**. Well-targeted learning events such as South-South exchanges have proven to be effective means of peer-to-peer learning among experts from different countries[101]. Experiences from countries with a higher level of maturity in the project implementation will be able to support the acceleration of less mature projects, by sharing the good practices and approaches to the programme implementation.
- **Reusing knowledge**: Reusing ideas, documents, and expertise minimizes rework, prevents problems, avoids repeating mistakes, saves time, and accelerates progress by adapting and adopting successful experiences and good practices. For instance, some of the background assessment elaborated by AEs and reviewed by the GCF Secretariat and iTAP for a specific FP could be reused or adapted by another AE.
- **Taking advantage of existing expertise and experience**: The more complementary the expertise of the team members, the greater the power of the team.
- **Providing methods, tools, templates, techniques, and examples as the building blocks for supporting processes and procedures**. Using these consistently streamlines work, improves quality and enhances overall efficiency.
- **Enabling data and evidence-based decision-making** by NDAs, DAEs and international AEs, GGW, GEF and AF focal points: Using knowledge that relies on the analysis of data and

[101] IAP Emerging lessons learned report

evidence and directed to specific audiences allows decisions to be based on actual experience and lessons learned.

- **Effective KM will promote operational excellence, technical innovation and efficiency gains** for NDAs, GCF projects under implementation and AEs. Innovations are shared systematically and timely among projects, countries, and entities, allowing for a faster replication and scaling up.

The benefits derived from the implementation of the knowledge management activities will contribute to the knowledge management outcomes of **GCF Updated Strategic Plan** (see figure below) by creating a transparent and collaborative environment for knowledge generation at country level and across GCF funded projects. Knowledge generated by GCF projects will be captured, analyzed and shared according to specific audiences to improve the efficiency and effectiveness of GCF projects as described above. The access to and appropriation of knowledge by GCF NDAs, GGW, GEF and AF focal points, AEs and DAEs will increase their capacities to replicate, streamline and scale up climate activities and investments that have proved to be effective in similar contexts.

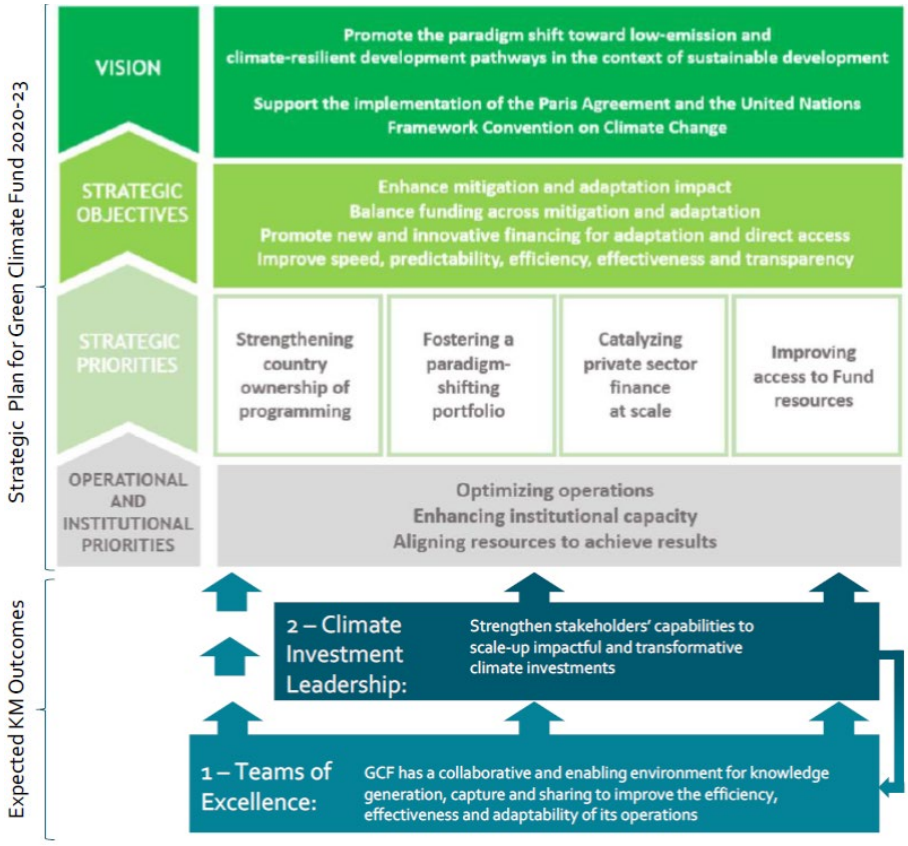


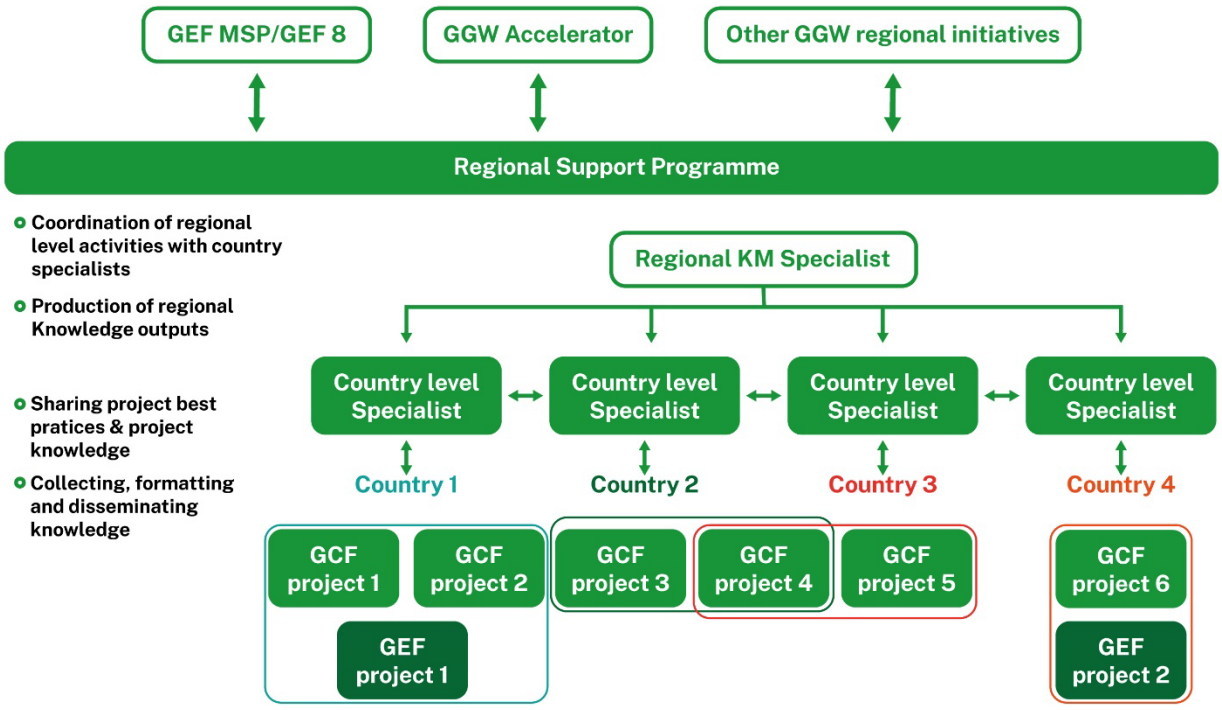
Figure 5: Expected KM outcomes that will support the Updated Strategic Plan for the Green Climate Fund: 2020-2023

Knowledge management structure

GCF projects have KM strategies and activities in place and have allocated the financial and human resources to achieve the proposed results. The support for knowledge management provided by the Umbrella Programme will not replace the existing KM strategies of each GCF project and the responsibilities of the corresponding AEs. On the contrary, it aims at creating the necessary bridges between all these project-specific KM strategies and resources and create a structured framework to ensure that project specific information and knowledge is properly captured and shared

systematically with other GCF projects, entities and GGW countries. The regional support Programme will provide support at two levels:

- **Regional level:** structure, streamline, analyze and disseminate knowledge generated by GCF projects across the GGW countries through a strategy, knowledge center, specific knowledge and communication products and the organization of events. In addition, synergies with the GGW Accelerator, GEF and AF will be created at regional level for specific activities described below. The Umbrella Programme Unit will count with a Regional Knowledge Management Specialist in charge of coordinating the activities at regional level.
- **Country level**: facilitate and support GCF projects in sharing the knowledge generated by each project and fostering linkages and learning based on past and present projects in the country. The Umbrella Programme will provide for a Knowledge Management Specialist in each country to be hosted by the NDA. The hosting by the NDA responds to the limited human resources assigned by each project for knowledge management and at the same time improves the anchor of the knowledge in the appropriate institution [102]. The Country Knowledge Management Specialist will be in charge of supporting the AEs in systematically formatting and sharing the knowledge through the different channels (knowledge center, events, knowledge products).



[102] IAP Lessons learned report on knowledge management shows the need for additional support at country level to ensure coordination of KM activities and formatting of knowledge products in a consistent manner.

Key activities include:

- **Activity 3.1.1 Establishing a knowledge baseline**. The rationale here is to map all relevant information for the programme in terms of climate financing within GGW countries and determine where relevant knowledge is missing. The exercise would single out existing interventions or knowledge resources in terms of climate finance and their results; as well as identify the existing knowledge gaps.

- **Activity 3.1.2. Developing a Knowledge and Communication Strategy**. Based on the assessment, a knowledge management and communication strategy[103] will be developed together with all AEs implementing projects in the GGW, including the role of KM and communication for the GGW UP (external communication, internal communication, gathering, analyzing, documenting, translating information, adapting information), strategic objectives, target audiences, articulation of products to be defined, timeline for reporting knowledge, templates, KM specific indicators, and responsibilities for individual projects. This activity will respond to the challenge faced by most regional programmes (IAP, BRICKS) of limited KM resources allocated in each project, projects being implemented in an isolated manner from one another and variety of institutional standards.

- **Activity 3.1.3 Creating a knowledge center.** The execution of the knowledge management strategy is structured around a knowledge center. The knowledge center will respond to the need to make knowledge and information on key thematic areas and country project activities easily available and easy to disseminate across multiple stakeholders. The knowledge will be organized around the five pillars of the GGW UP, key thematic areas (M&E, communication) and project-based or country-based, etc. New and existing knowledge disseminated through this platform will include good practices such as improved indigenous knowledge, climate-smart agriculture, land restoration, value chain development, climate-resilient infrastructures, water management, etc. Existing gender assessments, climate assessments and legal analyses prepared by AEs for GCF Funding Proposals as well as GEF project proposals[104] will be made available to all AEs, especially DAEs, in the GGW countries. With dual language functionality, the knowledge center will be primarily designed to address country project's needs. Nonetheless, it remains open access and allow country projects to easily upload as well as request for resources. The platform will be conceived as a collaborative platform to ensure interactivity with the projects and countries involved by including the options to contribute to blogs, news, online discussions, online communities of practice and enabling options to comment and share content easily. The platform will be hosted within an existing website or platform from an institution that covers the region and is very likely to continue to engage in the same area of work after the duration of the project and will be articulated with the GGW Accelerator knowledge hub currently under development to facilitate exchange and avoid duplication of information and efforts. The Regional Knowledge Management Specialist will be in charge of the development and implementation of the knowledge center while the Country Knowledge Specialists support AEs in sharing their knowledge products and reviewing the knowledge submitted to the center and promoting the use of knowledge center. The platform will include an interactive helpdesk function to facilitate the use of the platform and ensure all users can maximize their profit from the availability of knowledge in different formats and across different sections.

[103] An example of regional program KM strategy that brings knowledge generated by various project is the IAP knowledge management strategy:

[104] In line with the proposed activities of the long-term vision for collaboration between GCF and GEF

- **Activity 3.1.4. Creating communities of practice.** Communities of practices aim at connecting practitioners from GCF GGW, GEF, AF and other relevant projects/programmes aligned with the five pillars of the GGW Accelerator to learn from experiences and projects and incentivize cross-regional knowledge exchange. Based on IFAD's experience building communities of practices[105], the communities of practices will make available the best solutions based on evidence to foster the scaling-up of lessons for faster, more efficient delivery of GCF projects. The regional and national KM experts of the UP will support the creation and facilitation of the communities of practice, creating a constructive environment of mutual support and trust among the subject matter experts and other stakeholders: i) at the country level to connect the KM experts of the different GCF and relevant GEF projects[106] and programmes implemented in the country by different AEs and structure and systematize the exchange of information, good practices, lessons learnt, innovation among those projects, as well as draft policy recommendations with the GCF NDA, the GEF and AF national focal points, and the GGW focal point; and ii) at the regional level, mainly to enhance exchanges between countries and South/South exchanges.

- **Activity 3.1.5 Generating knowledge products to disseminate lessons learnt, scalable good practices and inform evidence-based investment and policy-making.** The Regional Support Programme will bring additional value to the existing knowledge generated by individual GCF as well as GEF projects[107] through the creation of knowledge products that analyze and tailor the knowledge generated across the 11 countries. By analyzing experiences across different countries and projects, a true generation of good practices that are adaptable and adoptable in similar contexts is generated and will significantly strengthen the value of country specific successful experiences. In addition, data gathered across the eleven countries will be used to develop specific knowledge products targeted to investors and policy-makers to inform evidence- based decision-making. Specific knowledge products such as policy brief, series, social media, monthly newsletters, internal bulletins, tool kits will be defined in the Knowledge Management and Communication Strategy (see activity 3.1.1). Relying on regular interactions with the Regional Support Programme KM specialists in each of the 11 GGW countries and with all GCF and GEF projects implemented in the GGW countries, as well as desk reviews, portfolio reviews and existing academic and public/private sector research, this activity will methodically gather, capture and share lessons learnt and best practices from all the key result areas of the GCF and relevant GEF projects which are contributing to the objectives of the GGW. The Country Knowledge Management Specialist will be in charge of drafting country level knowledge products and the Regional Knowledge Management Specialist will be coordinating the creation of regional products[108].

- **Activity 3.1.6 Organize regular peer-based knowledge exchanges and knowledge sharing activities.** Knowledge exchanges will be targeted to specific audiences and be organized at different levels. The exchanges and sharing activities will be part of a process

[105] https://ifadkmcentre.weebly.com/cops-in-ifad.html
[106] In line with the proposed activities of the long-term vision for collaboration between GCF and GEF
[107] In line with the proposed activities of the long-term vision for collaboration between GCF and GEF
[108] The MTR review of the IAP showed the importance of regional programs in playing an active role in the production and supporting implementing entities in defining and designing their knowledge products, trainings and approaches.

and not stand-alone activities, to ensure the actual uptake of the knowledge and the engagement in continuous learning:

- **Country level workshops** will include (i) awareness raising of stakeholder to improve the collective understanding of the relationship between KM, M&E, communications and advocacy, staffing plans and overall strategies of GCF projects (ii) training on thematic issues such as the application of analytical tools for regional-scale monitoring, knowledge platforms for learning, synthesis and dissemination and innovations. These workshops will also provide an opportunity to link with similar projects, such as GEF or AF funded projects, with similar intervention plans and objectives [109].

- **Annual Regional Knowledge Share Fairs** to bring together the knowledge and lessons learned from other GGW partners such as the Permanent Interstate Committee for Drought Control in the Sahel (CILSS) and independent units such as Agrhymet, the Sahara and Sahel Observatory (OSS), IUCN, the Economic Community of West African States (ECOWAS), FAO, the EU and other international partners, UNCCD, UNEP, World Agroforestry Centre (ICRAF), as well as knowledge providers such as the World Overview of Conservation Approaches and Technologies (WOCAT) and the Africa Regreening Initiative, among others. Knowledge Share Fairs are facilitated events that are designed to share knowledge in an interactive way. The key to a Share Fair's success lies in the linkages and connections people make at the event. Share Fairs bridge social, hierarchical and technological gaps through various participatory formats. The participatory aspect of the events also contributes to the generation of a community around the topics discussed.

- **South-South Exchanges** will be organized to share the best scalable good practices from other regions. These events will include training and periodic study tours of GCF projects, GEF and AF projects.

- **Activity 3.1.7. Enhance coordination & programming among GCF NDAs, AEs and GEF, AF and GGW national focal points**: At the regional level, the Regional KM Specialist will seek to build synergies between the Umbrella Programme and the GEF/UNEP regional project "Harnessing the Great Green Wall Initiative for a Sustainable and Resilient Sahel" (and the future GEF8 programme when defined) for the GGW through ongoing dialogues to ensure complementarity of activities and funding mobilization. At the country level, Coordination Committees will be established, building on relevant existing committees, bringing together NDAs, GGW Focal Points, GEF Focal Points, Adaptation Fund Focal Points, relevant sectoral ministries and relevant AEs. The committees will aim at streamlining the development of GCF Country Work Plan, GEF STAR Allocations, NDCs and to design of impactful climate-related projects through the sharing of work programmes, information, knowledge and updates on portfolio both at the design and implementation phases. Countries knowledge Management Specialist will coordinate the meetings and facilitate the activities of the Coordination Committees.

[109] These two types of workshops at country level have proved to respond to the needs of training on specific issues while also supporting country level project to understand the role of knowledge management and its contribution to M&E and policy-making (IAP Emerging lessons learned report)

The second output is related to innovation and digital transformation technologies and ecosystem

For this proposal, innovation is be defined as finding and applying new approaches to address existing problems or serve unmet needs. From a development perspective, an innovation is a new solution with the transformative ability to accelerate impact. Innovation can be fueled by science and technology, entail improved ways of working with new and diverse partners or involve new social and business models or policy, creative financing mechanisms or path-breaking improvements in delivering essential services and products. Innovation has been and will be pivotal for reaching sustained, scalable solutions to the world's complex problems[110].

Broadly considered one of the most important strategies for addressing climate change, innovation means finding creative ways to deliver better results quicker, by either using new approaches or applying existing techniques to new situations. The Paris Agreement, adopted by Parties in 2015, stipulates that accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development. The growing innovations associated with digital technologies create new opportunities for information-sharing, alternative forms of connectivity, financing models, and governance arrangements[111]. According to UN and other experts, artificial intelligence and digital technology could bring a 10-20% reduction in global carbon dioxide emissions by 2030. Disruptive climate solutions for technology, policy, finance, business models, leadership and capacity building are key to accelerate low-emission and climate-resilient development[112].

Innovation is closely linked to digital transformation, as innovation and digital transformation break down silos and create transparent and unified data for objective decision-making. Information and communication technologies offer solutions to monitor, mitigate and adapt to the impacts of climate change, from using remote sensing, observatory technologies to track deforestation to developing smart grids to accelerate the energy transition and strengthening early warning systems against the rising number of extreme weather events. In the context of the GGW, innovation and digital solutions can contribute to transform practices and bring new services at scale to sustainably increase food productivity, build resilience to climate change and protect natural resources. Examples of the emerging innovations include:

- **Social enterprise innovations** that bridge service delivery gaps: For instance, the firm Hello Tractor[113] in Nigeria connect producers with providers of agricultural services—e.g., tractor owners—using Internet of Things (IoT) platforms like the one used by Uber to connect drivers with passengers. These solutions not only provide farmers with access to machinery, but also connect them to an ecosystem of partners who use the tractor's data to provide additional services such as financing and crop-specific weather information.
- **Climate technologies** such as early warning systems that can provide farmers with information and advice on when to plant or sell their livestock. The FAO Global Information and Early Warning System provides countries with tools for crop monitoring, food prices monitoring and analysis and briefs in real time.

[110] This definition was published in the call for innovation in international development by USAID, Gates Foundation, DFID, Canada, Sweden, UNICEF, Australia, Rockefeller Foundation, Results for Development and the World Bank Group: https://www.usaid.gov/ffd3/innovation

[111] Bennett and Segerberg 2012; Karpouzoglou et al. 2016; Soma et al. 2016

[112] https://unfccc.int/news/un-climate-change-boosts-innovation-for-climate-action

[113] http://www.hellotractor.com/

- **Digital finance services** that can give access to credits to smallholder farmers who do not have access to traditional financial services. In Kenya, Apollo [114] provides an optimised bundled services for farmers that includes credit financing, farming inputs, advisory and insurance. Apollo's vertically integrated digital approach leverages machine learning and satellite data to service customers throughout the entire lifecycle, from acquisition, to credit decisions, and finally, collecting repayments.
- **Open data and geo-mapping** for improving planning and monitoring of natural resources in countries. Tools such as Open Foris, SEPAL [115], trends.earth [116] provide digital technology and satellite imagery to support countries can assess, monitor and plan land use, including monitoring deforestation and desertification. The technology offers wide coverage, is faster than ground methods and facilitates long term monitoring of land coverage and usage.
- **Clean technologies** (e.g., solar, wind) that provide sustainable energy. The World Bank Lighting Africa[117] provides electricity through off-grid solar products working with local distributorships in Ethiopia.
- **Financial innovations** (e.g., crowdfunding, social impact bonds, mobile money). FSD Africa has develop an innovative approach to financing mechanisms that drive sustainability in conservation areas in Kenya[118].
- **Innovative adaptation approaches** that provide climate-smart services to villages. CGIAR climate-smart villages [119] bring a holistic approach to village development combining agroforestry, precision application of fertilizers and energy-efficient machinery and climate-smart services such as testing climate-smart services, such as tailored weather forecasts to plan planting, harvesting and other activities on the farm delivered through phones which are also used to enable farmers to buy index-based insurance that gives them a measure of protection in the event of extreme weather.

In the context of the GGW and IGREENGIN, specific attention will be given to support accredited entities leverage opportunities to integrate precision technologies for farming in their projects given the potential that precision farming would enable value chain resilience as well as contribute towards landscape restoration. Precision technologies for farming can be defined as a whole-farm management approach using information technology, satellite positioning data, remote sensing and proximal data gathering allowing the use of targeted inputs and efficient use of water. In the context of the GGW, these technologies have the goal of optimizing usage of inputs whilst potentially reducing environmental impacts and reduced GHG emissions [120]. Broadly speaking there are three main components to technology applications, these are (1) Hardware and sensors (which are involved in acting upon or collecting data) (2) Data analysis and decision support systems (the software and/or cloud systems and machine learning algorithms which take data and process it into something meaningful) (3) Commodity and whole-farm focus (the process whereby decision support systems and models are made commercially and utilized across whole farms, and not just individual fields). Alongside the economic benefits of precision farming, there is also increasing discussion with regards to their vital role towards climate resilience and sustainable agricultural. Several studies note that precision farming enables equivalent or increased productivity/yields with a

[114] https://www.apolloagriculture.com
[115] https://www.fao.org/national-forest-monitoring/tools/en/
[116] https://trends.earth/docs/en/
[117] https://www.lightingafrica.org/about/our-impact/
[118] https://www.fsdafrica.org/programme/world-wildlife-fund-social-impact-bonds/
[119] https://ccafs.cgiar.org/climate-smart-villages
[120] https://www.europarl.europa.eu/RegData/etudes/note/join/2014/529049/IPOL-AGRI_NT(2014)529049_EN.pdf

reduction in overall inputs (including fuel, feed, nutrients or water etc.). As such, a reduction in greenhouse gas (GHG) emissions either directly or indirectly should be occurring. Whilst there is some direct evidence of emission reductions, limited direct GHG mitigation studies have been performed with regards to precision farming technologies to date[121].

Recent decades have seen considerable improvements in performance and the diffusion of several flagship adaptation and low-carbon innovations. Despite these many successes and encouraging trends, overall progress towards innovative solutions has been modest in the GGW since additional support need to be provided for (i) developing/strengthening innovation systems including understanding the context-specific needs of different countries where transformational innovation efforts must be based (ii) piloting/testing or expanding technologies in new environments and adapting climate technologies to local contexts (iii) fostering coordination mechanisms to effectively identify and prioritize climate technology solutions (iv) conducting feasibility assessments of selected climate technologies for mitigation and adaption (v) market preparation, business planning, and financing for deployment and scaling-up of climate technology solutions122.
Key activities include:

Activity 3.2.1 Build a digital and innovation ecosystem. An ecosystem is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important to promote adoption of digital technologies while promoting the multi-actor interaction that promotes development and deployment of innovative climate adaptability solutions that can be deployed at scale. An ecosystem provides the means to create economic stability and resource sharing that contribute to innovation and technologies as well as to create new market opportunities. Considering the challenges in the GGW, the UP will act as a broker of the digital ecosystem promoting collaboration of different actors including government(s) to contribute towards achievement of key objectives of the GGW by:

- **Mapping of existing services and digital platforms that provides extension services, financial services, farming precision technologies, digital technologies to monitor and plan the use of natural resources and other services.** The mapping of key players in the region and existing platforms and services including those promoted or implemented by GCF and GEF projects as well as technologies and platforms developed by SMEs, entrepreneurs and academia as well as other players in the region. The mapping will also include recommendations for opportunities in leveraging these technologies across the GGW pillars and the promising solutions than be promoted for scale for instance through GCF support to climate technology incubators and accelerators[123].
- **Providing technical support** for brokering the relationship between solutions providers participating in the marketplace and GCF, GEF and other partners at country level.
- **Facilitating a series of online events** to showcase specific innovations and share expertise across the region, accessible to GCF, GEF and other partners at country and regional level.
- **Organizing annual fairs** following the model of SahelInnov Expo [124] where climate technologies in the GGW region and beyond will be showcased focusing specific areas (e.g., farm precision technologies, digital solutions for monitoring and planning restoration, access

[121] https://businesswales.gov.wales/farmingconnect/news-and-events/technical-articles/can-precision-farming-help-mitigate-climate-change
[122] https://www.greenclimate.fund/sites/default/files/document/gcf-brief-support-technology_0.pdf
[123] https://www.greenclimate.fund/sites/default/files/document/gcf-brief-support-technology_0.pdf
[124] https://blogs.worldbank.org/psd/start-scratch-how-entrepreneurship-can-generate-sustainable-development-and-inclusion-sahel

to financing etc.) and sessions organized to address specific climate challenges. The fairs events can facilitate the interaction of different skills, resources, knowledge, or needs by matching interests or creating standardized technological interfaces and communication forums. Events will be complementary to the marketplace by providing opportunities for real-time demonstrations and networking.

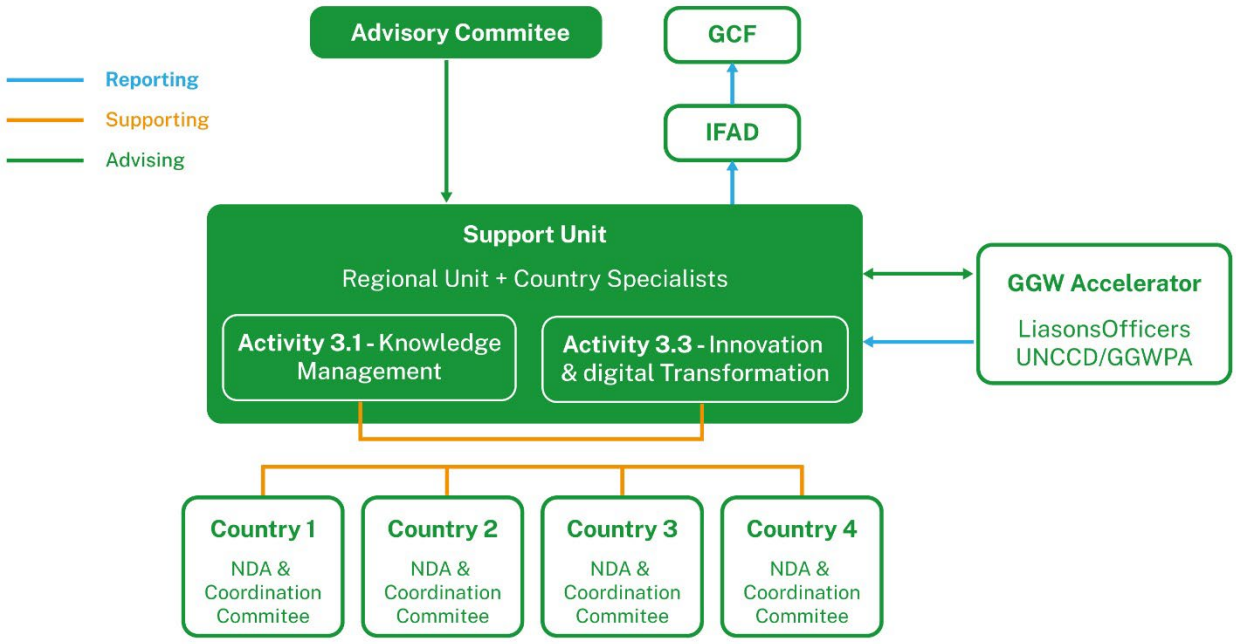
Activity 3.2.2 Create a digital marketplace with all services provided by platforms and other providers. Based on the mapping conducted in activity 3.2.1, an online marketplace will be created to bring together financial, non-financial institutions, civil society organizations, AgTech, FinTech agencies, value chain players, MSMEs that provides services for value chain development, climate solutions and landscape restoration as a one-stop-shop available to all across the region. In many productive sectors of economy, platforms have already become a preferred method of collaboration and value co-creation[125]. The marketplace will aim at enhancing accessibility, promote economies of scale and foster new market opportunities. The marketplace will feature platforms and services providers that provide extension services, financial services, farming precision technologies, digital technologies, organized by area of service or expertise and country and will provide a feature to directly enter in contact.

Activity 3.2.3 Identify new opportunities for investing in climate innovation in the GGW. While some innovation may be already implemented in other regions (e.g., carbon financing, PES schemes etc.) or at a small scale, their potential for being upscaled in the GGW still needs to be assessed. A series of knowledge products and feasibility studies for specific technologies will be conducted to identify new opportunities for solutions being implemented in the region through future GCF investments in the GGW based on the results of the Activity 3.2.1.

6. The GGW Regional Support governance

The management and oversight structure proposed below intends to take into account factors that ensure an efficient structure while still involving stakeholders with deep knowledge and experience in the GGW and national and regional actors.

[125] Smedlund, Lindblom, and Mitronen, 2018



Advisory Committee: provides overall advice on the Umbrella Programme components. The Committee will meet twice a year to review and make recommendations on knowledge management and innovation GGW UP direction and achievements through GCF projects, linkages with relevant initiatives and processes such as the GGW Accelerator. Foreseen composition: GCF, IFAD, UNCCD, GEF, African Union, the Great Green Wall Pan African Agency, two rotating GGW countries representing the different geographical region (East and West Africa) (e.g., on a yearly basis).

Support Unit: The Support Unit will be responsible for implementing activities under Component 3. It will be composed of a regional unit based in Dakar, Senegal and of one country-level specialists per country who will support the NDAs. It will be composed of a regional specialists and country level specialists:

- Regional Unit:
  - Program Coordinator: overall coordination of Component 3
  - Knowledge Management Specialist: responsible for Output 3.1
  - Innovation Specialist: responsible for Output 3.2
  - Finance Specialist
  - Administrative Assistant

Country level Specialists: For each country, IFAD will hire a Knowledge Management Specialist to support the NDAs and GGW Focal Point with the implementation of the Umbrella Programme's activities. Country specialists will report to the Regional Support Unit's KM Specialist and will share their time between the NDAs office and the IFAD office to coordination of activities. Country KM Specialists will be supported by the regional knowledge management and policy specialist. They will have a coordinating role for knowledge management, communication and policy in support of the NDAs.

GGW UP Liaison Officers: The GGW Accelerator will host a Umbrella Programme liaison officer to ensure close alignment and collaboration with the GGW Accelerator. These liaison functions will include:

- Ensure the collation of results and impacts by aligning the activities on knowledge management and innovation of the Umbrella Programme with those of the GGW Accelerator
- Coordinating the reporting of GGW UP activities and progress to the Accelerator to increase the collective impact of the UP and Accelerator projects and programmes
- Ensure alignment and regular feedback between the Umbrella Program knowledge hub and the Accelerator GGW knowledge hub on best practices and lessons learned
- Liaise with GGW structures, processes and institutions (PAAGGW, AU, GGW Steering Committee) to ensure they are well informed of the progress of the UP.

A second liaison officer will be co-funded with the UNCCD and hosted by the Great Green Wall Pan-African Agency to ensure coordination with the regional entity's activities.

Country Coordination Committees are composed of NDAs, GGW Focal Points, GEF Focal Points, Adaptation Focal Points, UNCCD, CBD and UNFCCC Focal Points, relevant sectoral ministries and relevant AEs. Building on relevant platforms wherever possible, committees are responsible for coordinating the alignment of GCF work programmes, GEF STAR allocations and prioritizing GGW investments at the country level. The Country Coordination Committees will also be responsible for the coordination of the activities reported to the GGW Accelerator to ensure transparent and comprehensive exchange of information and reporting. Countries may decide to invite additional stakeholders to take part in the Country Coordination Committee.

Accredited Entities (AEs) will be responsible for the elaboration, submission and implementation of the GCF project as per standard GCF procedures and their respective accreditation to the GCF. They will also be responsible for overseeing the monitoring of project/programme-level results and will be required to report against all project/programme-relevant core indicators and sub-indicators annually through APRs directly to the GCF. Accredited Entities participate in the Country Coordination Committees. They also closely collaborate with the Umbrella Programme.

Technical and Financial Reporting

The Support Unit will be responsible for preparing the following reports for submission to the IGREENFIN PMU Coordinator:

- M&E indicators
- Lessons learned, best practices
- Financial report
- Annual work plans
- Annual progress reports
- Bi-annual progress updates

The progress reports should present the main achievements, issues and constraints of the reporting period, information on financial and physical achievements in comparison with targets set in the annual work plans as well as possible impacts and outreach. The reports should highlight the implementation strategy and indicate challenges and the reasons for them. Specific reference should be made to recommendations by supervision missions.

Monitoring and Evaluation (M&E)

Activity	Indicators	Means of assessment
Activity 3.1.1 Establishing a knowledge baseline knowledge management and communication strategy		
Activity 3.1.2 Creating a knowledge center	• # key actionable findings, experiences, and lessons learned captured, evaluated, synthesized, and packaged • # of new KM outputs created and available, by type • **# or % of intended users applying knowledge gained from a KM output to improve program, service delivery, training/education, or research practice** • # of users per month • % growth in users per month • # of page views per month • % growth in page views per month • # pages per session • % growth in number of pages per session • Bounce rate • Session duration • Top 10 page views per month	Platform Analytics Surveys Annual reports
Activity 3.1.3. Create communities of practice	• # members per community of practice • # of exchanges • Impact stories • **User rating of usefulness of content/outputs shared in community of practice** • **# or % of group members who report knowledge sharing as a group norm** • **# or % of intended members applying knowledge gained from community of practice to improve program, service**	Surveys Feedback questionnaire

Activity	Indicators	Means of assessment
	delivery, training/education, or research practice	
Activity 3.1.4. Generating knowledge products to disseminate lessons learnt, scalable best practices and inform investment and policy-making	Newsletters • # of newsletters and mailers • # of subscribers • % growth in monthly subscribers • # opens, % of opens • # of clicks, % of clicks • Top links clicked Social media • # of posts • # of mentions • # of profile visits • # of impressions • # of followers, % growth in followers • Click-through-rate • # of likes • # of comments • # of shares or retweets • # of graphics or videos posted • # of social media Publications • #of products (and type) • # of people in distribution list • Resource page visits, download rate, Mailchimp and • social media click-through-rate • # of media kits distributed • # of social media posts about launch • # of media reports (articles, blog posts, etc.)	Mailchimp, Google Analytics, Twitter and Facebook Analytics Feedback questionnaire Case studies of tools, resources, approaches
Activity 3.1.5. Organize regular peer-based knowledge exchanges	• # of outreach/advocacy events • # of training/webinar events • # of programme/regional events • # of event participants • Type(s) of participants at event • # of presentations, modules # of participants • Qualitative feedback • Action taken as a result of the exchange (e.g., new networks developed, follow-up meeting, new approach adopted, etc.)	Annual Progress Reports Feedback questionnaire: satisfaction and impact surveys (after 6 months) Exchange visit report

Activity	Indicators	Means of assessment
	# of new members to the COPs after organization of an event	
Activity 3.1.5. Enhance coordination & programming among GCF NDAs, AEs and GEF, AF and GGW national focal points	• Level of commitment and support for shared vision • # of active partnerships with external • organisations, initiatives, programmes • # of co-produced events, products, or • campaigns • # of cross-promotions • # of meetings with external partners	

General recommendations

In light of the climate context described in this study and the rural finance gap in agriculture for smallholders, access to highly concessional climate finance to acquire and deploy agriculture technology to expand production beyond the rainy season (June-September) and improve yields, including major agricultural exports[126], is extremely limited in the target countries (ND–GAIN vulnerability index). Access to credit has a significant role to play, but remains a key constraint for smallholder farmers, farmers' organizations, cooperatives and MSMEs in the targeted countries particularly in post COVID-19 recovery efforts[127]. The inherent risks in smallholder farming discourage the private sector, particularly the banking sector, from investing in agriculture. Financial institutions in the target area still face numerous internal obstacles including: 1) the perception of small-scale agriculture as too risky, fostering reluctance to lend farmers money and the practice of charging them higher interest rates; 2) a lack of awareness on the potential benefits of investing in climate adaptation and mitigation; 3) an overestimation of risks due to a lack of technical knowledge, and 4) a lack of access to appropriate capital for on-lending[128].

For too long, financial institutions – especially agricultural banks – have been putting off changing their methods, as they carry on with "business as usual". When credit is available, interest rates remain high. While the agricultural banks in Burkina Faso, Côte d'Ivoire, Mali and Senegal have set interest rates at 10 per cent, commercial banks and MFIs, including Ghanaian banks, charge around 20 per cent, which is much higher than international standards[129]. Such high interest rates prevent smallholder farmers – especially youth and women as 'agripreneurs' – from investing in low emission, climate resilient agriculture and raising their productivity to respond to the high demand in the face of changing climate conditions[130]. These constraints limit the ability of the selected countries to leverage more resources to implement the objectives of the GGW. In a post COVID-19 context, contributing to the elimination of these technical and financial barriers would allow these institutions to finance transformational change towards climate compatible investments at a time when local financial institutions, FOs, cooperatives, MSMEs and governments are recovering from the impacts of the pandemic. The existing financial services intended for rural communities rarely benefit rural women and youth. Women's access to these services is constrained by sociocultural, economic, legal and, in some cases, educational barriers, as well as financial institutions' limited understanding of the dynamics of rural communities and the agricultural sector, particularly gender dynamics, plus high transaction costs when dealing with frequent small loans, and unclear and unfavourable land tenure and property rights.

As a financing mechanism, the **Inclusive green finance Initiative (IGREENFIN 1**) - greening agricultural banks to foster climate resilient, low emission smallholder aims to use a market-driven value-chain approach, by linking smallholder farmers, FOs, MSMEs and cooperatives to other players within the agricultural value-chain (agricultural banks and the governments) to establish long-term relationships and transform small-scale agriculture into sustainable businesses. The main objective of IGREENFIN 1 and the Regional Support Programme (Component 3 under IGREENFIN I Programme) is to build and scale up the resilience and adaptive capacity of farmers' organizations (FOs),

126 Major agricultural exports in the target countries include cashew, cocoa, coffee, onions and live animals, cotton, peanuts, cassava, legumes and high-quality rice.

127 IFAD 2021, https://www.ifad.org/en/web/knowledge/-/ifad-inclusive-financial-services-portfolio-stocktaking?p_l_back_url=%2Fen%2Fweb%2Fknowledge%2Fpublications%3Fdelta%3D125

128 Ibid.

129 World Bank, 2021.

130 IFAD 2021, https://www.ifad.org/en/web/knowledge/-/ifad-inclusive-financial-services-portfolio-stocktaking?p_l_back_url=%2Fen%2Fweb%2Fknowledge%2Fpublications%3Fdelta%3D125

cooperatives and micro, small and medium-sized enterprises (MSMEs) in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal by removing barriers to access to financial and non-financial services to accelerate the creation of a green financing market to promote the uptake of green agriculture practices and technologies. For the purposes of this funding proposal, the term "green" refers to investments in the selected agricultural value chains that promote climate resilient, low carbon practices in line with the GGWI objectives and the target countries' climate change adaptation and mitigation agenda.

To finance value chains development, the five selected countries have worked with IFAD to design climate resilient investment plans which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. This is an integrated approach where IFAD's past experiences and baseline investments serve as an entry point and a source of lessons learned to maximize the impacts of this additional climate financing on a larger number of beneficiaries.

Annex I - Detailed business models for key value chains

Sustainable (climate resilient) livestock production - Cattle

In West Africa, cattle populations are representative of both shorthorn (B. taurus brachyceros) and longhorn (B. taurus longifrons) humpless taurines, humped zebus (B. indicus) and Zebu/Taurine cattle (Soudre, et al., 2019). Cattle in the region are an important daily source of income, food and nutrition, draft power, nitrogen-rich manure for replenishing soils and other uses for estimated 800 million livestock keepers across the continent, especially rural populations (Soudre, et al., 2019). The Peul ethnic group, one of the poorest ethnic groups in Senegal for instance, are the major livestock keepers in West Africa; they associate livestock, especially cattle, with a social and wealth status rather than with the financial benefits they might generate (Busisiwe Nkonki-M et al., 2019). This is an appreciation that is important for understanding livestock production and consumption patterns of pastoralists in the region. The cattle population's genetic resources in West Africa possess important adaptive traits, which make them suitable to be raised in arid and semi-arid areas in the region and to cope with harsh agro-pastoral production systems such as lack of quality fodder and fertile soil and diseases (Dessie, T. and Mwai, O. (eds.). 2019).

With more than 29.4 million heads of cattle, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal are an exceptional livestock region whose meat production reached 432,997 tons in 2019, up 13.24% compared with 2010 whereas milk production decreased by 24.4% between 2010 and 2009 (FAOSTAT,2019). This represents 39% of the total main meat production[131] between the selected countries in 2019, which is a small decrease compared to its 46% share in 2010 (FAOSTAT,2019). This makes cattle the most important livestock production in the five selected countries. However, with some small-scale modern livestock-raising operations (semi-intensive and intensive), traditional livestock production systems (transhumant and extensive sedentary) that are characterized by high mortality risks and low reproductive efficiency are predominant in the region (FEWS NET, 2017). For example, the average annual milk production of a cow in sub-Saharan Africa is 6% of that in OECD countries (AfDB,2021).

Cattle value chains support approximately 70 million people in West Africa (Valerio VC, et al., 2020). The market concentration of cattle milk and meat production among the five selected countries are primarily in Mali accounting for about 41% of the total cattle main meat production, followed by Burkina Faso and Senegal, which produced 28% and 18% of cattle meat, respectively (FAOSTAT,2019). The difference between Mali and the rest of the selected countries is that a significant share of Mali cattle production is exported (FAOSTAT,2019). Indeed, exports of cattle from ECOWAS are estimated to surpass USD 800 Million each year and Mali is one of the top three live animal exporters in the region (Valerio VC, et al., 2020). This makes cattle alone the most important food product intra-regionally.

Looking at the cattle net trade on the latest FAOSTAT data, only two out of the five selected countries are cattle net exporters: Mali and Burkina Faso with a USD 74,039 thousands and USD 6,839 thousands surplus on average between 2005 and 2019, respectively (FAOSTAT,2019). A trade deficit in the remaining selected countries reflects strong internal demand for cattle, which is a bad prospect for producers in view of the current trends, particularly in terms of population growth, urbanization and incomes rise that lead to an increase in demand for cattle products. Meat consumption in the urban areas of Burkina Faso, for example, is expected to jump six-fold by 2030 compared to rates in

[131] In this analysis, main meats include cattle, sheep, goat and chicken.

2006, along with a four-fold growth in the compared to rates in 2006, along with a four-fold growth in the demand for milk (Dessie, T. and Mwai, O. (eds.). 2019).

Given the rapid increase in consumer demand compared to very limited opportunities of rural and small livestock producers in the labor market and their lack of financial resources to establish their own business, the desire to sustainably improve cattle productivity in West Africa is acute. Also, given high risks of crop production in arid and semi-arid areas in West Africa, livestock are one of the most promising ways for poverty reduction in the region. Furthermore, the livestock sector requires a significant number of natural resources and manure management emitted about 2832 Kilotonnes of carbon dioxide equivalents from methane and nitrous oxide in 2019 in the five selected countries (FAOSTAT,2019).

Climate smart adaptation and mitigation techniques aimed at reducing emissions of this sector are needed to limit the environmental burden from cattle production while ensuring a sufficient supply of cattle for a growing population in West Africa. To finance the development of climate resilient and low emission livestock value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The proposed interventions are presented in Table 1.

Table 1: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Sustainable (climate resilient) livestock production	Foster climate resilience in livestock systems for improved food and nutritional security and economic outcomes	Improving food security, building resilience and adopting mitigation activities.	– Conservation and selection of local cattle breeds[1] – Establishment or management of fodder banks[2] – Full crop-livestock system integration[3] – Pastoral infrastructure and equipment, establishing water reservoirs and livestock corridors[4] – Capacity building in livestock intensification[5] – Control of emerging and re-emerging animal diseases related to climate change[6]
Agricultural productivity and environmental restoration	Provide producers and extension agents with location-tailored information on soil characteristics and best	Improving food security, strengthening resilience, building sustainability,	– Integrated soil fertility management capacity building to regenerate soils with limited inputs[7]

Interventions	Description	Intervention objectives	Technical model examples using regional references
through integrated soil management	management practice recommendations, as well as the tools, products, partnerships, and policy environment to implement those recommendations.	transformation and adopting mitigation activities	– Soil information system development and implementation[8]
Renewable energy for sustainable livestock production and processing	Increase access to sustainable domestic energy sources to power irrigation pumps and cold rooms for the storage of meat, support health and reduce greenhouse gases (GHGs).	Building sustainability, adopting mitigation activities, improving soil fertility and health	– Create a sustainable source of on-farm energy using grid-connected solar photovoltaics systems for small farms [9] – Bolster research and development capacity for sustainable on-farm energy production technologies[10] – Raise public awareness of the benefits of sustainable energy production and use[11]

[1] Ouédraogo D et al. Genetic Improvement of Local Cattle Breeds in West Africa: A Review of Breeding Programs. *Sustainability*. 2021; 13(4):2125. https://doi.org/10.3390/su13042125

[2] Multispecies fodder bank as climate-smart option for an improved livestock nutrition in Northern Ghana (cgiar.org); Ollo, Sib et al. (2020). Establishing high-density protein banks for livestock in Burkina Faso (West Africa): agronomic performance under contrasting edaphoclimatic conditions. Agroforestry Systems. 94. 10.1007/s10457-019-00394-4

[3] Toward Integrated Crop-Livestock Systems in West Africa: A Project for Dairy Production Along Senegal River - ScienceDirect

[4] For West African Farmers, Reservoirs Hold Much More Than Just Water - Farming First; PowerPoint Presentation (wfp.org); Animal Health Context One Jan 2021.pdf (sustainablelivestockguide.org);

[5] Pastoral intensification in West Africa: implications for sustainability (osu.edu); Pg173_198 Batiano (icrisat.org)

[6] Fenollar, F, and O Mediannikov. "Emerging infectious diseases in Africa in the 21st century." *New microbes and new infections* vol. 26 S10-S18. 21 Sep. 2018, doi:10.1016/j.nmni.2018.09.004; Caminade, Cyril et al. "Impact of recent and future climate change on vector-borne diseases." *Annals of the New York Academy of Sciences* vol. 1436,1 (2019): 157-173. doi:10.1111/nyas.13950

[7]Jalloh and al, 2011. Nature and management of the soils in West and Central Africa: A review to inform farming systems research and development in the region. Conseil Ouest et Centre Africain pour la Recherche et le Development Agricoles/West and Central African Council for Agricultural Research and Development (CORAF/WECARD). CORAF/WECARD,Dakar, Senegal, available at:

NATURE AND MANAGEMENT OF SOILS IN WCA (coraf.org); Microsoft Word - 53_0944_Vanlauwe.doc (iuss.org); Fermont, A.M., Obiero, H.M., Van Asten, P.J.A., Baguma, Y. and Okwuosa, E. 2004. Improved cassava varieties increase the risk of soil nutrient mining: An ex-ante analysis for Western Kenya and Uganda. In: Bationo, A., Waswa, B., Kihara, J. and Kimetu, J. (eds). Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities. Springer, Dordrecht, The Netherlands. pp 511-519.

[8] The World Agroforestry Center (ICRAF) has developed spectral diagnostics enabling rapid and low-cost analysis of soil properties and plant nutrients that can be applied at scale for digital mapping.; Environment - Biodiversty and Climate Change | West Africa Regional | U.S. Agency for International Development (usaid.gov)

[9] IRENA (2018), IRENA Planning and prospects for renewable power: West Africa, International Renewable Energy Agency, Abu Dhabi.Available at *Planning and prospects for renewable power: West Africa (irena.org); (Em)powering Farmers in Africa: Small-scale Solar Lights a Path for Agricultural and Economic Impact (worldbank.org)

[10] Clean and Efficient Energy | West Africa Regional | U.S. Agency for International Development (usaid.gov); DistanceLearning.indd (columbia.edu)

[11] 33313-wd-africa clean energy corridor west africa clean energy corridor e.pdf (au.int); Developing Renewable Energy Sectors and Technologies in West Africa | United Nations

Table 2: Proposed model intervention: Access to affordable loans and financial green services (climate resilient and low carbon livestock production) in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production (FAOSTAT):* Average cattle meat produced per year: BF: 115,134 t; CI:31,466 t; GH:24,427 t; ML:167,126 t and SN: 72,689 t and average cattle milk produced per year: BF: 178,654 t; CI: 31,679 t; GH: 43,121 t; ML: 401,665 t and SN: 164,013 t holdings of 0.25-3 ha. Cattle meat yields per animal (an): BF: 1,002 hg/an; CI: 1,087 hg/an; GH: 1,568 hg/an, ML: 1,290 hg/an, and SN: 1,711 hg/an and cattle milk yields per an.: BF: 1,268 hg/an; CI: 1,184 hg/an; GH: 1,368 hg/an; ML: 1,965 hg/an and SN: 2,386 hg/an. Average cattle carcass weight is 112 kg in ordinary system and 113–114 kg in the fattening system. Production costs are estimated at 1.5 USD/kg and 2 USD respectively in pastoral and agropastoral systems against 3 USD and 5 USD in the semi-intensive and intensive systems. Price of cattle ranges between USD165 and USD827 in 2020. Even when supply is at its maximum during the peak sales period, prices are not falling and sometimes even continue to increase due to strong demand from coastal countries. *Collection and primary selection and transformation*: Extensive cattle production systems are predominant in West Africa (pastoral or transhumance and agropastoral or sedentary). Yields tend to be much lower, growth rate slower, time to maturity much longer. Also, unforeseen droughts can lead to devastating losses. As part of their strategy to sustainably improve cattle productivity, the five selected countries have promoted investments in fodder banks, manure composting for fertilization, intensification of cultivated pastures (animal in place and improved forages) and a selection of cattle breeds per agroecological zones. *Distribution and international trade:* ML were the largest net exporter with a USD 74 million surplus on average, followed by BF (USD 6.8 million). SN was the largest net importer, posting a USD 50 million deficit on average, followed by CI (USD 22 million) and GH (USD 3.9 million), as increases in production

	are unable to keep pace with the growing demand. Overall, the five selected countries face a cattle trade surplus, thanks to ML.
Technical services and best practices	As part of technical support and extensive services of livestock production to improve cattle productivity and resilience, the five selected countries will support multi-sectoral and multidisciplinary dialogue among stakeholders in the livestock value chain to appreciate the production, public health and environmental dimensions of livestock.
Financial services	Small livestock producers' access to credit from financial institutions is very limited for several reasons: lack of collateral, interest rates, inability to prepare loan applications, high transaction costs, etc. Loans available from banks and MFIs are often short-term, high interest and for only the current campaign, working capital or equipment. The budgetary support allocated to the development of the sector has been low. However, several projects and programmes have been implemented with the aim of improving animal health, genetics and the development of infrastructure at the farm and marketing level.
Climate vulnerability and other risks	Meta-analyses suggest that livestock disease probably kills 20% of ruminants in developing countries and more than 50% of poultry each year causing a loss of approximately USD 300 billion per year[1]. Climate change can exacerbate disease in livestock, and some diseases are especially sensitive to climate change (Rift Valley fever, Trypanosomosis, Ticks and tick-borne diseases etc.). Among 65 animal diseases identified as most important to poor people, 58% are climate sensitive. Climate change may also have indirect effects on animal disease, and these may be greater than the direct effects. As farmers try to cope with the impacts of climate change, it can be expected that pressure on natural resources (vegetation, soil, water) will increase due to obstruction of the tracks to pasture, water sources and urbanization, leading to overuse, degradation, potential conflicts, rural exodus and international emigration. To mitigate these effects, introducing adaptation measures and strengthening resilience is urgently needed.
Key Barriers and Enablers (based on interventions in Table 1)	Key potential climate-related barriers may include: - Sustainable (climate resilient) livestock production: Land tenure insecurity dissuades farmers from investing in trees and soil; Labor intensity of using manure as fertilizer alternative under extensive grazing system; Limited adoption of best agricultural practices; increase pastoralist-smallholder conflict; Low productivity as heat stress; Increase in mortality; Decline in feed sources. - Agricultural productivity and environmental restoration through integrated soil management: Fertilizer distribution may not reach all smallholders; Limited organic matter soil inputs available; Drought and flood events are increasing in frequency; Land tenure insecurity curbs smallholder investments; Low availability of quality planting material. - Renewable energy for sustainable livestock production and processing: Siting and transmission barriers decreasing sustainable energy generation and consumption; Insufficient energy availability could exacerbate inefficient soil and water management practices; Potential lack of use of renewable energy if electricity services have high capital costs in the long term, which could increase environmental degradation.

	Other key barriers include: limited access to affordable loans and financial services; ; poor access to inputs; lack of technical capacity and knowledge of farmers and government extension services on best climate resilient, low-emission practices and limited capacity to process and market cattle; lack of slaughterhouse infrastructures and processing; poor roads for cattle trade network; labour shortages; low mechanization levels, which increase production costs; insecure land tenure; limited cost-effective marketing channels; fragmented and disorganized livestock marketing system; long and extended supply chain linking smallholder producers with domestic consumers and export markets; lack of availability and quality of information about cattle prices; ; poor disease control, among others. Increasing access to financing will be fundamental for enabling farmers to overcome these barriers.
Current extents and potential program adoption	Of the five target countries, Mali and Burkina Faso are the largest cattle meat and milk producers and net exporters. Target of household adoption rate of 40% for the implementation of climate resilient, low-emission agriculture techniques and practices.
Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices; sustainable livestock production (sustainable breeding, processing, storage and marketing of cattle); integrated management of soil to ensure agricultural productivity and environmental restoration) and adoption of RETs to power cold rooms for the storage of meat and irrigation pumps
Mitigation activities and impacts (based on technical models in Table 1)	Frequent removal of manure for composting is an effective mitigation practice to reduce GHG emissions for cattle production systems. The use of solar energy instead of fossil fuels to power irrigation pumps and other equipment will also help reduce GHG emissions. Crop-livestock integration will provide smallholder farmers with more options to mitigate agro-environmental trade-offs. Livestock corridors support pastoralists in search of resources and protect smallholders from conflicts. Select cattle breeds per agroecological zones will help livestock producers to mitigate harmful effects of cattle production on climate change. Smallholders could keep hay on hand so there is no need to buy it during a drought.
Adaptation activities and impacts (based on technical models in Table 1)	Fodder banks will increase fodder production during critical times and fuel wood supply. Improved varieties of ruminants offer resource use efficiency and tolerance to adverse conditions. Manure composting for fertilization will improve soil quality and infiltration; Intensification of cultivated pastures (animal in place and improved forages) and efficient watering technologies (solar pumps, water tanks, ponds or creeks etc.) will increase water storage and ensure better use of water resources, which could become scarcer in some parts of the region. Integrated crop-livestock production systems are synergistically more productive and resilient than either system alone. Select cattle breeds per agroecological zones will help livestock producers to adjust to different agroecological conditions;

Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

[1] https://unfccc.int/files/documentation/submissions_from_non-party_stakeholders/application/pdf/516.pdf

Sustainable horticulture and vegetable production - Tomato

Smallholder tomato farmers in West Africa produce on small plots, with an average of 0.5ha, that are hand cultivated and watered by a variety of methods such as furrow, flood, gravity, drip irrigation, or sprinklers (Perez et al., 2017). Varieties planted are purchased in small quantities, or seed saved from precedent years, having few resistance genes. Hybrid varieties are more expensive for smallholders in rural areas, therefore are less used. For instance, commercial tomato production in Senegal, associated with canneries, relies on the use of hybrid seed on larger fields with modern technologies (mechanized, application of fertilizer and pesticides, drip irrigation).

Tomatoes thrive in well-drained, deep, uniform clay or silty loams. They are very sensitive to waterlogged soils and prefer a soil pH of between 6.0 -7.5[132]. They do best in temperatures of between 20°C – 27°C. Tomato production can be adversely affected when the temperatures get below 10°C or exceed 30°C, as fruit setting is affected. According to growers[133], the tomato cycle is quite varied, ranging from 4 to 7 months and a half depending on the growing conditions and variety. The tomato can be grown all year, although it is best to avoid the rainy season, which can result in significant damage if there are severe storms, unless it is grown under cover. After harvesting, tomato conservation procedures are developed, allowing for its use when it becomes scarce.

The tomato fruit is an important cash crop in the region, playing a crucial role in nutrition (source of vitamins and minerals). In the recent past demand for tomatoes in the region has increased tremendously. This demand can only be met by increasing production area and yield, which has been the case in Burkina Faso, Ghana, Mali, Cote d'Ivoire and Senegal (FAOSTAT,2019). Indeed, Burkina Faso's area harvested went from 1241 ha in 2010 to 1799 ha in 2019, with an output of 11281 kg/ha and 10861 kg/ha, respectively; Cote d'Ivoire's area harvested went from 3300 ha in 2010 to 3601 ha in 2019, with an output of 9467 kg/ha and 10372 kg/ha, respectively; Ghana 's area harvested doubled between 2010 and 2019 (from 44200 ha to 92045 ha), with an output of 7206 kg/ha and 4300 kg/ha, respectively; Mali 's area harvested multiplied by more than 4 between 2010 and 2019 (from 2482 ha to 10551 ha), with an output of 16637 kg/ha and 15162 kg/ha, respectively; and Senegal's area harvested went from 6680 ha in 2010 to 7148 ha in 2019, with an output of 24701 kg/ha and 20705 kg/ha, respectively. In terms of production, Ghana is among the leading tomato producers in Africa, with a production of 395 755 tons in 2019. Burkina Faso was at 19 539 tons, Côte d'Ivoire at 37 351 tons, Mali at 159 977 tons and Senegal at 148 000 tons (FAOSTAT, 2019).

Looking at the cattle net trade on the latest FAOSTAT data, only two out of the five selected countries are tomato net exporters: Senegal and Burkina Faso with a USD 10.2 million in 2019 and USD 1.7 million surplus in 2018, respectively (FAOSTAT,2019). A trade deficit in the remaining selected countries reflects strong internal demand for tomato, which is a bad prospect for producers in view of the current trends, particularly in terms of population growth, urbanization and incomes rise that lead to an increase in demand for tomato products.

In Sub-Saharan Africa's fruit and vegetable supply chains, tomato fruit has some of the largest postharvest losses (Affognon et al. 2015). Plant diseases, insect pests, and abiotic challenges such as low moisture, heat, and low soil fertility have all played a role in impending tomato plant

[132] https://farmersvoiceafrica.org/sites/default/files/2019-08/TOMATO%20GUIDE.pdf
[133] https://lefaso.net/spip.php?article102539

breeding and production in Sub-Saharan Africa. Better production methods, high-yielding and disease-resistant varieties will play a key role keeping up with the market demand. Moreover, unavailability of markets, labor and irrigation expenditures, and high transportation costs are all factors that contribute to low productivity134. Increased market participation, improved tomato producer welfare, increased product availability, and favorable contributions to food security all require a reduction in such losses (Adepoju, 2014).

The traditional farming of tomatoes in open fields, most used in the five-targeted countries, is more affected by climatic factors, than the modernized system using greenhouse structures. Extreme temperatures, excessive water or drought cause sub-optimal production. Water management is critical to obtain high yields and good quality products. With adaptation and mitigation measures to be supported by this project, however, tomato yields could increase (primarily in dry season irrigated systems) or the decreases would be significantly less. These effective adaptation measures include more efficient irrigation systems, various tomato varieties producing higher yields, resistant to diseases and that have long shelf-life, soil management techniques, particularly to address the issue of low soil fertility and salinity, drip irrigation and storage and conservation techniques powered by renewable energy technologies.

To finance the development of climate resilient horticulture value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The proposed interventions are presented in table 3 along with the proposed model intervention in table 4.

Table 3: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Sustainable horticulture and vegetable production	Increase productivity and climate resilience of horticulture and vegetable production while fostering economic opportunities for smallholders, especially women and youth, and minimize environmental impact.	Food security, resilience, value chains, sustainability, mitigation, livelihoods and inclusivity.	• Access and best management practices for improved varieties (e.g., micro tubers)[1] • Development of best management practice recommendations for vegetable storage and • preservation techniques, with a focus on correct use of chemical inputs and water quality standards[2] • Soil and water conservation techniques (zaï pits, half-moon technique, contour bunding, and mulching)[3] • Production and use of compost[4]

[134] http://www.bioline.org.br/pdf?cs20010

Interventions	Description	Intervention objectives	Technical model examples using regional references
			• Integrated pest and disease management (safe use of chemical inputs as needed)[5] • Best irrigation practices (water quality standards, use of drip irrigation, and use of solar pumps)[6]
Renewable energy for sustainable horticulture production and processing	Transform selected horticulture value chains products to Increase access to solar panels and low-carbon equipment for improved production and processing	Food security, resilience, value chains, transformation, sustainability and environmental quality	• Establishment of irrigation and water infrastructure using solar pumps for off-season crops in the dry season[7] • Production and sale of solar energy to farmers[8] • Capacity building for solar and water use efficiency[9] • Constructing storage facilities in wholesale markets designed to minimize postharvest losses using renewable energy (e.g., building and supplying cold chain infrastructure with solar pumps)[10] • Production and processing horticulture value chains with RETs

[1] Promoting Better Plant Varieties Development in West Africa – CORAF
[2] horticulture_-_capability_statement.pdf (snv.org); Good Agricultural Practices for Fruit and Vegetable Farms (purdue.edu)
[3] Partey et al, (2018). Developing climate-smart agriculture to face climate variability in West Africa: Challenges and lessons learnt. Journal of Cleaner Production. 187. 10.1016/j.jclepro.2018.03.199.
[4]Paulin, B, and O'Malley, P. (2008), Compost production and use in horticulture. Department of Primary Industries and Regional Development, Western Australia, Perth. Bulletin 4746. Available atL Compost production and use in horticulture (agric.wa.gov.au); Ouédraogo et al, (2001). Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. Agriculture, Ecosystems & Environment. 84. 259-266. 10.1016/S0167-8809(00)00246-2.
[5] Integrated-pest-management.pdf (croplife.org); principles_weed_pest_disease_management.pdf (kzndard.gov.za)
[6] pdf\CV\CV107\CV107-Dyo3u8mpyu.pdf (ufl.edu); Water Quality for Crop Production | Center for Agriculture, Food, and the Environment (umass.edu)
[7] Andrieu et al., "Prioritizing Investments for Climate-Smart Agriculture."
[8] Solar Pumps On Credit: Reducing Production Costs for Horticulture Producers Senegal (icco-cooperation.org)
[9] SOLtrain West Africa - ECOWAS Solar Thermal Capacity Building and Demonstration Program | ECREEE
[10] Agriculture and Food Security | West Africa Regional | U.S. Agency for International Development (usaid.gov)

Table 4: Proposed model intervention: climate resilient, low carbon tomato production in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production: planting, maintenance and harvesting:* Average smallholder producer **holdings** of 0.5 ha. **Yields**: BF, 108 610 (12.5t/ha); CI, 103 724 hg/ha; GH, 42 996 hg/ha (7.5 t/ha), ML, 151 623 hg/ha, and SN, 207 051 hg/ha. **Producer price** in CI: 511 USD/t (avg. 2010-2011); GH: 829.2 USD/t and ML: 703.6 USD/t in 2019, and SN: 387.8/t USD/t in 2018 (FAOSTAT). Overall, the yields are modest, with prices depending on the availability of products. Ghana is among the leading tomato producers in Africa, with a production of 395 755 tons in 2019. Burkina Faso was at 19 539 tons, Côte d'Ivoire at 37 351 tons, Mali at 159 977 tons and Senegal at 148 000 tons. The total area harvested in the five countries is 111 903 ha[1]. *Collection and primary selection and transformation*: On the tomato value chain, traders link producers to consumers. They bring produce from farms to markets in rural and urban centres. In Ghana, these traders are typically women and have the most power in the chain, capturing the largest margin share. Tomato processing is a solution to the challenge of important post-harvest losses of tomato, particularly when transported over long distances. The major challenge facing regional processing firms is accessing a steady supply of tomato all year. *Distribution and international trade:* The trade of tomatoes is essentially regional, with Ghana importing fresh tomatoes from neighbouring countries, particularly Burkina Faso. SN was the largest net exporter with a USD 10 million surplus in 2019, followed by BF (USD 1.7 million in 2018). GH was the largest net importer, posting a USD 818,000 deficit in 2019, followed by CI (USD 669,000) and ML (USD 212,000), as increases in production are unable to keep pace with the growing demand. Overall, the five selected countries face a tomato trade surplus, this is justified by SN.
Technical services and best practices	Hybrid varieties give better yields and are more resistant to disease and climate change. Post-harvest techniques are also used to reduce losses in order to improve profit margins, livelihoods and food security. Farmers need to select varieties that are resistant to diseases such as varieties that are resistant to Verticillium wilt (Vd), Fusarium wilt (Fol), Fusarium Crown and Root Rot (Fol) Nematodes (N), Alternaria solani (As) and Tomato Yellow Leaf Curl Virus (TYLCV). Also, the variety must guarantee that the fruit will remain fresh through the chain and especially during transportation.
Financial services	Smallholder tomato producers' access to credit from financial institutions is very limited for several reasons: lack of collateral, interest rates, inability to prepare loan applications, high transaction costs, etc. Loans available from banks and MFIs are often short-term, high interest and for only the current campaign, working capital or equipment. Government support in the form of subsidies for inputs are available, but often smallholders in remote areas are unable to access them.

Climate vulnerability and other risks	As tomato is mostly grown outdoors, it might be severely impacted by climate change. Tomato production is sub-optimal in major portions of the tomato crop-growing areas of the world due to unfavorable climatic circumstances produced by abiotic variables such as high or low temperatures, excessive water or drought. Other elements that affect tomato production, such as irrigation and fertilization, are applicable to both greenhouse and field-grown tomatoes. To get high yields and good quality fruit, cultivation necessitates efficient water management, which necessitates irrigation where natural rainfall is insufficient. Tomatoes, like climacteric fruits, are susceptible to rapid quality loss following harvest. These losses are highly dependent on the state of ripening at harvest. Sub-optimal handling, such as rough handling, poor cleanliness, and warm storage temperatures, can exacerbate the influence of the ripening stage on tomato postharvest quality, creating chances for losses.
Key Barriers and Enablers (based on interventions in Table 3)	Key potential climate-related barriers may include: - **Sustainable horticulture and vegetable production:** extreme heat, particularly in combination with drought, can result in insufficient availability of irrigation-quality water in wells and dams during the dry season[2]. Chemical inputs may be used incorrectly and/or in excess. Soil degradation, in combination with limited access to fertilizers, significantly limits yields. A lack of reliable transportation methods, optimized storage facilities, and cold chains implies very high postharvest losses. - **Renewable energy for sustainable horticulture production and processing:** siting and transmission barriers decreasing sustainable energy generation and consumption; Insufficient energy availability could exacerbate inefficient soil and water management practices; Potential lack of use of renewable energy if electricity services have high capital costs in the long term, which could increase environmental degradation. Other key barriers include: limited access to affordable technologies (improved seeds and hybrid varieties); degraded irrigation infrastructure and inefficient water management practices; lack of technical capacity and knowledge of farmers and government extension services on best climate resilient, low-emission practices and limited capacity to process, handle post-harvest tomatoes; lack of access to electricity; poor roads; labour shortages; insecure land tenure; limited market access; low margins for farmers who face the most risks; high pest and disease pressure; Increasing access to financing will be fundamental for enabling farmers to overcome these barriers.
Current extents and potential program adoption	Of the five target countries, Ghana and Mali are the largest producers. Target of household adoption rate of 40% for the implementation of climate resilient, low-emission agriculture techniques and practices.
Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices such as greenhouses, sustainable horticulture and

	vegetable production and renewable energy for sustainable horticulture production and processing including water management practices.
Mitigation activities and impacts (based on technical models in Table 3)	Compost production and targeted application prevents and mitigates soil degradation. Improved storage reduces postharvest losses. Community organization and engagement helps facilitate access to processes, equipment, and infrastructure that increase efficiency, improve resilience, and reduce losses. This may include, for example, solar dryers, storage facilities, cold chains, transportation, credit and loan, warehouse receipting, and bulk purchasing and sales[3]. Drip irrigation involves alternate wetting and drying with minimal water application, its adoption will reduce GHG emissions from flooded tomato fields. The use of solar energy instead of fossil fuels to power irrigation pumps, storage and conservation techniques will help reduce GHG emissions.
Adaptation activities and impacts (based on technical models in Table 3)	Use of organic fertilizer mitigate soil degradation and enhance soil quality, structure, and functioning. Improved storage enables smallholder farmers to fetch higher rates for their harvest by holding it until off-season. Drip irrigation is a key climate resilient, low emission approach to tomato production, enriching soils with organic matter, and reducing water use, to better withstand weather calamities such as drought, floods and strong winds, while assuring production. The adoption of improved tomato varieties will help farmers adjust to changes in the cropping calendar (resistant to diseases, with a long self-life and producing higher yields). More efficient irrigation techniques and equipment will ensure better use of water resources, which could become scarcer in some parts of the region.
Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

[1] https://knoema.com/FAOPRDSC2020/production-statistics-crops-crops-processed
[2] Expert Panel Workshop, Vegetable Production, Processing, and Storage Project Planning.
[3] CCAFS, "Climate-Smart Agriculture in Mali."
[1] https://knoema.com/FAOPRDSC2020/production-statistics-crops-crops-processed
[2] Expert Panel Workshop, Vegetable Production, Processing, and Storage Project Planning.

Restoring degraded land and agroforestry: Mango

West Africa produces roughly 1.5 million tons of mangoes each year, accounting for about 4% of global production[135]. While this is a key source of money for countries and exporters, the fruit fly, among other threats, has a negative impact on the region's horticultural economy. Between 50 and 80 percent of mango output is destroyed. Furthermore, post-harvest losses run from 50 to 80 percent, implying that less than 100,000 tons of fresh mangoes are exported each year and approximately 50,000 tons are processed domestically.

Based on collected data, the overall number of mangoes exported by West African countries to the European Union market climbed by 40% from 2014 to 2019, while rejects decreased by 57%[136]. (Fruit Fly Control Project, 2019).

The main varieties cultivated in West Africa are:

- The fibrous, polyembryonic Nunkourouni is widespread throughout West Africa. Adult trees are highly productive, with a very precocious production in the season, which makes them the first mangos on the market.
- Tommy Atkins: moderately fibrous, thick skin, hard, good appearance and easy to handle, travel well and its taste is average. It is the leader in the market, a dominant variety cultivated mostly in Brazil.
- Hayden: less fibrous, soft skin, good appearance and good taste.
- Kent: no fibre, very soft skin, difficult to transport, good appearance and good taste.
- Keitt: less fibrous, soft skin, good appearance, good taste, late production.
- Zill: less fibrous, quite soft skin, purple, good taste, early production.
- Amelie: yellow cultivar, cultivated all over West Africa, moderately or very fibrous, unwanted flavour (like turpentine), early production.

Ivory Coast is the greatest exporter, accounting for 41% of the region's exports with 14,000 tons, followed by Senegal (20%), Mali (18%), and Burkina Faso (16%). The table 1 gives a breakdown of the production and export level in the IGREENFIN countries.

Table 5: Mango production/export in IGREENFIN targeted countries[137]

Country	Production in ton	Export in ton	Export as % of production
Sénégal	80 936	6 797	8.4%
Mali	64 217	6 238	9.7%
Côte d'Ivoire	31 228	14 015	40.9%
Burkina Faso	9 300	5 580	60.0%
Ghana	6 639	568	8.6%

1. In the strategic orientation document for mango value chain in the economic community of West African states (ECOWAS), strengths and weaknesses of the field are identified and presented in the table 6 below.

[135] http://www.coraf.org/2019/07/31/west-african-mango-producers-smiling-again/
[136] https://wacomp.projects.ecowas.int/value-chains/mango/
[137] file:///C:/Users/a.dogbe/Downloads/ECOWAS_01.pdf

Table 6: Strengths/opportunities and weakness for the mango value chain in ECOWAS

Weaknesses	- Lack of know-how (inadequate management, language barriers, trade marketing information) - Low volumes produced (export volumes, lack of raw materials, ageing of orchards, growing urbanization) - Poor quality (fruit fly infestation, irregularity of products) - Inadequate logistics (lack of infrastructure, lack of specialized transportation of fresh fruits) - High costs of production (packaging, energy, inputs) - Lack of organization (lack of policy support, no stakeholders' consultations)
Strengths and opportunities	- Taste of mango (specific to the region/to the countries) - Good quality of specific varieties (for example Tommy Atkins) - Diversity of mango varieties - Existence of growing market for good quality mango

2. The price of a mango rises in proportion to its quality. Internal and external features of quality vary based on the year, country, and orchard. Quality is influenced by three factors:

- Variety: each variety has a unique influence on the quality, yield, and resistance to drought, diseases and time of maturation. The choice of the variety is very important because once planted, the orchard lasts for 15 to 30 years.
- Climate: climate influences mainly the yield and time of maturation, and to a lesser extent the quality. It is an important factor but the farmer cannot do anything about it.
- Agronomic practices used by the farmer affect both the quality and yield. The inadequate yield in West Africa is attributed to poor farming practices. Most farmers need to improve: - Irrigation; - Pruning practices; - Fertilization practices; - Pest and disease control (whiteflies, anthracnose); and - Harvest time.

3. In analysing profitability, export of dried mango from Burkina Faso to niche market, like bio and fair trade in Europe, permits excellent margins. Mali and Senegal on the other hand have better business opportunities by targeting the regional and local market: exporting fresh mango to Gabon for Mali (47% profit) and selling fresh mango to Morocco for Senegal (31% profit).

4. West African consumers are becoming more demanding in terms of quality, and they have more purchasing power. Consumption is currently at 650,000 tons, but it is expected to rise to one million tons in the next ten years. Mangoes destined for the local market can cost anywhere from 20% to 50% more.

5. Although the region's climate is conducive to mango production, smallholder mango producers are being affected by the low quality and high wastage of the mangoes they grow. Indeed, mango's susceptibility to environmental stressors means it is heavily affected by climate; crop yield and quality fluctuate considerably from year to year, and even within a season should any unexpected weather events occur. Climate change has caused newly emerging pests and diseases, such as fruit flies, which are causing an increasing number of

mangoes to rot[138]. A single pest found in a container destined for export will result in destruction of the entire lot, implying significant loss for producers[139]. Pest outbreaks can truncate the entire export season[140]. In addition, inefficient, costly transport as a result of poor infrastructure further exacerbates crop loss. Consequently, crop losses consume up to one-third of total annual production as an example in Cote d'Ivoire[141].

6. Climate resilient agricultural practices can significantly improve mango production and reduce post-harvest loss, thus, improve the climate resilience and productivity of mango plantations. Value-added processing can leverage products that do not meet fresh fruit quality standards to diversify and strengthen economic outputs. Therefore, mango is an exceptionally suitable crop for upscaling climate smart technologies and building resilience to climate change among the smallholder growers in West Africa due to the following key factors[142]:

- Mango is a perennial tree crop that has good tolerance to water stress.
- Mango is amenable to intercropping with short duration crops.
- There is high and increasing demand of fresh and processed mango products locally and internationally.
- There are diverse value-added products that can be obtained from mango
- There are many opportunities for economic participation of women, youth, marginalized and vulnerable groups along various nodes in the mango value chain.

7. To finance the development of sustainable mango value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The proposed interventions are presented in table 7 along with the proposed model intervention in table 8.

Table 7: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Climate resilient development of the mango value chain	Increase incomes in the West African mango sector via greater productivity through climate resilient and low emission practices and reduced post-production	Food security, resilience, value chains, sustainability, mitigation and livelihoods.	• Integrated soil fertility management such as organic fertilizer, intercropping[1] and improved varieties • Integrated pest and disease management (safe use of chemical inputs as needed)[2],[3] • Waste management for mango processers to address environmental issues (e.g., mango drying in the region)[4]

[138] Ban Koffi 2017
[139] Toure 2012
[140] van den Broek 2016
[141] Toure 2012
[142] mango-tot.pdf (kalro.org)

Interventions	Description	Intervention objectives	Technical model examples using regional references
	losses through value-added processing.		• Production of organic mangoes for drying[5] • Soil and water conservation techniques (e.g., mulching)[6] • Certifications for quality of mango production, through member associations for exports as well as local and regional markets, in next steps of training[7] • Collecting center with pack house facilities to facilitate its fresh mango suppliers to sell quality mangoes to exporters and processors[8]
Restoring degraded lands and agroforestry	Foster climate-resilient livelihoods and food sources for smallholders, especially women and youth, through agroforestry techniques and value-addition.	Food security, improved yield, resilience, value chains, sustainability, mitigation, livelihoods through improved returns to smallholders and inclusivity	• Integrated soil fertility management such as organic fertilizer, intercropping[9] and improved varieties[10] • Soil information systems (SIS)[11] • Forest and agroforest management to support mango trees productivity and soil health [12] • Bolster research and development capacity for sustainable mango production • Best irrigation practices (water quality standards, use of drip irrigation etc.)[13] • Improved pruning practices[14] • Mango tree assisted natural regeneration • Grafting techniques (quick method for the successful propagation of the mango tree) • Packaging with environmental norms and standards • Integration of mango trees in agroforestry systems for nutritional diversity and security
Renewable energy for sustainable mango production and processing	Transform selected crop value chains products to Increase access to solar panels and low-carbon equipment for improved	Food security, resilience, value chains, transformation, sustainability and environmental quality	• Producing and processing mango value chains powered by RETs (solar dryers) • Establishment of irrigation and water infrastructure using solar pumps for off-season crops in the dry season • Production and sale of solar energy to farmers

Interventions	Description	Intervention objectives	Technical model examples using regional references
	production and processing		• Capacity building for solar and water use efficiency • Constructing storage facilities in wholesale markets designed to minimize postharvest losses using renewable energy (e.g., building and supplying cold chain infrastructure with solar pumps) • Protection of water bodies and associated ecosystems

[1] Recha 2017
[2] In 2008, CORAF through the WAAPP project created an innovation platform as part of a larger program to improve food systems in West Africa. Available at: Integrated Pest Management Key To Improving Incomes on Orchards – CORAF; WEST AFRICA: IPM Empowers Farmers Not to Produce More, but Produce Better Mangoes – TFNet – International Tropical Fruits Network (itfnet.org)
[3] Integrated-pest-management.pdf (croplife.org); principles_weed_pest_disease_management.pdf (kzndard.gov.za)
[4]UNIDO Senegal: Waste management for mango processers in Casamance - COLEACP NEWS
[5] PSHP Technical Report Template (usaid.gov)
[6]Nyamekye, Clement & Thiel, Michael & Schönbrodt-Stitt, Sarah & Zoungrana, Benewinde & Amekudzi, Leonard. (2018). Soil and Water Conservation in Burkina Faso, West Africa. Sustainability. 10. 3182. 10.3390/su10093182.
[7] PSHP Technical Report Template (usaid.gov)
[8] PSHP Technical Report Template (usaid.gov)
[9] Recha 2017
[10] Mango Value Chain Development (farmafrica.org)
[11]The Africa Soil Information Service (AfSIS) has applied this technology to generate detailed national SIS in Ethiopia, Ghana, Nigeria and Tanzania and at smaller scales in Côte d'Ivoire. Organizations such as SoilCares, the Crop Nutrition Services Laboratory, the Gates Foundation, One Acre Fund and FoodAfrica have leveraged ICRAF's spectral diagnostic technology to generate soil maps, plan projects and conduct testing services across Africa. There are potential innovations to generate SIS in the Sahel through IGREENFIN 1 to predict mango production under Component 2, Output 3.3.
[12] Slide 1 (jica.go.jp); Tk, Kunhamu & Av, Santhoshkumar. (2012). Mango in agroforestry.
[13] Project Overview - West African Irrigation Project (WAIPRO) (iwmi.org); pdf\CV\CV107\CV107-Dyo3u8mpyu.pdf (ufl.edu); Water Quality for Crop Production | Center for Agriculture, Food, and the Environment (umass.edu)
[14] Gross, Emil R. (1997). PRUNING MANGO TO INCREASE YIELD. Acta Hortic. 455, 538-542 DOI: 10.17660/ActaHortic.1997.455.70 https://doi.org/10.17660/ActaHortic.1997.455.70
[1] Recha 2017
[2] In 2008, CORAF through the WAAPP project created an innovation platform as part of a larger program to improve food systems in West Africa. Available at: Integrated Pest Management Key To

Improving Incomes on Orchards – CORAF; WEST AFRICA: IPM Empowers Farmers Not to Produce More, but Produce Better Mangoes – TFNet – International Tropical Fruits Network (itfnet.org)
[3] Integrated-pest-management.pdf (croplife.org); principles_weed_pest_disease_management.pdf (kzndard.gov.za)
[4]UNIDO Senegal: Waste management for mango processers in Casamance - COLEACP NEWS
[5] PSHP Technical Report Template (usaid.gov)
[6]Nyamekye, Clement & Thiel, Michael & Schönbrodt-Stitt, Sarah & Zoungrana, Benewinde & Amekudzi, Leonard. (2018). Soil and Water Conservation in Burkina Faso, West Africa. Sustainability. 10. 3182. 10.3390/su10093182.
[7] PSHP Technical Report Template (usaid.gov)
[8] PSHP Technical Report Template (usaid.gov)
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[12] Slide 1 (jica.go.jp); Tk, Kunhamu & Av, Santhoshkumar. (2012). Mango in agroforestry.
[13] Project Overview - West African Irrigation Project (WAIPRO) (iwmi.org); pdf\CV\CV107\CV107-Dyo3u8mpyu.pdf (ufl.edu); Water Quality for Crop Production | Center for Agriculture, Food, and the Environment (umass.edu)
[14] Gross, Emil R. (1997). PRUNING MANGO TO INCREASE YIELD. Acta Hortic. 455, 538-542
DOI: 10.17660/ActaHortic.1997.455.70 https://doi.org/10.17660/ActaHortic.1997.455.70
[1] Recha 2017
[2] In 2008, CORAF through the WAAPP project created an innovation platform as part of a larger program to improve food systems in West Africa. Available at: Integrated Pest Management Key To Improving Incomes on Orchards – CORAF; WEST AFRICA: IPM Empowers Farmers Not to Produce More, but Produce Better Mangoes – TFNet – International Tropical Fruits Network (itfnet.org)
[3] Integrated-pest-management.pdf (croplife.org); principles_weed_pest_disease_management.pdf (kzndard.gov.za)
[4]UNIDO Senegal: Waste management for mango processers in Casamance - COLEACP NEWS
[5] PSHP Technical Report Template (usaid.gov)
[6]Nyamekye, Clement & Thiel, Michael & Schönbrodt-Stitt, Sarah & Zoungrana, Benewinde & Amekudzi, Leonard. (2018). Soil and Water Conservation in Burkina Faso, West Africa. Sustainability. 10. 3182. 10.3390/su10093182.
[7] PSHP Technical Report Template (usaid.gov)
[8] PSHP Technical Report Template (usaid.gov)
[9] Recha 2017
[10] Mango Value Chain Development (farmafrica.org)
[11]The Africa Soil Information Service (AfSIS) has applied this technology to generate detailed national SIS in Ethiopia, Ghana, Nigeria and Tanzania and at smaller scales in Côte d'Ivoire. Organizations such as SoilCares, the Crop Nutrition Services Laboratory, the Gates Foundation, One Acre Fund and FoodAfrica have leveraged ICRAF's spectral diagnostic technology to generate soil maps, plan projects and conduct testing services across Africa. There are potential innovations to generate SIS in the Sahel through IGREENFIN 1 to predict mango production under Component 2, Output 3.3.
[12] Slide 1 (jica.go.jp); Tk, Kunhamu & Av, Santhoshkumar. (2012). Mango in agroforestry.

[13] Project Overview - West African Irrigation Project (WAIPRO) (iwmi.org); pdf\CV\CV107\CV107-Dyo3u8mpyu.pdf (ufl.edu); Water Quality for Crop Production | Center for Agriculture, Food, and the Environment (umass.edu)
[14] Gross, Emil R. (1997). PRUNING MANGO TO INCREASE YIELD. Acta Hortic. 455, 538-542 DOI: 10.17660/ActaHortic.1997.455.70 https://doi.org/10.17660/ActaHortic.1997.455.70

[1] Recha 2017
[2] In 2008, CORAF through the WAAPP project created an innovation platform as part of a larger program to improve food systems in West Africa. Available at: Integrated Pest Management Key To Improving Incomes on Orchards – CORAF; WEST AFRICA: IPM Empowers Farmers Not to Produce More, but Produce Better Mangoes – TFNet – International Tropical Fruits Network (itfnet.org)
[3] Integrated-pest-management.pdf (croplife.org); principles_weed_pest_disease_management.pdf (kzndard.gov.za)
[4]UNIDO Senegal: Waste management for mango processers in Casamance - COLEACP NEWS
[5] PSHP Technical Report Template (usaid.gov)
[6]Nyamekye, Clement & Thiel, Michael & Schönbrodt-Stitt, Sarah & Zoungrana, Benewinde & Amekudzi, Leonard. (2018). Soil and Water Conservation in Burkina Faso, West Africa. Sustainability. 10. 3182. 10.3390/su10093182.
[7] PSHP Technical Report Template (usaid.gov)
[8] PSHP Technical Report Template (usaid.gov)
[9] Recha 2017
[10] Mango Value Chain Development (farmafrica.org)
[11]The Africa Soil Information Service (AfSIS) has applied this technology to generate detailed national SIS in Ethiopia, Ghana, Nigeria and Tanzania and at smaller scales in Côte d'Ivoire. Organizations such as SoilCares, the Crop Nutrition Services Laboratory, the Gates Foundation, One Acre Fund and FoodAfrica have leveraged ICRAF's spectral diagnostic technology to generate soil maps, plan projects and conduct testing services across Africa. There are potential innovations to generate SIS in the Sahel through IGREENFIN 1 to predict mango production under Component 2, Output 3.3.
[12] Slide 1 (jica.go.jp); Tk, Kunhamu & Av, Santhoshkumar. (2012). Mango in agroforestry.
[13] Project Overview - West African Irrigation Project (WAIPRO) (iwmi.org); pdf\CV\CV107\CV107-Dyo3u8mpyu.pdf (ufl.edu); Water Quality for Crop Production | Center for Agriculture, Food, and the Environment (umass.edu)
[14] Gross, Emil R. (1997). PRUNING MANGO TO INCREASE YIELD. Acta Hortic. 455, 538-542 DOI: 10.17660/ActaHortic.1997.455.70 https://doi.org/10.17660/ActaHortic.1997.455.70

Table 8: Proposed model intervention: climate resilient and low carbon mango production in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production: planting, maintenance and harvesting:* Average smallholder producer holdings of 5-10 ha. Yields: BF: 9 300 t, CI: 31 228 t, GH: 6 639, ML: 64 217 t, SN: 80 936 Producer price in GH was US$244.9/t and US$530.9 in ML in 2019, and US$630.1/t in SN in 2018 (FAOSTAT). Mango value chain composed of nursery suppliers, mango producers, harvesters and assemblers, processors and traders. *Collection and primary selection and transformation*: The current value chain in BF, Côte d'Ivoire, Ghana, Mali and Senegal is traditional and only recently professionalized to develop export markets. **5 categories of mango quality:** Top quality: fresh mangoes exports by air, rare and sold with a premium First quality: fresh mangoes exports by sea, meant for exports Second quality: fresh mangoes for national and regional market, dried, juice pulp Industrial quality: edible with too many visual defects to be consumed fresh Lower quality: for post-harvest losses *Distribution and international trade:* West Africa produces roughly 1.5 million tons of mangoes each year, accounting for about 4% of global production. Ivory Coast is the greatest exporter, accounting for 41% of the region's exports with 14,000 tons, followed by Senegal (20%), Mali (18%), and Burkina Faso (16%).
Technical services and best practices	The strategy is to develop the production and modernize the traditional orchards by increasing the cultivated surface and adopting adapted practices to improve yields (farming techniques, maintenance, preventive treatment, quality control). Value chain competitiveness based on 4 principles: inclusive development strategy with the participation of all involved stakeholders (private and public); development of competitive and integrated value chains; quality of trade infrastructure for competitiveness (human resources, access to capital and technology…); permanent adaptability to changes in markets.
Financial services	Access to micro-credit schemes, through associations offering independently managed village savings schemes and short-term loans Small-scale farmers finance their exploitation from their own savings or informal service providers Access to formal financing from banks mainly by large-scale farmers who can meet the lending criteria
Climate vulnerability and other risks	Influence of climate on yield and time of maturation and to some extent on the quality. Use of poor farming practices leading to inadequate yield. Fruit flies and anthracnose are the two primary pest issues associated with mango production in West Africa[1], among other diseases that lead to consequent losses. Access to land can be source of conflicts in communities. Mango production involves modest surface areas, and it is a perennial crop not requiring major topographic alterations. The most pollution comes from

	transporting the mangoes from the packing stations to the ports or airports (can be on thousands of kilometers, causing pollution and some road network damage)
Key Barriers and Enablers (based on Table 7)	Key potential climate-related barriers may include: - **Climate resilient development of the mango value chain**: Incorrect or excessive use of inputs such as fertilizers, herbicides and pesticides to control weeds and pests, which is increasing soil and water degradation, outdated production techniques exacerbating environmental degradation, water shortage during dry season and limited access to timely information and techniques to support decision-making to use more sustainable production and processing practices. - **Restoring degraded lands and agroforestry:** Limited knowledge on improved harvesting techniques and reported use of rudimentary methods to harvest mango fruits that cause injury to the mango fruit skin; Little or no access to improved planting materials which increases environmental degradation; Overexploitation of forest resources continuing deforestation and environmental degradation; Land tenure insecurity, particularly for women; Low diversification increasing smallholder vulnerability to economic & food insecurity under climate change. - **Renewable energy for sustainable horticulture production and processing:** siting and transmission barriers decreasing sustainable energy generation and consumption; Insufficient energy availability could exacerbate inefficient soil and water management practices; Potential lack of use of renewable energy if electricity services have high capital costs in the long term, which could increase environmental degradation. Other key barriers include: Inconsistent or absent value chain infrastructure, (e.g., transportation, cold chain, storage facilities); degraded irrigation infrastructure and inefficient water management practices; High proportion of infested mango by pest and disease; lack of technical capacity and knowledge of farmers and government extension services on best climate resilient, low-emission practices and limited capacity to process and handle post-harvest mangoes; lack of access to electricity; a heavy dependence on intermediary traders to bring their products to market; Lack of or poor market structure ; High cost of capital; Existence of production potential lands; high transportation cost; bad road network as roads are seasonal, weak (or even non-existent) communication facilities and thus making timely communication with buyers; labour shortages; insecure land tenure; limited market access; low margins for farmers who face the most risks; Increasing access to financing will be fundamental for enabling farmers to overcome these barriers.

Current extents and potential program adoption	Export of dried mango from Burkina Faso to niche market, like bio and fair trade in Europe, permits excellent margins. Mali and Senegal on the other hand have better business opportunities by targeting the regional and local market: exporting fresh mango to Gabon for Mali (47% profit) and selling fresh mango to Morocco for Senegal (31% profit).
Proposed intervention (based on Table 7)	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices such as Improvement of post-harvest techniques and practices (reduce post-harvest losses from 317,000 tons to 45,000 tons); climate resilient development of the mango value chain and restoring degraded lands and agroforestry.
Mitigation activities and impacts (based on table 7)	Profitable protection and management of forests and soils while contributing to carbon sequestration, agricultural productivity and the buffering of climate change and variability. Integrated soil fertility management that is, targeted, location-specific optimization of interactions between fertilizers, organic inputs and improved varieties. Waste management for mango processers to address environmental issues (e.g., mango drying in the region). Build resilience through diversification and of income sources and nutritional sources, as well as environmental sustainability. Mango trees used as component of agroforestry because of their large carbon sequestration, they use up more carbon than they emit through of process of growing, harvesting and exporting them. Processing mango value chains powered by RETs to reduce GHG emission (use of fossil fuels and wood as energy source)
Adaptation activities and impacts (based on table 7)	Sustainable mango production using soil information systems, intercropping with cereals, improved varieties, improving irrigation systems with drips, pruning, fertilization, Integrated pest and disease control and adapted harvest time in order to improve yield. A processing unit aggregating organically produced local and regional mangos for export market involving storage and logistics. Integration of mango trees in agroforestry systems for nutritional diversity and security. Collecting center with pack house facilities to facilitate its fresh mango suppliers to sell quality mangoes to exporters and processors.
Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

Restoring degraded land and agroforestry: Cashew

8. In the 1960s, cashews were introduced to West Africa to combat erosion and deserts. Increased demand, orchard development, and government prioritizing have made raw cashew nut (RCN) production a significant commercial activity for smallholder farmers and a substantial revenue stream for governments during the last decade. Indeed, cashew has specific nutritional features including vitamin B, antioxidants and minerals, such as manganese, magnesium, iron and zinc.

9. In the last 15 years, global demand for cashew kernels has grown at an estimated 6% annual average pace. West African production is also expanding faster than any other region, with a 10 percent increase in the last decade and $1.5 billion in export sales for over 1.1 million farmers. In 2017, African cashew output accounted for almost 59 percent of global cashew production. Nigeria, Benin, Burkina Faso, and Ghana are the world leaders in cashew output, followed by Côte d'Ivoire. In 2018, Côte d'Ivoire produced an estimated 780,000 tons of cashew nuts, accounting for roughly a quarter of global production, and employing an estimated 350,000 people.

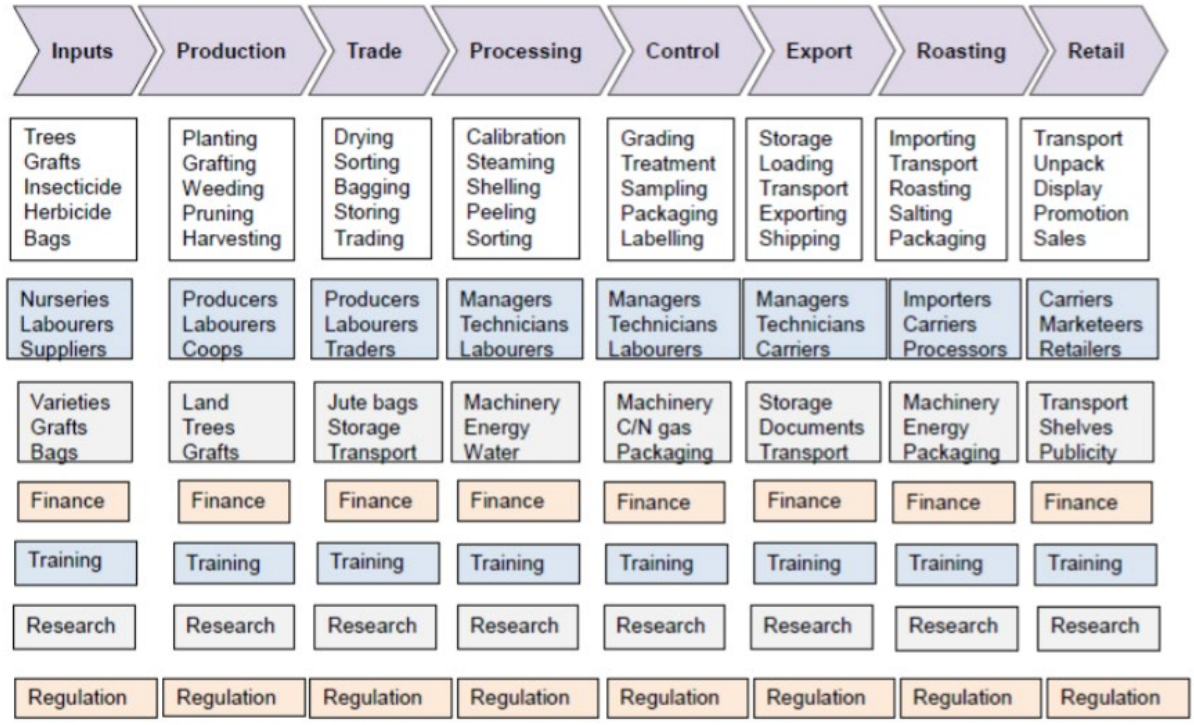
10. Nearly 90% of RCN are shipped from West Africa, primarily to Vietnam and India, where they are processed into raw cashew kernels (RCK), then conditioned, packaged, and distributed, primarily to importers in the United States and Europe. Following that, the kernels are roasted and salted according to consumer tastes in the consumer country. More than half of the cashew kernels traded internationally come from the United States, while Europe accounts for around a third. China, Russia, Japan, and the Middle East are all important consumer markets.

11. During the dry season, or off-season, when few other crops are available for sale, producers collect and sell raw cashew nuts from February to April. Only a few months are available for the sale of RCN, and only a few growers have access to and knowledge of adequate drying and storage facilities. RCN can be stored in the right circumstances for up to two years without deterioration. RCN quality, on the other hand, rapidly deteriorates without adequate storage.

12. In 2018, the price of cashew kernels exported from India to the European Union was nearly 3.5 times more than the price paid to cashew growers in Côte d'Ivoire, a discrepancy of 250 percent. The price of cashew kernels, after secondary processing in the EU, was around 2.5 times more than when they were exported from India – and about 8.5 times higher than when they left the farm in Côte d'Ivoire[143]. Figure 1 presents a general summary of the cashew value chain, showing the main actors involved at the different levels of production, processing and trade.

[143] https://unctad.org/news/cashing-cashews-africa-must-add-value-its-nuts

Figure 1: Cashew kernel value chain



Source: https://www.cbi.eu/sites/default/files/vca-cashew-west-africa_0.pdf

Cashew farming does not necessarily convert into high yield per hectare, especially in underdeveloped countries where normal agronomic procedures are difficult to apply, despite the increased interest and high value of cashew as an export product. Furthermore, having a cashew plantation to ensure ownership of fallow land may be more significant than production. The low yield per hectare has been linked mostly to difficulties in improving cashew types by conventional breeding, for which there is still a lack of knowledge about vegetative propagation methods and other aspects such as pruning, fertilizing, and so on.

13. The cashew market has a number of characteristics suggesting it is an immature market, which increases financial risks. Such elements include:

- Export trade of RCN is controlled by a limited number of large traders.
- Demand for cashew kernels is increasing rapidly, but how long it will last is unknown.
- The global cashew nut processing capacity is concentrated in just a few countries.
- A small number of large international traders dominates cashew kernel trade.
- There is no acknowledged international pricing mechanism for cashew and no clear and transparent world cashew market price.

14. The cashew nut processing business in West Africa has yet to pique the interest of many banks and financial institutions for large-scale investment and low-interest financing. Cashew processors face average interest rates ranging from 8% to 12% in Côte d'Ivoire and as high as 30% to 35% in Ghana, depending on the country and currency. This is in contrast with interest rates of 7–8% or lower, which are reportedly prevalent in India and Vietnam, and especially with the 1–2% interest rates international banks give to large international buyers. This contrasts with interest rates of 7–8% or lower, which are said to be common in

India and Vietnam, and especially with the 1–2% interest rates given to large foreign buyers by international banks.

Table 9: Strengths/opportunities and weakness for the cashew value chain in targeted countries

Weaknesses	- No decision power on the international trade and determination of prices - Lack of or low cashew nut processing capacity which causes loss of value creation - High average interest rates faced by cashew processors for large-scale - Limited knowledge of smallholder farmers on how to increase productivity per hectare - Lack of appropriate infrastructure in support of the development of the value chain - Weakness or absence of interprofessional organizations to govern the value chain
Strengths and opportunities	- 90% of the raw cashew nuts traded in the global market are grown in West Africa - Global consumers growing taste for healthier snacks and preference for environmentally friendly and ethically sourced food products - Essential source of income for smallholder farmers and for the government in terms of tax revenues (exportation of RCN)

15. The cashew value chains are rife with environmental issues that threaten the sustainability and ongoing profitability of these industries[144]. Climate change may pose problem for cashew cultivation since cashew is grown in ecologically sensitive areas such as coastal belts, hilly areas and areas with high rainfall and humidity. The flowering, fruiting, insect pest incidence, yield and quality of cashew nut and kernels are more vulnerable for climate change[145]. Indeed, unseasonal rains and heavy dew during flowering and fruiting periods are the major factors which adversely affect the yield and quality of cashew nut. Cloudy conditions, high relative humidity and heavy dew are favourable for outbreak of insect pests and diseases. Drought conditions drastically reduce cashew nut production. Low yields aggravate agricultural expansion, decrease nutritional stability, and exacerbate poverty. Technical inefficiency among producers is strongly correlated with lack of training, experience, and land security.

16. The climate change-induced drought can be partially mitigated by adopting mulching, conservation agriculture and soil and water conservation measures, by providing protective/drip irrigation/fertigation during the fruit development stages. In addition, catalysing improved productivity through robust extension support would particularly benefit smallholders. Climate resilient practices focused on intensification rather than expansion of tree cropping [146] are foundational to climate change mitigation, national nutritional security, and continued socioeconomic development. Indeed, agroforestry offers many benefits that directly translate to improved productivity, household livelihoods and food security, national economic growth, and domestic food supplies in West Africa. For example, Ghanaian farmers are also incentivized to practice agroforestry through grants,

[144] Predicting the Impact of Climate Change on Cashew Growing Regions in Ghana and Cote d'Ivoire. Available at: https://www.ipcc.ch/apps/njlite/ar5wg2/njlite_download2.php?id=8585

[145] Chapter 6 Cashew - Impact of climate change on plantation crops.pdf (icar.gov.in)

[146] Cashew expansion is a driver of forest loss and has been at the expense of food crops.

farming inputs, capacity training, public nurseries, and improved access to markets and over 85 percent of female Ghanaian farmers already practice agroforestry via alley cropping, scattered trees on farmland, taungya, and home gardens[147]. Agroforestry represents an important opportunity to engage women and youth more fully in the region agricultural sector. These women farmers are highly engaged in all farm management activities except applying agrochemicals. Thus, training women in agroforestry and/or as agroforestry focal farmers could significantly enhance agroforestry practices and extension services. Cashew trees offer particular benefits for livelihoods and nutritional security; the cashew harvest occurs in the 'lean months' of other major food crops and can provide timely supplementary income.

17. To finance the development of climate resilient cashew value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The proposed intervention is presented in table 10 along with the proposed model intervention in table 11.

Table 10: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Restoring degraded lands and agroforestry	Foster climate-resilient livelihoods and food sources for smallholders, especially women and youth, through agroforestry, techniques and value-addition.	Improved productivity, household livelihoods and food security, national economic growth, and domestic food supplies	• Management of soil fertility (e.g., mulching, organic fertilizer and intercropping with arable crops[1]) • Integrated pest and disease management (safe use of chemical inputs as needed)[2] • Farm diversification with alternative crops (citrus, yam, maize and millet), mainly to avoid • monocrops, protect natural resources, and ensure food security[3] • Forest and agroforest management to support cashew productivity and soil health [4] • As the current growing areas become drier, farmers should implement activities to prevent bushfires[5] • Water management (water quality standards, use of drip irrigation etc.)[6]

[147] World Bank and Ministry of Food and Agriculture. Climate-smart agriculture investment plan for Ghana. Washington, DC: World Bank Group; 2020. Available at Public Disclosure Authorized Agriculture Investment Plan ... (worldbank.org)

Interventions	Description	Intervention objectives	Technical model examples using regional references
			• Waste management for cashew processers to address environmental issues[7] • Integration of cashew in agroforestry systems for nutritional diversity and security: Diversification, Intensification, including heat-and drought-tolerant, disease-resistant cashew varieties[8] • Implement new technologies available mainly for germplasm to improve quality and quantity of • yield[9] • Advisory systems to promote agroforestry practices[10] • Realigning policy with national goals to support profitability and sectoral sustainability
Renewable energy for sustainable cashew production and processing	Transform selected crop value chains products to Increase access to solar panels and low-carbon equipment for improved production and processing	Food security, resilience, value chains, transformation, sustainability and environmental quality	• Processing cashew value chains powered by RETs[11] • Establishment of irrigation and water infrastructure using solar pumps for off-season crops in the dry season[12] • Production and sale of solar energy to farmers[13] • Capacity building for solar and water use efficiency[14] • Constructing storage facilities in wholesale markets designed to minimize postharvest losses using renewable energy

[1] (PDF) Analysis of Cashew Farmers Adaptation to Climate Change in South-Western Nigeria (researchgate.net)

[2] Adeniyi, Dele & Animasaun, David & Abdulrahman, Abdullahi & Olorunmaiye, Kehinde & Olahan, Ganiyu & Adeji, Olaitan. (2020). Integrated System for Cashew Disease Management and Yield. 40-48. 10.4314/cajeb.vol13i1.6.

[4] West Africa Cashew Project (PRO-Cashew) | CNFA; Scientific background for soil monitoring on National Forests and Rangelands: workshop proceedings; April 29-30, 2008; Denver, CO (fs.fed.us)
[5] Hennessy et al., 2005
[6] Project Overview - West African Irrigation Project (WAIPRO) (iwmi.org); pdf\CV\CV107\CV107-Dyo3u8mpyu.pdf (ufl.edu); Water Quality for Crop Production | Center for Agriculture, Food, and the Environment (umass.edu); Nyamekye, Clement & Thiel, Michael & Schönbrodt-Stitt, Sarah & Zoungrana, Benewinde & Amekudzi, Leonard. (2018). Soil and Water Conservation in Burkina Faso, West Africa. Sustainability. 10. 3182. 10.3390/su10093182.
[7]2018-A4A_Report_ACA-study-cashew-by-products_Final.pdf (away4africa.nl)
[8] Wato, Tamirat & Amare, Mekides. (2020). Opportunities and Challenges of Scaling up Agroforestry Practices in Sub-Saharan Africa: A Review. Agricultural Reviews. 41. 10.18805/ag.R-154.
[9] Motagi, Babu & Desmae, Haile & Ajeigbe, H. & Echekwu, Candidus & Dramane, Sako & Tabo, Ramadjita & Monyo, Emmanuel & Upadhyaya, Hari & Varshney, Rajeev. (2016). Germplasm Enhancement for Increasing Groundnut Productivity and Production in West and Central Africa.
[10] PB19108-en.pdf (worldagroforestry.org)
[11] West Africa - Water and Energy for Food Grand Challenge (we4f.org)
[12] Andrieu et al., "Prioritizing Investments for Climate-Smart Agriculture.";
ESMP_SUMMARY_FOR_SOLAR_POWER_IRRIGATION_PROJECT_SUDAN.pdf (afdb.org)
[13] Solar Pumps On Credit: Reducing Production Costs for Horticulture Producers Senegal (icco-cooperation.org)
[14] SOLtrain West Africa - ECOWAS Solar Thermal Capacity Building and Demonstration Program | ECREEE

Table 11: Proposed model intervention: climate resilient and low carbon cashew production in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production: planting, maintenance and harvesting:* RCN Production (2018 data[1]) Burkina Faso: 80 000 MT, 2.3% of world production. Forecast in 2025: 131 000 MT Côte d'Ivoire: 700 000 MT, 23.8% of world production. Forecast in 2025: 1 345 000 MT Ghana: 80.000 MT, 3.1% of world production. Forecast in 2025: 177 000 MT Mali: 70 000 MT, 1.1% of world production. Forecast in 2025: 65 000 MT Senegal: 30 000 MT, 0.8% of world production. Forecast in 2025: 41 000 MT Burkina Faso: Approx 65,000 cashew farmers, over 45,000 households involved with cultivating area over 140,000 hectares of land. Côte d'Ivoire: 330,000 cashew farmers, sector feeds approx. 1.5 million people directly and indirectly, surface cultivated of 16 million ha Ghana: Approx. 125.000 cashew farmers, with a surface of 9 million ha Mali: Around 200.000 cashew farmers, with a surface of cashew production of 5 million ha Senegal: Around 352.000[2] cashew farmers, surface of cashew production of 2.5 million ha[3] *Collection and primary selection and transformation*: Main actors involved at different levels of the value chain are input suppliers, producers, traders, processors, service providers, exporters and retailers. Raw cashew nuts (RCN) are collected in the five countries (Burkina Faso, Côte d'Ivoire – about a quarter

	of the global cashew nut production, Ghana, Mali and Senegal), then exported to Vietnam and India for processing into raw cashew kernels (RCK), then conditioned, packaged and distributed to importers in the USA and Europe. The RCK are roasted and salted according to market preferences. *Distribution and international trade*: Nearly 90% of raw cashew nuts (RCN) are shipped from West Africa, primarily to Vietnam and India, where they are processed into raw cashew kernels (RCK), then conditioned, packaged, and distributed, primarily to importers in the United States and Europe. In 2017, African cashew output accounted for almost 59 percent of global cashew production. Nigeria, Benin, Burkina Faso, and Ghana are the world leaders in cashew output, followed by Côte d'Ivoire.
Technical services and best practices	Cashew farming does not necessarily convert into high yield per hectare, especially in underdeveloped countries where normal agronomic procedures are difficult to apply, despite the increased interest and high value of cashew as an export product. Furthermore, having a cashew plantation to ensure ownership of fallow land may be more significant than production. The strategy consists in creating a favorable environment for investment in infrastructures for processing of cashew nuts in countries. Facilitate access to markets and to financing to develop plantation productivity. Improve the value chain governance by strengthening organization of producers and cooperatives
Financial services	Few operators can self-finance their investment and operations. Financing needed for capital for factory and machinery, crop purchase and working capital. Cashew considered expensive so in a less stable market, less attractive to financial institutions. Average interest rates between 8% and 12% (Benin and Côte d'Ivoire), between 30% and 35% in Ghana.
Climate vulnerability and other risks	Increased temperature, rainfall and humidity can lead to higher incidence of pests and disease, two major constraints to cashew production. Though highly tolerant to drought, low rainfall during vegetative stage can prevent trees from obtaining enough water to sustain flowering. Irregular rains, violent winds and droughts affect the yield and quality of cashew nut. COVID-19 pandemic has a negative impact on global demand for cashew nuts what diminishes prices. Limited access to financing, with extremely high interest rates preventing investment on cashew value chain
Key Barriers and Enablers	Key potential climate-related barriers may include: - **Restoring degraded lands and agroforestry:** Little or no access to improved planting materials which increases environmental degradation; Overexploitation of forest resources continuing deforestation and environmental degradation; Land tenure insecurity, particularly for women; Low diversification and high expansion prevalence of cashew trees increasing smallholder vulnerability to economic & food insecurity under climate change. Incorrect or excessive use of inputs such as fertilizers, herbicides and pesticides to control weeds and pests, which is increasing soil and water degradation, outdated production techniques exacerbating environmental degradation, water shortage during dry season and limited access to timely information and techniques to support decision-making to use more sustainable production and processing practices.

	- **Renewable energy for sustainable agriculture production and processing:** siting and transmission barriers decreasing sustainable energy generation and consumption; Insufficient energy availability could exacerbate inefficient soil and water management practices; Potential lack of use of renewable energy if electricity services have high capital costs in the long term, which could increase environmental degradation. Other key barriers include Lack of: (i) institutional resources to enforce forest conservation laws; (ii) integrated management and traceability systems; (iii) commitment and support from government, private sector, and non-profit stakeholders; and (iv) research outputs on best agroforestry practices in the targeted region cashew production. High prevalence of pests and diseases. Inconsistent or absent value chain infrastructure, (e.g., transportation, cold chain, storage facilities); degraded irrigation infrastructure and inefficient water management practices; Institutional culture discourages collaboration between implementing governing bodies and sectors and inertia discourages increasing transparency and efficiency of current policy practices. Limited farmer access to knowledge, economic, and agronomic resources to support innovation. Prioritization of cash crops can decrease nutritional security and cause land conflicts. Low productivity of cashew plantations exploited with traditional unproductive practices. Difficult access to inputs and equipment. Limited access to financing opportunities and capital to invest in develop their operation. Low level of organization of value chain actors. Difficult access to land for marginalized groups (youth and women).
Current extents and potential program adoption	In 2018, the price of cashew kernels exported from India to the European Union was nearly 3.5 times more than the price paid to cashew growers in Côte d'Ivoire, a discrepancy of 250 percent. The price of cashew kernels, after secondary processing in the EU, was around 2.5 times more than when they were exported from India – and about 8.5 times higher than when they left the farm in Côte d'Ivoire[4]
Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices such as finance the implementation of processing units to increase the benefits perceived by countries and producers from post-harvest activities or facilitate the development of the value chain by supporting the restructuring of farmers' organizations.
Mitigation activities and impacts	Climate resilient practices focused on intensification rather than expansion of tree cropping are foundational to climate change mitigation to control soil erosion and for reforestation of savannah woodlands. It is also ideal for nutritional diversity, security and carbon sequestration. Climate resilient agriculture can boost cashew resilience through agroforest systems. Processing cashew value chains and water infrastructure using RETs to reduce GHG emissions. Yield.

Adaptation activities and impacts	Adopting mulching (to retain soil moisture, prevent weed growth and enhance soil structure), conservation agriculture and soil and water conservation measures, by providing protective/drip irrigation/fertigation during the fruit development stages to strengthen resilience, heat-and drought-tolerant and disease-resistant cashew varieties and use of organic fertilizer to increase productivity of cashew trees. Investment in storage, conservation and processing techniques and infrastructure for reduced post-harvest losses and value addition. Farm diversification with alternative crops to avoid monocrops, protect natural resources, and ensure food security.
Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

[1] https://www.nitidae.org/files/41dc7432/wa_cashew_sector_review_2019_nitidae.pdf
[2]https://www.senegal-export.com/la-noix-de-cajou-un-marche-qui-cache-bien-des-realites.html#:~:text=Aujourd'hui%2C%20selon%20l',pays%2C%20entre%20Kolda%20et%20S%C3%A9dhiou.
[3] https://www.nitidae.org/files/41dc7432/wa_cashew_sector_review_2019_nitidae.pdf
[4] https://unctad.org/news/cashing-cashews-africa-must-add-value-its-nuts

Sustainable cereals-staple crops production : Rice

18. West Africa is the rice basket of sub-Saharan Africa, producing over two-thirds of its rice. As the most important calorie source in this region (Macauley and Ramadjita, 2015), rice is a particularly strategic commodity for food security. Consumption has quickly expanded since the 1960s, driven by demographic growth, rising per capita consumption and urbanization (Mendez del Villar and Lançon, 2015). The annual per capita rice consumption steadily increased from 10 kg in 1961 to 54 kg in 2017 (USDA, 2018) and is expected to rise 32% until 2025 (from 18.2 to 24.1 million tons of milled rice). In 2016-2017, per capita consumption per year in the five target countries was: Burkina Faso (BF) 32 kg, Côte d'Ivoire (CI) 122 kg, Ghana (GH) 37 kg, Mali (ML) 102 kg and Senegal (SN) 108 kg[148].

19. Although rice production has also increased in recent years, domestic rice value chains (VCs) have not caught up with consumption, leading to an increasing gap that is satisfied through imports. This places a heavy burden on government budgets and exposes the region to the volatility of world market prices. In response, ECOWAS launched a regional Rice Offensive in 2013 whose goal is to achieve rice self-sufficiency by 2025.

20. In 2017, West African farmers produced rice on 7.3 million hectares of land. In the five target countries, there are close to 10 million people working in rice value chains, the majority of which are smallholder producers. Women are strongly present in rainfed systems, while men are more predominant in irrigated ones. The three main rice systems used in the region are: i) irrigated systems in which irrigation water is either added to supplement rainfall (irrigated wet season system) or is essential when rainfall is very low (irrigated dry season systems); ii) upland rice systems, in which rainfall is the only water source and rice is grown under non-flooded dryland conditions on freely draining aerobic soils. Retaining water in these systems is of utmost importance; and iii) rainfed lowland systems, which are characterized by non-continuous flooding of rice fields of variable depth and length. The flooding either occurs due to rainfall, surface runoff or seasonally rising rivers or other water bodies. In rainfed rice landscapes, farmers often use more than one rice system simultaneously in fields in different locations (lowland versus upland).

21. Upland rice systems occupy 43 percent of West Africa's rice-growing area but only account for 37 percent of total production. Rainfed lowland systems cover 40 percent of the total area and account for 42 percent of total production. Average yields for these two systems are 1.38 t/ha and 1.65 t/ha, respectively, although yields vary within countries and from one country to the next. Irrigated production occupies only 11.6 percent of the rice land area (this percentage is much higher for Senegal), but accounts for about 17 percent of total production and has average yields of 2.32 t/ha. A fourth category includes fewer common systems such as mangrove and recession systems (5 percent of the area and 4 percent of total production). Irrigated and rainfed lowland systems are the most productive, but they are also significant greenhouse gas emitters due to methane released by bacteria in flooded fields.

22. The long tradition of rice growing in the region dates back to the domestication of the African rice variety Oryza glaberrima over 3,500 years ago, meaning that there is a wealth of traditional knowledge and varieties in the region. The Oryza Sativa variety, originally from Asia, was introduced to the region in the 16th century. Numerous higher-yield and/or

[148] https://www.adaptation-fund.org/wp-content/uploads/2021/05/OSS_RIE-Regional_Full_Proposal-RICOWAS_Project-Benin-al-26April2021.pdf

drought and pest-resistant varieties have been developed and disseminated in the region since the 1980s. One of the most well-known ones is the NERICA varieties created as a hybrid between O. glaberrima and O. sativa in the 1990s.

23. Rice production is highly vulnerable to the impacts of climate change, as detailed in the table below. Rising temperatures, changes in rainfall patterns and prolonged periods of drought are projected to have devastating effects on rice crops. Without adaptation measures, rice yields across West Africa could fall between 5-25 percent and up to 80 percent depending on the location and rice system employed. The largest decreases (40-80 percent) are predicted for the irrigated rice systems in the Sahel zone in the hot-dry season, which is attributed to reduced plant photosynthesis at extremely high temperatures. With adaptation measures, however, rice yields could even increase (primarily in wet season irrigated systems) or the decreases would be significantly less (Van Ort and Zwart, 2018).

24. One tried-and-tested agroecological, low-input and climate-resilient rice production methodology has proven effective in increasing yields (by more than 50 percent and up to 9 t/ha in some cases) in the five target countries: System of Rice Intensification (SRI). SRI allows farmers to use 90 percent less seed, 30-50 percent less water and 30-100 percent less agro-chemicals. Other effective adaptation measures to be supported by this project include more efficient irrigation systems, short-cycle varieties and soil management techniques, particularly to address the issue of low soil fertility and salinity.

25. To finance the development of climate resilient rice value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The proposed intervention is presented in table 12 along with the proposed model intervention in table 13.

Table 12: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Sustainable rice intensification system promotion	Improve nutritional and economic outcomes by scaling System of Rice Intensification (SRI) to increase rice productivity and climate resilience.	Food security, resilience, value chains, sustainability, mitigation, livelihoods and inclusivity.	Climate resilient rice production[1] such as: • Seed soaking before planting • Unflooded nurseries • Transplantation of a single seedling per hill • Early transplantation (8-12 days) • Wide spacing in rows (25x25cm) • Alternate wetting and drying, using minimal water application[2] • Mechanical weeding and soil aeration • Organic matter as primary fertilizer • Best practices for effectively building producer capacity in SRI, including comparison plots, field

Interventions	Description	Intervention objectives	Technical model examples using regional references
			schools, inter-farmer visits, and technical training • Investments in bolstering the rice sector (Bolstering supply of mechanized equipment available at centers, and continued subsidization of on-farm technology to mechanize production processes)[3] • Access and best management practices for improved varieties[4] • Promotion of irrigated areas by ATI for agricultural development • Valorisation of rice residuals[5] • Integrated pest and disease management (safe use of chemical inputs as needed)[6]
Renewable energy for sustainable crop production and processing	Transform selected crop value chains products to Increase access to solar panels and low-carbon equipment for improved production and processing	Food security, resilience, value chains, transformation, sustainability and environmental quality	• Development and rehabilitation of irrigated perimeters and water solar pumps[7] • Capacity building for solar and water use efficiency[8] • Processing and packaging systems with new climate proofed infrastructures with RETs and eco-friendly technologies and transport systems [9] • Development of less expensive, lower maintenance, and/or more efficient mechanization tools using RETs to improve working conditions, in particular for women smallholder farmers[10]

[1] CIIFAD, "System of Rice Intensification - Frequently Asked Questions (FAQs)."
[2] Innovated methodology to reduce emissions, climate resilient varieties, revised production calendars to account for climate change, and low-cost soil erosion control practices from irrigation rice production
[3] ReliefWeb, "As Africa's Need for Food Grows, Mali's Rice Turnaround Shows a Way Forward - Mali.
[4] African Rice Center, which is both a CGIAR research center and an intergovernmental association of African countries dedicate to global research for a food-secure future
[5]Grow Africa .
[6] Weed Management in **Rice**-Based Cropping Systems in **Africa** ; Integrated-pest-management.pdf (croplife.org); principles_weed_pest_disease_management.pdf (kzndard.gov.za)

[8] SOLtrain West Africa - ECOWAS Solar Thermal Capacity Building and Demonstration Program | ECREEE
[9] Agriculture and Food Security | West Africa Regional | U.S. Agency for International Development (usaid.gov)
[10] The Alliance for Food Sovereignty in Africa; Africare (Styger et al., "Application of System of Rice Intensification Practices in the Arid Environment of the Timbuktu Region in Mali.")

Table 13: Proposed model intervention: climate resilient, low carbon rice production in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production: planting, maintenance and harvesting:* Average smallholder producer holdings of 0.25-3 ha. Yields: BF, 1.5-3.5 t/ha; CI, 0.75-4.0 t/ha; GH, 2.5-4.5 t/ha, ML, 1-4 t/ha, and SN, 1-5t/ha. Producer price in GH was US$273/t and US$247.1 in ML in 2019, and US$234/t in Senegal in 2018 (FAOSTAT). Many producers belong to POs or cooperatives, but organizations need strengthening. Prices are volatile and domestic rice competes with cheaper imports from Asia. SRI has been found to increase revenues by 70% (WAAAP assessment, WB). *Collection and primary selection and transformation*: A major bottleneck for rice VC development is milling. Traditional mills generally produce rice of low quality, often with a mix of varieties and high rates of broken grains and impurities, leading to low cooking quality and urban consumers' preference for imported rice. As part of their strategy to achieve self-sufficiency in rice, the five target countries have promoted investment in milling; SN has advanced the most in this sense. *Distribution and international trade:* West Africa faces a structural rice deficit, as increases in production are unable to keep pace with the growing demand and is the second biggest rice importer in the world after China. Together, the five target countries imported 4.24 million tons of rice in 2020. While ML is very close to reaching self-sufficiency in rice (95%), self-sufficiency rates for the other target countries are much lower: CI 49%, BF and SN both at 39% and GH, 37%. CI and SL exported US$8.4 and US$50.9 million tons of rice in 2019.
Technical services and best practices	Technical support and agricultural extension services are very limited in these countries and direly needed to support smallholders in the adoption of best climate resilient, low-emission practices. Several projects have promoted SRI and sustainable and efficient water and soil management techniques, but these practices are not yet widely spread.
Financial services	Small rice producers' access to credit from financial institutions is very limited for several reasons: lack of collateral, interest rates, inability to prepare loan applications, high transaction costs, etc. Loans available from banks and MFIs are often short-term, high interest and for only the current campaign, working capital or equipment. Rice producers tend to turn to mill owners or input suppliers for advances on contracts, or to family members and friends for loans. Government support in the form of subsidies for inputs are available, but often smallholders in remote areas are unable to access them.

Climate vulnerability and other risks	As rice production is predominantly rainfed, increasing climate variability – particularly changes in rainfall patterns and high temperatures – will disrupt growing seasons, shorten crop seasons and result in prolonged dry spells, drought and heat waves. It will also increase the risk of floods, water shortages, strong winds and storms, and changes in incidences and geographic range of pests and diseases - all of which can lead to substantial rice yield reductions or crop failure. Without adaptation measures, estimated reductions in rice yield across West Africa range from 5-25% and up to 80%, primarily in irrigated rice systems in the Sahel in the hot-dry season. In the same area in the rainy season (slightly cooler), irrigated rice yields were predicted to decrease by around 40%. In the Sudanian and Guinean climate zone, where rainfed systems dominate, rice yields will especially be affected. In the coastal areas, rice will be highly sensitive to the combination of increased temperature, humidity and rainfall intensity, leaving it more vulnerable to pests and diseases that thrive in warmer, wetter conditions, such as the rice gall midge, rice weevil and bacterial leaf blight. In low-lying coastal areas, a relatively small rise in sea level can result in rice land inundation, followed by land and freshwater salinization. As farmers try to cope with the impacts of climate change, it can be expected that pressure on natural resources (vegetation, soil, water) will increase, leading to overuse, degradation, potential conflicts, rural exodus and international emigration. To mitigate these effects, introducing adaptation measures and strengthening resilience is urgently needed.
Key Barriers and Enablers	Key potential climate-related barriers: - **Sustainable rice intensification system promotion**: Low and irregular rainfall; floods high low; mismanagement of water; extreme temperatures sandstorms; political and security crises; smallholder risk aversion; producer preference for large, lower investment plots; long timeline for establishment of demonstration plots; labor shortages at time of transplant. - **Renewable energy for sustainable agriculture production and processing:** siting and transmission barriers decreasing sustainable energy generation and consumption; Insufficient energy availability could exacerbate inefficient soil and water management practices; Potential lack of use of renewable energy if electricity services have high capital costs in the long term, which could increase environmental degradation. Other key barriers include: limited access to affordable loans and financial services; degraded irrigation infrastructure and inefficient water management practices; lack of technical capacity and knowledge of farmers and government extension services on best climate resilient, low-emission practices and limited capacity to process, package and market rice; lack of storage facilities and access to electricity; poor roads; labour shortages, lack of small farm equipment (especially for post-harvest operations) and low mechanization levels, which drive up production costs; insecure land tenure; limited market access; low farmgate prices and low yields discourage farmers from producing rice; low soil fertility and soil degradation; high weed, pest and disease pressure; limited adoption of improved varieties and best agricultural practices, and lack of good

	quality seeds; among others. Increasing access to financing will be fundamental for enabling farmers to overcome these barriers.
Current extents and potential program adoption	Of the five target countries, Mali and Côte d'Ivoire are the largest producers: in 2016-2017, ML produced 2.710 million tons; CI, 2.234 million; SL, 1.062 million; GH, 609,375 and BF, 381,000 tons. Target of household adoption rate of 40% for the implementation of climate resilient, low-emission agriculture techniques and practices.
Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices such as SRI; improved short-cycle rice varieties; efficient irrigation techniques and solar-powered pumps; management of soil salinity (namely drainage, flooding and organic matter addition) and adoption of RETs to power processing facilities.
Mitigation activities and impacts	Deliberate water management, conservation, and resource-use efficiency are necessary to create resiliency in the face of climate change-induced droughts, floods, and land degradation. As SRI involves alternate wetting and drying with minimal water application, its adoption will reduce GHG emissions from flooded rice fields. Mitigation activities using SRI include a higher tiller number per plant, significantly improved yields, drastically reduced seed use, water savings of 25-50%, greater drought resilience, improved soil fertility, reduced use of agrichemical inputs, reduced production costs, and reduced greenhouse gas emissions. The use of solar energy instead of fossil fuels to power irrigation pumps and other equipment will also help reduce GHG emissions.
Adaptation activities and impacts	SRI is a key climate resilient, low emission approach to rice production. Based on the principles of early plant establishment, reduced competition among plants, enriching soils with organic matter, and reduced water use, rice plants grow more vigorously and can better express their genetic potential than under conventional approaches. Healthier and stronger plants with deeper roots can better withstand weather calamities such as drought, floods and strong winds, and assure production, while conventionally planted crops succumb more easily to these forces, often leaving farmers without harvests. The adoption of improved short-cycle varieties will help farmers adjust to changes in the cropping calendar. More efficient irrigation techniques and equipment will ensure better use of water resources, which could become scarcer in some parts of the region.
Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

Alternative crops – Cassava (Manihot esculenta Crantz)

26. Cassava is a woody shrub of the Euphorbiaceae family that is native to South America, which is simple to cultivate, able to grow on marginal lands that are difficult to use for other crops, resist to drought conditions, with a possibility of leaving it in the ground and harvesting it progressively 149 , thus, allowing for extensive management of its food consumption (Ndjouenkeu, 2020). Given its ability to grow on marginal lands, cassava is sociologically perceived as the culture of the poor in West Africa. Cassava is cultivated in the humid forest zones and the sub humid savanna of West African countries and provides increased income for farming households; increased employment opportunities; potential to target development benefits to women; potential lower food prices for consumers; competitively priced raw materials and more convenience (e.g., improved traditional products) (Coulibaly et al.,2014).

27. Cassava is characterized by a high value of nutritional value whose roots are starch-rich with small amounts of vitamin C, phosphorus, and calcium and leaves are a rich protein source but deficient in certain amino acids (WorldAtlas, 2017). The main demand for cassava is as a food crop in three main forms: (i)food product, whose processes and denominations differ from one region to another, even within the same region (e.g.: gari, attiéké (Côte d'Ivoire), fufu (Ghana), Placali (Côte d'Ivoire), Agbelima (Ghana and Côte d'Ivoire) etc.) (Filbert et al, 2016); (ii) industrial product (High quality cassava flour (HQCF), ethanol and other industrial products) and (iii) animal feed, including chips mainly for chickens and fermented and dried cassava peelings mainly for goats, sheep and cattle (CABRI,2019). Fermented products are the main form of cassava use in Africa, accounting for almost 75% of the cassava-based foods (Ndjouenkeu, 2020). As the main component of the food ratio of more than 25% of the African population for an average annual consumption of 100 kg of roots per inhabitant, cassava is, in Western Africa, a crop destined totally and exclusively for human food (Ndjouenkeu, 2020).

28. In terms of production, Africa is the largest producer in the world, led by West Africa150, which accounts for 55% of the production of cassava in Africa and 33.5% of the world production (WACOMP-ECOWAS,2020). This is justified by Nigeria - the world biggest producer, in this region. In Burkina Faso, Cote d'Ivoire, Ghana, Mali and Senegal, the total production of cassava multiplied by two between 2010 and 2019 (from 16 million tonnes to 28.8 million tonnes: FAOSTAT,2019). Among the five selected countries, Ghana is the largest producer of cassava, with 22 million tonnes in 2019, the 2nd largest crop in terms of area harvested 151 and the fifth world producer of cassava in aggregate value (WACOMP-ECOWAS,2020). In Africa, Cote d'Ivoire is the fifth cassava producer with an average cultivated area of 627,000 ha that gave an output of 39.6 million tonnes with an average yield of fresh roots at 6390 kg/ha between 2010 and 2019. Cassava production requires minimum labor, with the wide use of traditional, low-yielding varieties and low levels of fertilizer and inputs.

29. Unfortunately, there is a lack of accurate and reliable information and statistical FAO data on the exact quantity of cassava trade in the five targeted countries152, however, according to a regional cassava value chains analysis in West Africa, the major type of cassava that is exported is dried and the percentage exported is very low compared to the quantity of

[149] Cassava matures in 6 to 9 months and can then be left in the ground for up to a year. Source: CABRI,2019
[150] The total production was 93 million tonnes in 2018
[151] The estimated total land cultivated with cassava production between 2010 and 2019 was 925,493 hectares. Source: FAOSTAT,2019
[152] To fill this gap, there is a need to undertake periodical panel data collection at different borders of each country.

cassava produced in Africa (Coulibaly et al.,2014). This shows that cassava is either used for domestic purposes in the five selected countries or that it plays such an important role in the population consumption pattern that the quantity produced is not sufficient to meet their needs (there is a need for importation). Moreover, cassava commercialization in West Africa is often negatively impacted by domestic and international regulations and fast-changing market dynamics (tariffs, subsidies, prices, competition), rapid spoilage upon harvest and a lack of processing capacity close to isolated production areas (Ndjouenkeu, 2020). These are constraints which limit cassava productivity and its access to the market and contribute to reducing the level of its industrial valorization. In Central and Western Africa, only Nigeria has embarked on a policy of industrial valorization of cassava (Ndjouenkeu, 2020).

30. Cassava will become even more crucial to the nutritional security of African smallholders in the face of climate change. Cassava has been identified as one of the staple crops most likely to be resilient to climate change in Africa, with predicted changes in suitable growing area ranging from minor losses to minor gains[153]. In contrast, the suitable growing areas in Africa for beans, maize, banana and finger millet are projected to shrink by 30%–50%[154]. Wild cassava strains have shown significant variability in terms of adaptation, nutritional content, toxins, resistance to pests and disease, and postharvest shelf life[155]; this implies a high potential for development of new varieties displaying beneficial characteristics. As a result, Developing and refining climate smart adaptation and mitigation techniques will help address the primary vulnerabilities of cassava crops in the region. Cassava is sensitive to some pests and diseases such as mosaic, brown streak and mites and has a poor pre-processing shelf life[156]. Along with general climate smart agriculture practices (such as intercropping, agroforestry and integrated pest management), innovation in varietal development and distribution[157], as well as in postharvest processing methodology and mechanization[158], have been shown to help overcome production, processing and marketing challenges.

31. To finance the development of climate resilient crop value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The proposed intervention is presented in table 14 along with the proposed model intervention in table 15.

[153] Jarvis et al., "Is Cassava the Answer to African Climate Change Adaptation?" Rippke et al., "Timescales of Transformational Climate Change Adaptation in Sub-Saharan African Agriculture."

[154] Ramirez-Villegas and Thornton, "Climate Change Impacts on African Crop Production."

[155] Research Program on Roots, Tubers, and Bananas, "Cassava".

[156] Hahn, "An Overview of Traditional Processing and Utilization of Cassava in Africa"; Research Program on Roots, Tubers, and Bananas, "Cassava."

[157] CGIAR, "RTB Scientists at the Forefront of Developing Technologies to Help Farmers Cope with Climate Change"; Ayemou et al., "Innovations in
Cassava Production for Food Security and Forest Conservation in Western Côte d'Ivoire."

[158] Chapuis et al., "Pneumatic Drying of Cassava Starch"; Gnahoua et al., "Assessment of Low-Input Technologies to Improve Productivity of Early
Harvested Cassava in Côte d'Ivoire."

Table 14: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Sustainable cassava production and processing	Increase the cassava sector's capacity to practice climate resilient practices by providing producers, processors and extension agents with technical assistance and increased access to improved varieties and up-to-date research outputs.	Improving food security and building resilient systems; increasing income and savings of poor farmers; increasing on-farm efficiencies; supporting improvement of smallholder sector; potential to boost exports for cassava; adding new value chains	• Adoption of climate resilient practices for cassava, including zero/reduced tillage, mulching, cover cropping, hedgerows (e.g., of rubber trees), legume intercropping and integrated pest management (e.g., using Ocimum grattisumum)[1] • Heat-tolerant, drought-tolerant, fast-growing, and disease-resistant cassava made available for commercial propagation[2] • Approaches for supporting producers in transitioning to new varieties • Improved resource-use efficiency and economic resiliency using crop residues as livestock feed and others[3] • Optimized crop productivity through integrated soil fertility management and integrated pest and disease management[4] • Bolster commercialization organizations through improved access to appropriate mechanization tools, training in new processing techniques to diversify product options, technical assistance in improved processing efficiency (i.e., mechanization)[5], systemization of the creation of working agreements with private sector business partners (e.g., store fronts, packaging producers, etc.), and entrepreneurship training and mentorship programs (e.g., with private industry business partners)) • Ensuring ongoing funding availability for cassava research and innovations • Breeding focused on adaptation to specific agroecological zones, end-uses, cropping systems and adverse climactic conditions with minimal need for inputs such as agrochemicals and irrigation[6] • Prioritizing genome-wide characterization of genetic diversity, filling gaps in landrace collections and creating natural reserves[7] • Routine propagation and distribution of disease-free planting material[8]

Interventions	Description	Intervention objectives	Technical model examples using regional references
			• Bolstering multi-way communication and feedback between research institutions, extension agents and cassava producers[9]
Renewable energy for sustainable crop production and processing	Transform selected crop value chains products to Increase access to solar panels and low-carbon equipment for improved production and processing	Food security, resilience, value chains, transformation, sustainability and environmental quality	• Development and rehabilitation of irrigated perimeters and water solar pumps[10] • Capacity building for solar and water use efficiency[11] • Appropriate post-harvest storage technique powered by RETs[12] • Appropriate mechanization technologies for processing (e.g., boiling, pressing, drying) using RETs[13]

[1] CASSAVA.pdf (kcsap.go.ke)
[2] GoSeed Cassava » IITA GOSEED
[3]Valorization of cassava residues for biogas production in Brazil based on the circular economy: An updated and comprehensive review - ScienceDirect.
[4] World Bank Document
[5] Chapuis et al., "Pneumatic Drying of Cassava Starch."
[6] Home - NextGen Cassava
[7] Prospects for Genomic Selection in Cassava Breeding (wiley.com)
[8] Cassava (manioc) | Diseases and Pests, Description, Uses, Propagation (psu.edu)
[9] An Analysis of a Cassava Integrated Research and Development Approach: Has it Really Contributed to Poverty Alleviation? (cgiar.org)
[10]The Cornell International Institute for Food, Agriculture, and Development"
[11] SOLtrain West Africa - ECOWAS Solar Thermal Capacity Building and Demonstration Program | ECREEE
[12] Towards closing cassava yield gap in West Africa: Agronomic efficiency and storage root yield responses to NPK fertilizers - ScienceDirect; Agriculture and Food Security | West Africa Regional | U.S. Agency for International Development (usaid.gov)
[13]8th-Inaugural-Lecture.pdf (unn.edu.ng)

Table 15: Proposed Model intervention: climate resilient, low carbon cassava production in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production (FAOSTAT):* **Average area harvested (2010-2019):** 1.6 million ha (BF: 3,574 ha; CI: 626,624 ha; GH: 925,493 ha; ML: 4,828 ha, and SN: 45,659 ha). **Yields in 2019**: BF: 1 t/ha; CI: 7 t/ha; GH: 24 t/ha; ML: 13 t/ha, and SN: 12 t/ha. **Average producer price (2010-2019):** BF: 170 USD/t; CI**:** 255 USD/t; GH: 144 USD/t; ML: 344 USD/t, and SN: 314 USD/t (FAOSTAT). There are large variations in prices amongst and within countries and between seasons, with prices varying by up to 50 per cent above and below the national average of each country. Large scale buyers of cassava roots, grits or wet pastes often make requirements for quantity and quality of raw cassava roots that are not easily met by smallholder farmers. In order to work with smallholders to meet the demand for specific quality requirements, they need to provide participatory, easily verifiable and cost effectiveness quality monitoring support, involving end-user who buys the raw materials and establish a reward for compliance with quality requirement. *Collection and processing*: Transport of roots from the field to markets and to processing workshops is the first bottleneck in the cassava sector. The highly perishable character of cassava, due to its water load, limits its consumption period to a few days after harvest. Most of the postharvest operations at the peasant scale are carried out manually, due to the lack of inadequacy of high-performance processing tools. The manual workload induced by postharvest cassava operations results in as many losses during the various operations. The most important losses are induced by the various processing operations (23.2%), harvesting (13.6%), and handling operations (8.5%). The development of processing equipment and appropriate water control is therefore a priority issue for the improvement of the productivity of the cassava system. *Distribution and international trade: C*assava has been consumed domestically or marketed locally, so the crop is often regarded as a "non-traded commodity" in the selected countries. Although GH is the main cassava production country among the targeted countries and achieved its self-sufficiency concerning cassava availability for human consumption, the share of exports of cassava is limited due to high costs of processing and transporting making GH less competitive on the world market. CI has globally achieved its self-sufficiency concerning cassava availability for human consumption but import very limited quantity of cassava. Data were not available on the part of cassava or cassava products exportation and importation for the remaining countries.
Technical services and best practices	Technical support and agricultural extension services are very limited in these countries and direly needed to support smallholders in the adoption of best climate resilient, low-emission practices. Several projects have promoted sustainable and efficient water and soil management techniques, but these practices are not yet widely spread.

Financial services	Small rice producers' access to credit from financial institutions is very limited, especially for women, for several reasons: lack of collateral, interest rates, inability to prepare loan applications, high transaction costs, low level of education etc. Loans available from banks and MFIs are often short-term, high interest and for only the current campaign, working capital or equipment. Government support in the form of subsidies for inputs are available, but often smallholders in remote areas are unable to access them.
Climate vulnerability and other risks	Although cassava is a crop which will likely be highly resilient to future climate change stressors, a study from Jarvis et al. (2012) has shown that cassava production will be vulnerable to pests and diseases and climate change can exacerbate disease in livestock, and some diseases are especially sensitive to climate change (Foodtank, 2020). Over a third of attainable cassava yield is lost every year to pests and disease alone. For instance, In Côte d'Ivoire, Fargette et al. (1996) noted that high temperatures are associated with high fecundity, rapid development, and greater longevity of the whitefly, which is a pest of cassava and transmitter of pathogens in Africa. As farmers try to cope with the impacts of climate change on pests and diseases, it can be expected that pressure on water will increase, leading to overuse, degradation, potential conflicts, rural exodus and international emigration. To mitigate these effects, introducing adaptation measures and strengthening resilience is urgently needed.
Key Barriers and Enablers	Key potential climate related barriers include: - **Sustainable cassava production and processing**: low soil fertility and soil degradation; low-emission practices and limited capacity to process package and market cassava; degraded irrigation infrastructure and inefficient water management practices; lack of access to fertilizer and other inputs, which is one of the primary causes of - agricultural encroachment on natural spaces. - **Renewable energy for sustainable crop production and processing**: siting and transmission barriers decreasing sustainable energy generation and consumption; Insufficient energy availability could exacerbate inefficient soil and water management practices; Potential lack of use of renewable energy if electricity services have high capital costs in the long term, which could increase environmental degradation. Other key barriers include: limited access to affordable loans and financial services;; lack of technical capacity and knowledge of farmers and government extension services on best climate resilient,; high cost of transport and transport risk for long distance; lack of storage facilities and access to electricity; poor roads; labour shortages for processing, lack of small farm equipment (especially for post-harvest operations) and low mechanization levels, which drive up production costs; insecure land tenure; limited market

	access;; high weed, pest and disease pressure; limited adoption of improved varieties and best agricultural practices, loss of customers because of scarcity of products and poor quality product; among others. Increasing access to financing will be fundamental for enabling farmers to overcome these barriers.
Current extents and potential program adoption	Of the five targeted countries, Ghana and Côte d'Ivoire are the largest producers: in 2019, GH produced 22 million t; CI: 5.2 million t; SL: 1 million; ML: 70,312 and BF: 4,046. Target of household adoption rate of 40% for the implementation of climate resilient, low-emission agriculture techniques and practices.
Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices, sustainable cassava production and processing and renewable energy for sustainable crop production and processing.
Mitigation activities and impacts	Cassava crop root and peel residues, as well as for foliage and shoots that can be harvested several times through the year. These can be used as feed for cattle, sheep, goats, pigs, rabbits, broiler and layer poultry, and fish without adverse effects on growth or productivity, and in many cases a great benefit. Composting using biodigesters is an effective mitigation practice to reduce GHG emissions for cassava productions. Conservation agriculture uses cover crops, crop rotation, and minimal tilling in the production of annual crops avoids emissions and sequesters carbon. Restoration of degraded agricultural land through sustainable land management store and sequester carbon. The use of solar energy instead of fossil fuels to power irrigation pumps and other equipment will also help reduce GHG emissions.
Adaptation activities and impacts	Wild cassava strains have shown significant variability in terms of adaptation, nutritional content, toxins, resistance to pests and disease, and postharvest shelf life[1]; this implies a high potential for development of new varieties displaying beneficial characteristics. The adoption of better planting periods will help farmers adjust to changes in the cropping calendar. More efficient irrigation techniques and equipment will ensure better use of water resources, which could become scarcer in some parts of the region. Along with conservation agriculture uses integrated pest management, intercropping, cover crops, crop rotation, and minimal tilling in the production of annual crops that mitigate soil degradation and enhance soil quality, structure, and functioning, innovation in varietal development and distribution, as well as in postharvest processing methodology and mechanization, have been shown to help overcome production, processing and marketing challenges. Similarly, sustainable land management improves water availability and quality, mitigate damages caused by extreme weather events or natural hazards and regulate pests and diseases.

Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

[1] Research Program on Roots, Tubers, and Bananas, "Cassava."

Sustainable cereals-staple crops production : Groundnut (Arachis hypogaea)

32. Africa is the second largest groundnut producing continent accounting for about 40% and 31% of the global area and production, respectively. West and Central Africa region accounts for more than 70% of the groundnut production in Africa where the crop is cultivated by smallholder farmers. Groundnut is a major cash crop for many households, and it is a nutritious food that contributes to improved nutrition and health of the rural population. Despite its importance, the productivity of groundnut in Africa remains low with unshelled yield of less than 1 ton/ha compared with global average of about 1.7 tons/ha and over 3 tons/ha in USA and China attributed to various constraints including biotic, abiotic stresses and socioeconomic factors. In addition, low availability of breeder and foundation seeds of improved varieties and weak formal seed distribution systems contribute to the low productivity of the crop[159].

33. Varieties of groundnut found in five countries include: Burkina Faso (ICGV 93305 (Miou Paale), ICGV 91328, KIEMA, ICGV-IS 13830, ICGV-IS 13912, ICGV-IS 13806, and ICGV 01276) Coté d'Ivoire (from Dikodougou (AR1D, AR2D AR3D, and AR4D) and Korhogo (AR1K, AR2K)); Ghana (Sarinuts 22, Sarinuts 23, Yenyawoso, Nkatiesari and Oboshie); Mali (JL24, Fleur 11, ICGV 86124 and ICGV 86 015) and Senegal (Fleur 11, GC 8-35, Spanish and Virginia)

Burkina Faso

34. In Burkina Faso, groundnut contributes significantly to both food security and poverty alleviation. As in many low-income countries in Africa and Asia, the crop is primarily grown for subsistence by smallholder farmers, predominantly women, under rain-fed and low input conditions. Groundnut can account for up to 50% of cash income while providing many benefits including a food rich in digestible proteins, high-quality oils, and many functional compounds and elements such as iron and zinc, which are important to nutrition and health, especially in children. As a legume crop, groundnut cultivation improves soil fertility and productivity by fixing atmospheric nitrogen. Additionally, the plant's haulm and by-products have value as a feed for livestock.

35. The groundnut value chain in Burkina Faso employs a significant number of people and contributes substantially to the economy and to family wellbeing. Clearly, groundnut improvement has a direct positive impact on the nutritional and economic status of

[159] https://knowledge4food.net/research-project/upscaling-improved-groundnut-varieties-ghana-and-mali/

smallholder farmers. Despite the importance and benefits of groundnut for farmers and consumers in Burkina Faso, the production of this legume has been unsteadying for the last 20 years or so. Groundnut yields have remained low (~800 kg/ha) in sharp contrast with the crop's potential which can provide up to 5000 kg/ha in intensive agriculture systems like in the USA. This low level of productivity is attributable to several constraining factors including diseases and pests, erratic rainfall, drought, poor soils, market instability, and lack of locally adapted high-yielding varieties. The highest production in Burkina Faso was 519,345 tonnes in 2016, more due to the extension of cultivated land than to an increase in crop productivity. The stagnation of domestic production has been exacerbated by an unreliable seed supply system for groundnut and weak organisation of the groundnut industry, which has left a current gap in processing capacity. Groundnut breeding in Burkina Faso has been tightly correlated with activities in the crop's value chain, which drive the whole groundnut industry including the research and development [6]. For more than a decade now, no major action plan has been established to develop the groundnut industry, especially after the 2008 food crisis. To this extent, the focus of breeding efforts at INERA (Institute of Environment and Agriculture Research) was directed to the main staple food crops (i.e., maize, pearl millet, sorghum, rice) overlooking groundnut, which is often considered a cash crop, and thereby hampering groundnut cultivar development.

36. At present, information about progress and the current state of groundnut breeding in Burkina Faso is patchy. Most research results are confined to annual reports of individual projects with little published in international journals. To our knowledge, publications in recent years have focused mainly on yield evaluation and disease of local and exotic varieties for early leaf spot. Earlier research activities involved the evaluation of resistance to foliar diseases in lines introduced from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) or the USA through the Peanut CRSP (Peanut Collaborative Research Support Program) and similar development programmes.[160]

Côte d'Ivoire

37. With a height oscillating between 30 and 50 cm, groundnut is an annual herb, which grows preferentially in areas where the annual rainfall does not exceed 1000 mm. One of its specificities is its ability to bury its fruits, which are pods that can contain between 1 and 5 protein seeds. These seeds also contain significant proportions of fatty substances, which also make peanuts an oil plant. This plant, which grows in the tropics and subtropics, was known to the indigenous populations of Côte d'Ivoire, long before the arrival of the settlers. Groundnuts were then a condiment plant that was used to make sauces. Unlike Senegal, where groundnuts are used primarily for oil production, Ivorian groundnut production is oriented towards consumption in boiled or grilled form and the making of sauce. Once dominated by women from the central and northern regions, groundnut cultivation is attracting more and more male producers because of its high financial value.

38. Once a hut culture, groundnuts have gradually become a cash crop for northern women due to its growing demand in urban markets. Indeed, the peanut sauce, together with the seed sauce and the eggplant sauce, is one of the three sauces that are served in almost all restaurants in the city. There are more and more plantations in pure cultivation, since men are interested in the cultivation of groundnuts. The centre and north are the main production

[160] https://www.mdpi.com/2073-4395/10/5/704/htm

areas in Côte d'Ivoire. In areas where the rain regime allows it, the cultivation can be conducted over two cycles. In the north, groundnuts are part of an alternating crop rotation where we find cotton and corn. With an estimated production of 150,000 tons, Côte d'Ivoire is the 17th largest producer in the world[161].

Ghana

39. Groundnut production in Ghana is predominantly conducted in Northern Ghana, with the region accounting for 94% of the annual groundnut production. Production is mostly conducted under smallholder settings characterized by small pieces of land and resource constraints. Frequently rotated with maize or other common cereals, groundnut cultivation forms an integral part of the mixed cropping-livestock system characteristic of Northern Ghana. In this region, over 650,000 households (representing about 74% of households in Northern Ghana) participate in groundnut production, with a total groundnut cultivated area of about 400,000 hectares. Across Northern Ghana, groundnut is prized for its higher profitability compared to commonly cultivated cereals such as maize and sorghum. Groundnut production in these smallholder farming systems is therefore almost always market oriented, making the crop a key income source for rural communities. This is particularly the case for rural women as the cultivation, marketing and processing of groundnut is primarily conducted by women.

40. While annual groundnut production in Northern Ghana is about 500,000 metric tons, mean farm yields are often low at about 0.9 tons per hectare compared to attainable yields of 2.5 tons per hectare. Low groundnut yields in Northern Ghana are mainly due to declining soil fertility and high disease infestations. Diseases such as leaf spot, rust and groundnut rosette result in yield losses of close to 100% in wet seasons, and up to 50% in moderate seasons. Groundnut production in smallholder farming systems of Northern Ghana can be enhanced through the use of certified seeds and increased use of pesticides and fungicides to control pest and disease infestations. Increased nutrient applications particularly in form of fertilizers is also required to substantially increase yields, as organic nutrient sources such as manure are inadequate in these farming systems. Resulting increases in groundnut yields would improve household incomes given the higher profits associated with groundnuts compared to other crops. Studies on current consumption and demand patterns also show that any increase in groundnut production can be readily absorbed by the Ghanaian domestic and export markets.

Mali

41. Groundnut production is concentrated in the West, South and parts of the Center covering the regions of Kayes, Koulikoro, Sikasso and Segou. These regions account for 97% of area and 98% of groundnut production in Mali. Rainfall ranges from 400 to 800 mm per year. The Tropical Legumes II program sites are located in the regions of Koulikoro and Kayes. The region of Kayes is the major groundnut producing region accounting for 33% of area and 35% of groundnut production in Mali. The region of Koulikoro accounts for 21% of groundnut area and 24% of groundnut production in Mali (DNSI, 1996/97). Kolokani is one of the largest

[161] Groundnut - Agroforestry Côte d'Ivoire (agroforesterie.ci)

groundnut-producing areas in the Koulikoro region. It has a history of experiencing repeated droughts one year out of three.

42. Groundnut is the main source of rural livelihoods representing 37% of the total cultivated area. It is mostly planted as a sole crop and in rotation with cereals. Only about 8% of groundnut area is cultivated in association with cereals. Groundnut is cultivated on collective plots by all household members or individual plots owned by either men or women in the household (DNSI, 1996/97). Yields are higher in Kita (1249 kg/ha) compared to 661 kg/ha in Bougouni and 760 kg/ha in Kolokani (CPS/IER, 1998). The low yields are partly due to the poor quality of seed used by farmers. Thirty-two percent reported poor quality seed to be a major constraint to groundnut production. Almost all farmers complain of low supply of seed of improved varieties. Farmers also use very little inorganic fertilizer.

43. Since 1996, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Institut d'Economie Rurale (IER) have been working in Kolokani area, developing a range of varieties tolerant or resistant to many foliar diseases. In 2000, ICRISAT initiated a small-scale seed production scheme with farmers in the villages of Bambabougou, Kanekebougou, Tioribougou and Komokorobougou in the Kolokani region. Seed was marketed using small-scale pack seed (Ndjeunga et al. 2003). Since 2003, the groundnut seed project (GSP) continued to promote a range of seed multiplication and delivery schemes in other regions of Mali[162].

Senegal

44. Senegal has a "groundnut basin," in which most of the country's crop is grown. The basin covers a large swathe of central and western Senegal, north of Gambia. This area is large indeed: in 2010, over 40 percent of land under harvest was dedicated to the cultivation of groundnuts. Further, the groundnut sector both directly and indirectly employs about 1 million Senegalese people (close to 7 percent of the Senegalese population). Groundnuts typically require between 500 and 700 mm of rain to achieve good yields (this is similar to how much water corn needs to grow successfully). Senegalese droughts, which are not uncommon, have devastated production levels in the past, recently in 2002 and 2011.

45. The 1960s were very good years for Senegalese peanuts. At the peak in 1965, Senegal produced 1.1 million tonnes of groundnuts, and exported about 300,000 tonnes of them — which represented roughly 20 percent of total global peanut exports. In the subsequent years, Senegalese production began to slip, as the country's former colonizer, France, lifted the price support it had been offering under the Lomé Accord. Meanwhile, global tastes in oils began to diversify as soybean oil, sunflower oil, and others became increasingly popular. China quickly filled the void left by Senegal and others, increasing production drastically thanks to agricultural reforms and the increased adoption of new varieties.

46. Over the next two decades, Senegal was only able to achieve strong groundnut production in 1974, 1978 and 1982. Nevertheless, after that, production trended downward, and was

[162]https://www.researchgate.net/publication/279467020_Farmer_preferences_for_groundnut_traits_and_varieties_in_West_Africa_Cases_of_Mali_Niger_and_NigeriaWorking_Paper_Series_no_27

extremely erratic, so that the country did not again achieve production in excess of 1 million tonnes until 2000, and then again in 2010[163].

Impact of climate change on groundnut production in all five countries

47. Groundnuts are a mainstay of the West African Sahel region diet and critical for food security. Cereal-staple crop rotations dominate the region savannah, providing vital household nutrition and income. However, groundnuts deplete soils, require management techniques that are not climate resilient, and are often low yield. Improved groundnut varieties are needed to create resiliency given climate impacts. Groundnuts can improve soils and productivity. Current soil fertility levels strongly influence the benefits realized and soil fertility levels vary significantly both across the savannah zones and between farms. There is a dramatic opportunity to increase overall Cereal-staple crop production and resilience. This will mitigate agricultural expansion, improve household nutritional and economic outcomes, and foster national food supplies and economic stability. This climate smart agriculture integration builds on existing systems[164] and improves the components tailoring existing Cereal-staple crop systems such as groundnuts for improved soil quality and economic outcomes. Site-specific tailoring is vital to optimize production, and most farmers are unaware of opportunities to tailor groundnuts to their particular region, soils, and farm management goals.

48. To finance the development of climate resilient crop value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The proposed intervention is presented in table 16 along with the proposed model intervention in table 17.

Table 16: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Sustainable cereals-staple crops production	Introduce and optimize current cereal-staple crop rotations by developing climate-resilient crop varieties and introducing the best soil fertility management practices.	Raises income, increase yields, build cropping resilient systems at household scales, improve soil quality, reduce land degradation, increase food security, and provide a basis for groundnut	• Integrated soil fertility management, including the use of organic and inorganic fertilizers, most appropriate sowing dates, mulching, intercropping, and reduced tillage [1] • Heat, drought and disease-resistant or tolerant crop varieties [2] • Integrated pest and disease management[3] • Mobile extension, soil, and climate information services—enabled by

[163] https://gro-intelligence.com/insights/articles/polishing-peanuts-the-senegalese-groundnut-story
[164] rather than building a different system

Interventions	Description	Intervention objectives	Technical model examples using regional references
		exports and demonstrate high likelihood of success.	weather stations, big data, machine learning, and mobile technology—to support decision making[4] • Improved resource-use efficiency and economic resiliency using crop residues such as transforming groundnut into oil, couscous etc. to contribute to green jobs creation for youth and women and food security[5] • Purchase of eco -equipment's land development • Better access to farm input financing for sustainable cereals production such as groundnut, millet and rice (seeds and organic fertilizers etc.)[6] • Mobile platforms—enabled by big data, machine learning, and mobile technology—to support input supply and product markets • [7]
Renewable energy for sustainable crop production and processing	Transform selected crop value chains products to Increase access to solar panels and low-carbon equipment for improved production and processing	Food security, resilience, value chains, transformation, sustainability and environmental quality	• Development and rehabilitation of irrigated perimeters and water solar pumps[8] • Capacity building for solar and water use efficiency • Appropriate post-harvest storage technique powered by RETs[9] • Appropriate mechanization technologies for processing (e.g., boiling, pressing, drying) using RETs[10]

[1] https://africafertilizer.org/wp-content/uploads/2018/10/2018-10-FeRWAM.pdf; 562-ASHC-English-Groundnut-A4-bw-lowres.pdf (cabi.org)

[2] Desmae, H and Ntare, B and Motagi, B N and Falalou, H and Upadhyaya, H D and Oteng-Frimpong, R and Sako, D and Echekwu, C and Miningou, A and Monyo, E and Varshney, R K (2017) Advances in groundnut breeding for drought prone West and Central Africa. In: InterDrought-V, February 21-25, 2017, Hyderabad, India. URI: http://oar.icrisat.org/id/eprint/10722
[3] Microsoft PowerPoint - Osiru integrated management of aflatoxins18nov13.pptx (aflatoxinpartnership.org); Peanut (groundnut) | Diseases and Pests, Description, Uses, Propagation (psu.edu)
[4] Promising Agriculture Technologies: Groundnut (cgiar.org)
[5]https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Revitalization%20of%20the%20Groundnut%20sector%20in%20West%20Africa_Dakar_Senegal_12-3-2010.pdf; Mumuni, Eliasu & Zuberu, Sumaila & Oladele, O.I. (2013). Comparative economic analysis of groundnut oil and soya milk production in the Tamale Metropolis of the Northern Region of Ghana. International Journal of Development and Sustainability. Volume 2. 2267-2277.
[6] https://myfarmbase.com.ng/2018/09/21/how-to-make-profits-from-groundnut-farming/
[7] ABJNA-5-6-252-258.pdf (scihub.org)
[8]Prospects for Solar Powered irrigation systems (SPIS) in South Africa (sabi.co.za)
[9] Groundnuts post-harvest, handling & storage Tips – Livelihoods and Food Security Programme (lfspzim.com)
[10]TRADITIONAL AND MODERN GROUNDNUT PROCESSING (modishproject.com)

Table 17: Proposed model intervention: climate resilient, low carbon groundnut production in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production: planting, maintenance and harvesting:* Average smallholder producer holdings of 1-5 ha. Productivity 8,156Hg/ha in Burkina, 1.4t/ha in Cote d'Ivoire, 0.9t/ha in Ghana, 0.8t/ha in Mali and 12,794 Hg/Ha in 2019. A ton of groundnut currently sells at $1,450[1]. Many producers belong to POs or cooperatives, but organizations need strengthening *Collection and primary selection and transformation:* The groundnut production business is not as structured as some products like cocoa and coffee in the region, however, the prospects exist for establishing aggregation centers and other market enablers. *Distribution and export:* The market price of groundnut in the region is far below $650MT, which is price for Asia and $700MT obtainable in South Africa and Argentina. In assessing the current and foreseeable market opportunities for groundnut of West African origin, it will be crucial to build slowly and deliberately on existing strengths (including the availability of improved seed through the current project).
Technical services and best practices	Technical support and agricultural extension services are very limited in these countries and direly needed to support smallholders in the adoption of best climate resilient, low-emission practices. Several projects have promoted Good Agronomic Practices, sustainable and efficient water and soil management techniques, but these practices are not yet widely spread.

Financial services	Small groundnut producers' access to credit from financial institutions is very limited for several reasons: lack of collateral, interest rates, inability to prepare loan applications, high transaction costs, etc. Loans available from banks and MFIs are often short-term, high interest and for only the current campaign, working capital or equipment. Rice producers tend to turn to mill owners or input suppliers for advances on contracts, or to family members and friends for loans. Government support in the form of subsidies for inputs are available, but often smallholders in remote areas are unable to access them.
Climate vulnerability and other risks	Studies suggest that climate change could be expected to result in modest positive increase in groundnut yields in the region. This is largely related to the fact that peanut is an indeterminate crop that is not as susceptible to earlier maturity with warmer temperatures as is the case with maize and sorghum. As groundnut is currently one of the region's most important cash crop, as well as important food security crop, these results are encouraging and in broad agreement with a recent study by Hathie et al. (2017) and contrary to the expectation that climate change will inevitably lead to yield losses for West African agriculture mainly for cereals (Roudieret al., 2011; Sultan et al., 2013). As peanut is a legume that can fix atmospheric nitrogen, its wider inclusion in crop rotations and as an inter-crop should be further explored as a climate smart option. As farmers try to cope with the impacts of climate change, it can be expected that pressure on natural resources (vegetation, soil, water) will increase, leading to overuse, degradation, potential conflicts, rural exodus and international emigration. To mitigate these effects, introducing adaptation measures and strengthening resilience is urgently needed.
Key Barriers and Enablers	Key potential climate-related barriers include: - **Sustainable cereals-staple crops production**: Poor farmer access to advisory services and climate services; Poor access to labor-saving technologies for groundnut harvesting; irrigation water supply such as degraded irrigation infrastructure and inefficient water management practices; limited adoption of improved varieties and best agricultural practices; gender inclusivity; gaps in finance and labor resources; farm mechanization; and climate information services and lack of good quality seeds that are resilient to climate change. - **Renewable energy for sustainable crop production and processing:** siting and transmission barriers decreasing sustainable energy generation and consumption; Insufficient energy availability could exacerbate inefficient soil and water management practices; Potential lack of use of renewable energy if electricity services have high capital costs in the long term, which could increase environmental degradation. Other key barriers include: limited access to affordable loans and financial services; technology cost; lack of technical capacity and knowledge of farmers and government extension services on best climate resilient, low-emission practices and limited capacity to process,

	package and market rice; lack of storage facilities and access to electricity; poor roads; labour shortages, lack of small farm equipment (especially for post-harvest operations) and low mechanization levels, which drive up production costs; insecure land tenure; limited market access; low farmgate prices and low yields discourage farmers from producing rice; low soil fertility and soil degradation; high weed, pest and disease pressure; input access , and; among others. Increasing access to financing will be fundamental for enabling farmers to overcome these barriers.
Current extents and potential program adoption	In West Africa, although Nigeria and Senegal are the largest producers of groundnut, Mali and Niger are also important groundnut producers. In Mali groundnut is grown on 0.29 million ha with an average production and productivity of 0.26 million tones and 880 kg ha−1, respectively. In Niger, groundnut is grown on a larger area (0.44 million ha) than in Mali, but with greater fluctuation in production due to variable climate. Average production and productivity of groundnut in Niger is 0.21 million tons and 480 kg ha−1 (mean of 2001 to 2010 production data reported in FAO 2012). Target of household adoption rate of 40% for the implementation of climate resilient, low-emission agriculture techniques and practices.
Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices; cereal-legume systems integration and renewable energy for sustainable crop production and processing
Mitigation activities and impacts	Groundnut is an atmospheric nitrogen-fixing crop, which reduces GHG emissions and limits the quantity of chemical soil amendments. This has mitigation and adaptation benefits as it maintains soil health. Cereal-legume systems greatly improve food security and soil quality, supporting both crop and household resilience to climate extremes. Intensification and slowing land conversion accrue sequestration benefits. The use of solar energy instead of fossil fuels to power irrigation pumps and other equipment will also help reduce GHG emissions.
Adaptation activities and impacts	Sustainable agronomic practices (i.e. crop diversification, CSA, use of improved varieties that are the most tolerant to drought for zones with recurring drought periods, shortening of the growth cycle of high yielding varieties, no-till, intercropping, precision nutrient management, and integration of indigenous knowledge), Forest, land, and water management, increasing efficiency in water use (i.e. expansion and/or rehabilitation of irrigation systems), and continued agricultural research to use the most appropriate sowing dates to optimize the available moisture in the soil and face the effect of eventual higher temperatures during the growth phase of the crop (e.g., through detailed crop simulation models). The use of seasonal forecast by farmers in the planning of agricultural operations as well as greater agro-meteorological assistance and a strengthening of early warning systems (especially in view of rainfall distribution in the three main

	rainfall months) will also build the adaptive capacities of the farmers. Marginal coffee cultivation economics will be improved increasing coping capacities and generating employment.
Number and size of beneficiaries and financial demand	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

[1] https://www.indexmundi.com/commodities/?commodity=peanuts

Sustainable cereals-staple crops production : Millet

49. Millets are cereal crops, producing small seeds with good nutritional properties, important for food and nutrition security in most developing countries, particularly in Asia and Africa. The global production, estimated at 28.37 million metric ton in 2019, is dominated by India with 36% of global market share, according to FAO data[165]. The majority of the top ten producers are countries in West and Central Africa (WCA), among which three IGREENFIN countries (Burkina Faso, Mali and Senegal). Mali is the largest producer of millet, among the five IGREENFIN countries, followed by Burkina Faso, Senegal, Ghana and Cote d'Ivoire. In 2019, there were 1.99 million hectares harvested and 1.88 million tonnes produced in Mali[166]. For consumption, Africa is ranked at the first place with more than 40% of global millet consumed, mainly in Niger, Mali, Nigeria, Burkina and Sudan[167]. There are many different millet species grown on nearly 20,42 million hectares in 2019 in Africa according to FAOSTAT. Pearl millet (Pennisetum glaucum) and Finger millet (Eleusine coracana) are the two major millets worldwide. Pearl millet appears to have emerged and first been domesticated in the Sahel zone of the West African drylands, and Finger millet is the most important small millet in the tropics cultivated in the East African subhumid uplands.

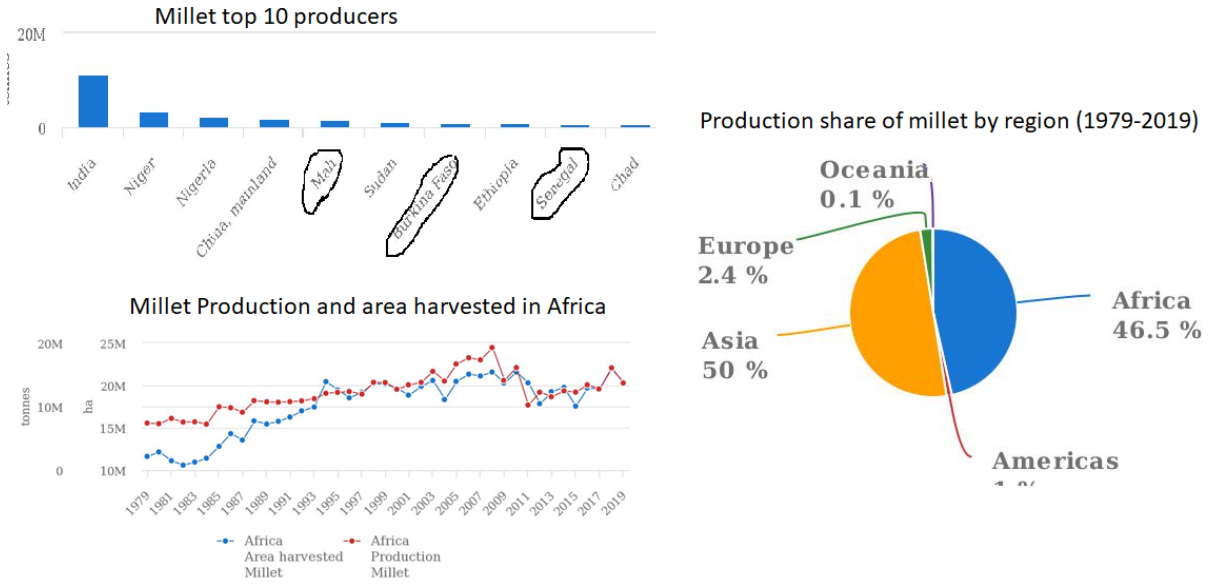
50. Pearl millet accounts for about 50% of the total global production of millets, and more than 90% of the large areas under millets (15,7 million hectares) in the WCA region is dedicated to pearl millet[168]. For this region, an increase of 130% of Pearl millet is noted since 1980 according to ICRISAT[169]. Furthermore, more than 90 million poor people, generally living in drier parts of Africa and Asia, depend on Pearl millet for food and income. Finger millet, which is the most important small millet in the tropics cultivated in more than 25 countries in Africa and Asia, represents 12% of the global millet area[170]. It has higher yield potential, more than 5 t/ha under optimum irrigated conditions, even if it is grown mainly in marginal environments as a rainfed crop with low fertility and limited moisture. Millets are known for being nutritious food, surpassing most cereal crops for protein quality and some

[165] http://www.fao.org/faostat/en/#compare
[166] http://www.fao.org/faostat/en/#data/QCL/visualize
[167] https://www.researchandmarkets.com/reports/4520082/millet-market-growth-trends-covid-19-impact?utm_source=CI&utm_medium=PressRelease&utm_code=2lkpvm&utm_campaign=1278170+-+Global+Millet+Markets+2019-2024+-+India+Dominates+Global+Production+%26++Africa+Dominates+Global+Consumption&utm_exec=chdo54prd
[168] http://exploreit.icrisat.org/profile/Pearl%20Millet/178
[169] International Crops Research Institute for the Semi-Arid Tropics
[170] http://exploreit.icrisat.org/profile/Small%20millets/187

micronutrients. Their good nutritional values including high levels of quality protein, ash, calcium, iron and zinc, which make millet nutritionally superior to most cereals, are now being enhanced through biofortification and micronutrient research[171].

51. Furthermore, millet are climate resilient crops and they have an inherent ability to grow in various environments, including in adverse conditions. Millets are known for their climate-resilient features including adaptation to a wide range of ecological conditions, less irrigational requirements, better growth and productivity in low nutrient input conditions, less reliance on synthetic fertilizers, and minimum vulnerability to environmental stresses[172]. Pearl millet landraces are characterized by highly diverse agro-morphological and adaptive traits, including flowering time, photoperiod sensitivity, or drought tolerance, and it is adapted to a wide range of climate[173]. Moreover, millets are among the cereal crops with lower carbon footprints, compared to wheat, rice or maize. Pearl millet is grown in areas having marginal soil with low annual rainfall in the range of 200-500 mm and it can thrive at higher temperatures, while Finger millet can be cultivated with medium rainfall and temperatures ranging from 11 to 270C[174]. However, with climate change, millet yields are expected to decrease having impact on farmers' incomes. An increase in the West African temperature by 10C would result in an increased frequency of heat and rainfall extremes, and a reduced average yield of millet by 10-20%, leading to a loss of USD 2.33-4.022 billion in monetary terms.

Figure 2: Production share of millet by region (1979-2019)



Source: FAOSTAT[175]

52. To finance the development of climate resilient crop value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The

[171] https://pdfs.semanticscholar.org/4b7e/89ed623bf79da687522d8eb5eeed9a4ed02e.pdf?_ga=2.26637309.1152407806.1628709772-2147179150.1628709772
[172] Kole, C., Muthamilarasan, M., Henry, R., Edwards, D., Sharma, R., Abberton, M., et al. (2015). Application of genomics-assisted breeding for generation of climate resilient crops: p
[173] https://www.nature.com/articles/s41467-020-19066-4.pdf
[174] Saxena. R, Vang, S. K., Wang, J., Orsat, V., Raghavan, V. 2018. Millets for food security in the context of climate change: A review. Sustainability 2018, 10, 2228; doi:10.3390/su10072228
[175] http://www.fao.org/faostat/en/#data/QCL/visualize

proposed intervention is presented in table 18 along with the proposed model intervention in table 19.

Table 18: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Sustainable cereals-staple crops production	Introduce and optimize current cereal-staple crop rotations by developing climate-resilient crop varieties and introducing the best soil fertility managemen t practices.	Raises income, increase yields, build cropping resilient systems at household scales, improve soil quality, reduce land degradation, increase food security, and provide a basis for millet exports and demonstrate high likelihood of success.	• Integrated soil fertility management, including the use of organic and inorganic fertilizers, most appropriate sowing dates, mulching, intercropping, and reduced tillage [1] • Heat, drought and disease-resistant or tolerant crop varieties [2] • Integrated pest and disease management[3] • Mobile extension, soil, and climate information services—enabled by weather stations, big data, machine • learning, and mobile technology—to support decision making[4] • Improved resource-use efficiency and economic resiliency using crop residues by transforming millet into couscous or generating fertilizer and clean cooking fuel from on-farm resources, protecting forests and reducing costs and labor[5] • Purchase of eco -equipment's land development • Better access to farm input financing for sustainable cereals production such as groundnut, millet and rice (seeds and organic fertilizers etc.)[6] • Mobile platforms—enabled by big data, machine learning, and mobile technology—to support input supply and product markets • [7]

Renewable energy for sustainable crop production and processing	Transform selected crop value chains products to Increase access to solar panels and low-carbon equipment for improved production and processing	Food security, resilience, value chains, transformation, sustainability and environmental quality	• Development and rehabilitation of irrigated perimeters and water solar pumps[8] • Capacity building for solar and water use efficiency • Appropriate post-harvest storage technique powered by RETs[9] • Appropriate mechanization technologies for processing (e.g., boiling, pressing, drying) using RETs[10] • Bolster research and development capacity for sustainable on-farm energy production technologies (using biogester systems from millet)[11] • Raise public awareness of the benefits of sustainable energy production and use

[1] https://africafertilizer.org/wp-content/uploads/2018/10/2018-10-FeRWAM.pdf; 562-ASHC-English-Groundnut-A4-bw-lowres.pdf (cabi.org)
[2] Michael Chipeta - Innovation Lab for Crop Improvement (cornell.edu)
[3] Program Update 2017 PDF Low Res.pdf (k-state.edu)
[4] Microsoft Word - climate-258588.docx (weadapt.org)
[5]West Africa: Biodigesters | Ci-Dev
[6] https://myfarmbase.com.ng/2018/09/21/how-to-make-profits-from-groundnut-farming/
[7] https://web.stanford.edu/~fafchamp/mobiles.pdf
[8]solar water pump – Africa RISING (africa-rising.net); Prospects for Solar Powered irrigation systems (SPIS) in South Africa (sabi.co.za)
[9] Improved postharvest technologies for promoting food storage, processing, and household nutrition in Tanzania (core.ac.uk)
[10]TRADITIONAL AND MODERN GROUNDNUT PROCESSING (modishproject.com)
[11] World Bank, "The Power of Dung."

Table 19: Proposed model intervention: climate resilient, low carbon Millet production in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production (FAOSTAT):* Average area harvested (2009-2019): 1.895 million ha for Mali; 1.245 million ha for Burkina Faso; 856,586 hectares for Senegal; 172,074 hectares for Ghana and 67,932 hectares for Cote d'Ivoire. Avera. Average quantity produced (2009-2019): 1.674 million tonnes for Mali; 992,344 tonnes for Burkina Faso; 683,133 tonnes for Senegal; 180,879 tonnes for Ghana and 54,515 tonnes for Cote d'Ivoire. In terms of prices, the annual value in GH was US$333.5/t, US$22.3/t in ML in 2019, and Us$334.5/t in Senegal. According to ICRISAT, the major constraints to pearl millet production include: such bacterial diseases as bacterial spot and bacterial leaf streak; various fungal and pseudo-fungal diseases, which can significantly reduce productivity; insect pests, including millet head miner and stem borers; abiotic stresses such as drought, soil acidity, soil salinity, and high temperatures during the time when seedlings are just starting to grow and when the plants are flowering. In Senegal, the millet value chain actors are the producers, producers organizations, traders, processors, and the providers of inputs, services and support. Women are heavily involved in adding value to millet through processing and linking rural women to markets for value-added cereals offers opportunities to improve their economic standing. An example is the market for hulled millet in Dakar—currently millet is transported to Dakar with its hull and manually processed there, but there are opportunities to hull the millet in rural areas and transport the hulled product to Dakar for sale[1]. Internal national and regional trading of millet is susbstantial. In 2019, Burkina Faso has the most important volume of millet exported, followed by Senegal and Mali (to Mauritania, Senegal, Guinea and Niger), 5200 tonnes, and Côte d'Ivoire the highest quantity imported 452 tonnes.
Technical services and best practices	Technical support and agricultural extension services on forest management, agroforestry and processing techniques are limited and thus, needed. This must go hand-in-hand with increased access to credit and training on how to develop and implement viable, bankable green business plans. Limited government extension services for smallholders; projects executed by INGOs, NGOs, etc. offer capacity-building and technical assistance, but unable to meet all needs.
Financial services	Access to credit from financial institutions is very limited, especially for millet considered as a noncommercial crop. In Mali, Producers Organisations generally lack relationships with commercial lenders, and Banks are wary of lending for agricultural production, especially for sorghum and millet cultivation. Major constraints to credit include: 1) lack of bankable business plans; 2) a reluctance to finance sorghum and millet, which are non-commercial crops; and 3) limited capacity of traders and

	processors to provide internal value chain financing to producers. In Senegal, credit is a key constraint to expanded business activity in this value chain, particularly for women. To enhance women's access to credit, options should include capacity building with women's producer organizations to build their credit worthiness and ability to pursue and manage credit, working with financial institutions to sensitize them on women's credit needs, promotion of innovative financial instruments that address women's particular needs and constraints in accessing credit, and working with MFIs to expand their lending to women[2].
Climate vulnerability and other risks	Millet is mostly farmed in family farming systems utilizing native cultivars in rainfed environments with no further irrigation (or landraces). Pearl millet landraces have a wide range of agromorphological and adaptive features, including as flowering duration, photoperiod sensitivity, and drought tolerance. Furthermore, pearl millet can grow in a variety of climates, with annual precipitation ranging from 200 to over 1000 mm[3]. It can therefore grow under drought conditions with substantial yield and minimal input and has a low water footprint. It is considered as a sustainable alternative to major cereals. Other major risks are related to pest and diseases
Key Barriers and Enablers	The lack of supply of quality seeds and poor output, the lack of investments in research and mechanization, cultivation practices, harvest technologies, value addition and food processing (millet-based products), and the low level of subsidies compared to major crops (maize, wheat, rice…) are some of the major barriers to promoting millet. However, it has been recognized for its climate-resilient characteristics and the potential to solve global nutritional security challenges (2023 has been declared the International Year of Millets), what could lead to more investments toward its sustainable production.
Current extents and potential program adoption	Of the five targeted countries, Mali, Burkina Faso and Senegal are the largest producers and they are among the top 10 producers worldwide according to FAO data. Target of household adoption rate of 40% for the implementation of climate resilient, low-emission agriculture techniques and practices.
Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices to improve soil fertility and water retention in soil; Sustainable cereals-staple crops production and renewable energy for sustainable crop production and processing to power households and post-harvest processing equipment and storage facilities.
Mitigation activities and impacts	Millet cultivation promotes a shift towards sustainable agriculture, with a reduced dependence on synthetic fertilizers and pesticides. Crop leftovers have a high carbon content, making them particularly significant for maintaining and increasing soil carbon levels, for sustainable cropping systems, and, when appropriate, for supplying feed for livestock[4].

Adaptation activities and impacts	Crop and varietal diversity of millet for a better adaptation to climate conditions could reduce the yield loss and the agricultural risks in the most vulnerable areas. In other words, planting different varieties adapted to different regions and climate conditions Millet varieties with a short growing season can be used in a variety of cropping methods, both irrigated and dry farming. Appropriate storage conditions allow to keep the harvest for a considerable amount of time.
Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

[1] https://pdf.usaid.gov/pdf_docs/PA00MMW4.pdf
[2] https://pdf.usaid.gov/pdf_docs/PA00MMW4.pdf
[3] https://www.nature.com/articles/s41467-020-19066-4

Restoring degraded land and agroforestry: Shea

53. Shea (*karité* in French), or *Vitellaria paradoxa C.F. Gaertn,* is the most economically and culturally important tree species in the Sudano-Sahelian region where oil palm does not grow. Its natural range extends across 21 countries from eastern Senegal and Gambia to the high plateau of East Africa, forming an almost unbroken belt 6,000 km long and averaging 500 km wide. Naughton, Lovett and Mihelcic estimated that there were 1.84 billion trees on an area of 3.41 million km^2 (Boffa, 2015).

54. While the flesh of the shea fruit is widely consumed by local people and used for animal fodder, the kernel is the tree's most economically valuable product. It is used to produce edible oil or fat (shea butter) for local consumption (primary source of oil for more than 80 million rural people) and is commercially sold as an ingredient in cosmetic, pharmaceutical and edible products. Used in traditional medicine and ceremonies, the edible flowers from shea trees support honey and essential oil production and the nut husks are used for mulch and fuel (ITC and EIF, 2015).

55. The vast expanses of existing shea parklands are the result of self-sown propagation. That said, local agricultural communities play a key role in their management, primarily due to their role in the protection and selection of the trees in agroforestry parkland systems that combine shea with annual crops. Successive fallow and cultivation cycles are fundamental for their regeneration. Studies conducting in southern Burkina Faso found that the relative occurrence of shea trees in cultivated fields was five times greater than in uncultivated savannah. Also, the average number of fruits per tree, the proportion of fruiting trees in the population, fruit size and weight are all higher in agroforestry parklands than in neighbouring woodlands due to tree selection, soil management, tree density reduction (removal of other species), protection against fire and grazing control (Boffa, 2015).

56. Shea trees are well adapted to poor shallow soils and dry environments and have a life span of between 200 and 300 years. They start producing at about 15 years of age and reach full production by 45 years. A mature tree can bear on average 15-30 kg of fruit per year (3-6 kg of kernel) and up to 50 kg during very good harvest years (Boffa, 2015). Shea production is cyclical: two good harvests tend to be followed by one bad harvest. Collectors harvest only a fraction of nuts, which is then transformed into butter or sold as kernels. As obtaining shea butter from kernels is a labour-intensive process and requires a significant amount of wood for energy and water, only a small portion of the kernels are turned into butter locally. Processing capacity is still limited in most shea-producing countries.

57. Shea is an important source of income for women in the region. An estimated 16 million women – half of which are in West Africa – are involved in shea-related activities. Four million are involved in the export value chain with US$200 million generated as income every year in producing communities (FAO-GSA, 2020). Approximately 4 million women collectors collect shea fruits and sell both kernels and butter, and another 4 million gather very small amounts for their own consumption. Women earn revenues from shea during the lean season and unlike most agricultural cash crops, they traditionally retain control of them. By organizing in groups (cooperatives, SMSEs, associations), they can increase their profit by up to 50 per cent above farmgate prices (GSA, 2019).

58. The shea market has grown 600 per cent over last 20 years and is expected to increase another 50 percent in the next five years. The gross production value of shea in West Africa

is about US$284 million and a value added of US$203 million. West Africa exported at least 500,000 tons of shea between Aug 2019 and July 2020, beating the previous record from 2017-2018. The majority (90-95 percent) is exported as kernels (only 5-10 percent as butter) and Europe is the main destination, absorbing 80 percent. There, shea is mainly used in the food industry, often as a substitute for cocoa butter or palm oil in chocolate and flavour enhancer in other food products. This is not the case in US, where the use of shea is strictly limited to cosmetics. Ghana is said to be the leading exporter, accounting for 50 per cent of the total volume (tons). Burkina Faso accounts for 25 per cent of the region's shea exports, followed by Benin and Côte d'Ivoire. IFC (2020) recently stated that Mali accounted for 20 percent of the global shea supply.

59. Shea also has enormous potential for climate adaptation and mitigation in the target countries. At present, the shea value chain fixes 1.5 million tons of CO2 every year and every ton of shea kernel produced has a negative carbon footprint of 1.04 tons of CO2 (FAO-GSA, 2020). This positive environmental impact stems from its production system: shea trees grow naturally and are integrated with crops on smallholder farms, creating an agroforestry landscape that acts like a carbon sink. Agroforestry parklands conserve the natural resource base, improve soil fertility and enhance their resilience to the harsh and variable climate and allow farmers to diversify production. Such important resilience impacts will be strategic considering the Sahel's climate change hotspot status.

60. To harness shea's full potential, however, urgent action is needed to shield the shea trees and farmers from the impacts of climate change and deforestation. Shea tree populations have been under pressure from: (i) the extension of cultivation periods and decreasing use or abandonment of fallow periods, which are fundamental for the regeneration of shea populations; (ii) large-scale agricultural development projects for high intensity, mechanized food and biofuel crop production that remove shea trees from fields, (iii) uncontrolled tree cutting for firewood and charcoal production, and (iv) past droughts which have shifted the species distribution southward (Boffa, 2015).

61. Strengthening women-led SMSEs, cooperatives and FOs' organizational and technical capacities is key to improving their income, as it enables them to earn better prices and increases their access to financial services and capacity-building. Improved access to green credit lines is needed for women to invest in renewable energy technologies, as well as processing, storage and marketing capacity. RETs help free up women's time for productive activities and can be used to power processing and storage equipment. Greater awareness and knowledge on climate resilient, low-emission practices such as assisted natural regeneration and Zaï should be tied with access to credit to boost women's role in the sustainable management of forest and water sources.

62. To finance the development of climate resilient shea value chains, the five selected countries have worked with IFAD to design climate resilient investment projects which combine IFAD baseline investments, additional climate financing from the GCF and other co-financers. The proposed intervention is presented in table 20 along with the proposed model intervention in table 21.

Table 20: Proposed interventions and respective examples used in the region

Interventions	Description	Intervention objectives	Technical model examples using regional references
Restoring degraded lands and agroforestry	Increase agricultural productivity and minimize climate-related risks by fostering climate-resilient livelihoods and food sources for smallholders, especially women and youth, through agroforestry techniques and value-addition.	Resilient agroforestry practices ensure long-term productivity and reduce forest loss, enhanced ecosystem services mitigate climate change impacts and food production, and security is maintained or improved	• Assisted natural regeneration[1] • Management of soil fertility (e.g., zai, intercropping, cover cropping, mulching, contour farming and improved length and frequency of fallows in shea parkland)[2] • Integrated pest and disease management (safe use of chemical inputs as needed)[3] • Forest and agroforest management to support shea productivity and soil health [4] • Integration of shea in agroforestry systems for nutritional diversity and security, including heat- and drought-tolerant, disease-resistant shea varieties[5] • Economic incentives for shea tree protection such as aggregating the production of shea butter for export market involving storage and logistics and through the development and strengthening of women's cooperatives[6] • Improved business infrastructure to increase shea production[7] • Build efficient shea butter value chains to increase economic benefits (processing and packaging for local and regional markets, building storage facilities which meets

Interventions	Description	Intervention objectives	Technical model examples using regional references
			environmental norms as well as the packaging systems and transport etc.)[8] • Water management (water quality standards, use of drip irrigation etc.)[9]
Renewable energy for sustainable shea production and processing	Transform selected crop value chains products to Increase access to solar panels and low-carbon equipment for improved production and processing	Food security, resilience, value chains, transformation, sustainability and environmental quality	• Producing and processing shea value chains powered by RETs[10] • Establishment of irrigation and water infrastructure using solar pumps for off-season crops in the dry season[11] • Production and sale of solar energy to farmers[12] • Capacity building for solar and water use efficiency[13] • Constructing storage facilities in wholesale markets designed to minimize postharvest losses using renewable energy [14]

[1] Regenerating the shea butter tree – Livelihoods Funds
[2] Ghana Shea Landscape Emission Reductions Project | UNDP in Ghana
[3] WA_IPPM_case study_web_1.pdf (fao.org)
[4] West Africa Cashew Project (PRO-Cashew) | CNFA; Scientific background for soil monitoring on National Forests and Rangelands: workshop proceedings; April 29-30, 2008; Denver, CO (fs.fed.us)
[5]Evergreen Inception Report_25June.pdf (worldagroforestry.org)
[6] USAID AEG - Agroforesty Fact Sheet - FTF - Nov '16_FINAL.pdf; Pnadu686.pdf (usaid.gov)
[7] Lovett, Peter. (2004). The Shea Butter Value Chain: Production, Transformation & Marketing in West Africa.
[8] Global Shea Alliance; Lovett, Peter. (2004). The Shea Butter Value Chain: Production, Transformation & Marketing in West Africa.
[9]PA00TGBP.pdf (usaid.gov).
[10] Clean and Efficient Energy | West Africa Regional | U.S. Agency for International Development (usaid.gov)

[11] Andrieu et al., "Prioritizing Investments for Climate-Smart Agriculture.";
ESMP_SUMMARY_FOR_SOLAR_POWER_IRRIGATION_PROJECT_SUDAN.pdf (afdb.org)
[12] Solar Pumps On Credit: Reducing Production Costs for Horticulture Producers Senegal (icco-cooperation.org)
[13] SOLtrain West Africa - ECOWAS Solar Thermal Capacity Building and Demonstration Program | ECREEE
[14] Ademola, A. (2012). Assessment of Shea Butter Processing among Rural Dwellers in Atisbo Local Government Area of Oyo State, Nigeria. European Journal of Business and Social Sciences. 1. 1-8.

Table 21: Proposed Model intervention: climate resilient shea in agroforestry parklands in Burkina Faso, Côte d'Ivoire, Ghana, Mali and Senegal

Value chain structure, yields and prices	*Production/harvesting:* Women collectors collect an average of 340 kg per year, average sale price US$24/kg; est. average annual gross income per collector is US$75 (FAO-GSA, 2020). Revenues from organic shea are 3 to 4 times higher, but certification costs are high and lack of training on adherence to standards. Est. annual total of shea nuts collected (2004): BF 75,000t; CI 40,000t; GH 130,000t; ML 150,000t and SN 500t. *Primary selection and transformation:* Hundreds of women-led cooperatives, MSMEs and associations are involved in the shea value chain, but no data on % of women who are members, as much of collection and sales is done on an informal basis. In eight West African countries responsible for 99% of exports: over 6,000 intermediaries agents and collectors earning an average annual income of US$2,000, and 12 mid-size processing enterprises, which only process part of the production, with a gross annual income of around US$600,000 (FAO-GSA, 2020). *Distribution and export:* 43% of all shea is exported, mainly as kernels, and 57%, consumed locally. The global shea butter market is estimated to reach US$2.9 billion by 2025. The largest exporting countries of shea nuts are Mali (75,000 shea nut-equivalent tons – SET), Burkina Faso (70,000 SET) and Ghana (60,000 SET). Measures to raise collection rates (currently at 50%, at approx. 820,000t) and build value-adding capacity (shea processing) in the target countries would create major opportunities for economic growth in producer countries.
Technical services and best practices	Technical support and agricultural extension services on forest management, agroforestry and processing techniques are limited and thus, needed. This must go hand-in-hand with increased access to credit and training on how to develop and implement viable, bankable green business plans. Limited government extension services for smallholders; GSA offers training to members; projects executed by INGOs, NGOs, etc. offer capacity-building and technical assistance, but unable to meet all needs.

Financial services	Access to credit and financial services is a key to the development of the shea sector but remains very limited. Only 2% of all credit goes to agriculture in general, of which only a small portion goes to smallholders, and an even smaller percentage to women due to social and cultural constraints. In sub-Saharan Africa, female-owned businesses account for a disproportionate share of the SME finance gap: 33 per cent of the total SME finance gap (US$1.5 trillion). Loans available tend to be short-term and high interest, and thus unaffordable and not adapted to smallholders' needs.
Climate vulnerability and other risks	Although a resilient and highly adaptable plant, shea is not impervious to the impacts of climate change. A recent study concluded that the favourable habitats of shea trees will decline by 12% (RCP4.5) and 13% (RCP8.5) by 2070 due to climate change. Stakeholders also identified the following climate-related impacts: higher temperatures and changes in rainfall patterns causing the trees to shift southward, with impacts on the trees' growth, regeneration and production levels; higher risk of losing flowers and fruit due to heavy rainfall and winds; drought, flooding and wildfires increasing tree mortality, preventing communities from harvesting nuts and other logistical issues; decrease in water supply limiting the amount of processing done; droughts (projected to become more frequent and prolonged) leading to the abortion of fruit. The biggest threat to shea trees, however, is anthropogenic factors driving deforestation.
Key Barriers and Enablers	Key potential climate related barriers: - **Restoring degraded lands and agroforestry:** Decreased length and frequency of fallows in shea parkland; unsustainable harvesting of wood fuels and timber and other outdated production techniques exacerbating environmental degradation; low economic incentives for shea tree protection; Reduced economic benefits due to the inefficiencies in the shea butter value chain increasing overexploitation of forest resources continuing deforestation and environmental degradation; Little or no access to improved planting materials which increases environmental degradation; Land tenure insecurity, particularly for women; Incorrect or excessive use of inputs such as fertilizers, herbicides and pesticides to control weeds and pests, which is increasing soil and water degradation, water shortage during dry season and limited access to timely information and techniques to support decision-making to use more sustainable production and processing practices. - **Renewable energy for sustainable cashew production and processing:** siting and transmission barriers decreasing sustainable energy generation and consumption; Insufficient energy availability could exacerbate inefficient soil and water management practices; Potential lack of use of renewable energy if electricity services have high capital costs in the long term, which could increase environmental degradation.

	Other key barriers include: Historical limited access to finance and credit, particularly women, which is especially needed to improve processing and marketing capacity; lack of capacity to prepare and execute bankable green business plans and limited knowledge of best climate resilient forest management techniques; limited extension services; need to raise awareness on importance of protecting shea trees and agroforestry parklands; land rights and cultural norms that restrict women's access to financial services and land and leave them little time for productive activities outside the home; lack of access to electricity and RETs for processing, and high certification costs.
Current extents and potential program adoption	Of the 5 target countries, BF, GH and ML lead production and exports. Target of household adoption rate of 40% for the implementation of climate resilient, low-emission agriculture techniques and practices.
Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices such as assisted natural regeneration and Zai to improve soil fertility and water retention in soil, restoring degraded lands and agroforestry as well as renewable energy for sustainable shea production and processing.
Mitigation activities and impacts	The programme will take advantage of shea's enormous potential to fix CO2 and thus mitigate climate change in the five target countries. It is expected that CO2 emissions (-19 352 424 tCO2 eq) will be reduced during the programme's lifecycle thanks to agroforestry and SLM practices on 100,000 ha of land, although only a portion of this will be generated by the shea value chain. Integrating shea into agroforestry systems significantly improves climate resiliency by contributing to climate change mitigation through carbon sequestration, improved soil quality, temperature control, soil moisture regulation, and reduced erosion. Importantly, the value of shea tree products also serves as a direct incentive to communities to reduce deforestation or even expand forest area, thus preventing and mitigating the effects of climate change. Trees also serve as a fire break to help minimize the risk of losing entire shea plantations to bushfire. The adoption of RET by shea gathering communities will also contribute to the reduction of GHG emissions due to fossil fuel and wood use.
Adaptation activities and impacts	Shea production has a positive impact on adaptive capacity: by enhancing the economic value of shea trees especially for women collectors through development and strengthening of women's cooperatives, it encourages the retention of trees in the landscape which will continue to provide buffering ecosystem services, promoting water and soil retention and guarding against desertification. Similarly, shea trees diversify smallholder's nutritional options when the shea harvest is insufficient. A healthy shea nut industry therefore promotes landscape-scale adaptation to climate change through practices such as intercropping, cover cropping, mulching, and contour farming help retain soil and water resources.

	Assisted natural regeneration, incentivized planting campaigns, and raising awareness of the benefits and importance of forest resources can help ensure fodder, fuelwood, and other tree resources are planted at replacement rates. Supporting farmer groups, bolstering product value chains, and negotiating trade agreements help ensure sustainable livelihoods and reliable markets for smallholders.
Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

Annex II – Market Assessment and Business Model for Energy Value Chain

I - Renewable Energy Markets Outline in the 5 Countries

Senegal

In 2019, 52.2 % of the population in rural Senegal did not have access to electricity yet the country largely depends on its rural population to generate livelihood. Government of Senegal goal is to achieve 90% electrification rate in the rural areas by 2025 with a commitment to universal access by 2030. To achieve this, the country has developed and adopted a Renewable Energy and Energy Efficiency Action Plan and has promulgated a set of policy and regulatory texts to assist efforts on rural electrification. With regards to mini-grids and small-scale rural electrification operations, Government of Senegal policy framework is translated into the following two major undertakings:

> (i) The PPER (Programme Prioritaire de l´Electrification Rurale – Priority Programme for Rural Electrification) which divided Senegal in 11 electrical territories, 1 belonging to the main utility Senelec and 10 belonging to private sector operators who have the right to install power generation, transmission and distribution assets on their awarded territories.
> (ii) The ERIL framework (Electrification Rurale d´initiative Locale – Rural Electrification by Local Initiatives) which recognizes the gaps of the 11 concessions awarded by PPER in small communities and provides legal ground for local mini-grid development and Solar Home Systems distributions to supplement grid extension efforts by operators in areas that would not be economically viable through PPER interventions.

Local SMES and community cooperatives are permitted to become ERILs in Senegal and thus to establish small scale mini-grid operations. The licensing process is under the administrative authority of ASER, the Senegalese Rural Electrification Agency, and the requirements are the signature of an agreement with ASER upon submission of a business plan and a technical offer.
The ERIL framework provides for both standalone solar and mini-grid interventions though the majority of mini-grids to date are government-owned or predominately funded by international organizations and donors. For instance, in partnership with PERACOD and INENSUS West Africa[176], ASER implemented a rural electrification pilot project in Sine Moussa Abdou financed by the German Federal Ministry of Economics and Technology and organized by the German development agency GIZ. The government is granting Senegalese companies' concessions under the terms of which they make a commitment to supply a given territory with electricity for a period of 15 years. In return, the concessionaires are permitted to levy a charge determined by the Senegalese regulatory authority[177].

Despite these policy and regulatory efforts, a few barriers are still impeding the uptake of mini grids in rural Senegal. Those are (I) long processing time for obtaining a license as an operator, which induces some risks on sites that have been claimed by the private sector in the event of grid arrival; (ii) lack of government tariff subsidy that would lead to a uniform electricity pricing. These barriers are limiting private companies' appetite for owning and operating mini grids in Senegal. By working with the Agricultural Bank of Senegal and providing concessional finance to small farmer cooperatives in Senegal for owning mini-grids, IGREENFIN will reduce the needs for tariff subsidies by small holder farmers and enable the adoption of Renewable Energy Technologies alongside agricultural value chains. Energy demands for agricultural processing and transformation within

[176] Rural_Electrification_wind_Solar_Senegal_INENSUS-PERACOD_Project_Factsheet.pdf (energypedia.info)
[177] Complete issue.pdf (giz.de)

IGREENFIN scope of work in Senegal have been estimated at 3580 MWh annually. These demands are to support the following activities:

- Storage of vaccines to address growing livestock diseases due to climate change
- Powering drip irrigation to address declines in agricultural yields
- Powering processing techniques to reduce post-harvest losses

The energy demands will be fully covered by solar + storage solutions. In the absence of the GCF proceeds for renewable energy technologies these energy demands would be covered using diesel generators which would have led to an estimated 110,367 tCO2 eq emissions in Senegal over the project´s lifetime.

Burkina Faso

The power sector in Burkina Faso is characterized by a low electrification rate (18.4% in 2019 according to World Bank) and a heavy reliance on expensive thermal generation (90% of total power generation capacity). Rural areas of Burkina Faso are far way underserved with electricity, with an access rate of only 4.7%[178]. The Government of Burkina Faso has set as targets by 2027 to achieve: (i) 80% national electricity coverage; (ii) national electrification of 60%; (iii) 90% national urban electrification; and (iv) rural national electrification of 30%. The Government has also set itself the goal of increasing and diversifying the supply of electricity through the massive development of renewable energies (solar in particular) in order to increase its share to 50% in total electricity production. By 2027, the country is committed to devoting a great deal of effort and resources to making electric power "available and accessible to all" by correcting the current disparities between urban and rural areas[179]. This has created an opportunity for green mini-grid technologies in Burkina Faso, given the quick pace at which these technologies can be deployed compared to alternative electrification solutions.

In order to promote a fair coverage of the national territory in electricity, the government of Burkina Faso has put in place the Burkinabe Rural Electrification Agency (ABER) whose main mission is rural electrification, support the implementation of rural electrification pilot projects and facilitate rural people's access to electricity. Since 2017, ABER has been using a local cooperative (COOPEL) model as a mechanism to promote electrification in rural areas where the National Electricity Company of Burkina (SONABEL), due to technical and financial constraints, was not able to serve. Currently, there are more than 90 COOPELs with an authorization or concession to manage a local distribution network, which are mainly connected to the grid and purchase power in bulk from SONABEL, but several have generation capacity[180]. One third are estimated to include PV systems. These mini-grids average 300 customers but may supply anywhere from 50 to a few thousand customers. COOPELs are generally managed by a small team of people, often volunteers, which execute simpler tasks such as administration, invoicing and bill collection. There is a national coordinator, the National Union of Electricity Co-operatives in Burkina Faso (UNCOOPEL), which lobbies for financing of the COOPELs and conducts trainings and support visits.

Under concession agreements, independent power producers such as EDENE, GG-Y and BERCODE can carry out studies, manage energy supply systems and support COOPELs as well as municipalities

[178] Access to electricity, rural (% of rural population) - Mali, Burkina Faso, Cote d'Ivoire, Ghana | Data (worldbank.org)
[179] Burkina Faso | Africa Energy Portal (africa-energy-portal.org)
[180] GMG%20Burkina%20Faso%20report%20-%20final.pdf (afdb.org)

and users in the implementation of their projects. Medium- to long-term infrastructure projects, including private-sector projects, are often financed by development partners rather than commercial banks in the country. Multilateral lending institutions such as the World Bank (WB), the African Development Bank (AfDB) and the International Finance Corporation (IFC) have shown interest in providing funding for agribusiness, small business and infrastructure projects among other areas of support.

Despite these institutional efforts, a few barriers are still impeding the uptake of mini grids in rural Burkina Faso. Those are: (i) limited technical capabilities to COOPELs, which increase reliance on external technical providers (so called fermiers in French) to manage the distribution network[181]; (ii) financial constraints impacting the capacity of COOPELs to pay fermiers and reimburse the concessional loans provided by the Electrification Development Fund (FDE), which coordinates electrification programmes and provides funding to rural electrification promoters in the form of grants and loans. These barriers are limiting private companies' appetite for owning and operating mini grids in Burkina Faso. By working with the Agricultural Bank of Burkina Faso and providing concessional finance to small farmer cooperatives for owning mini-grids, IGREENFIN will reduce financing barriers for COOPELS while enabling the adoption of Renewable Energy Technologies alongside agricultural value chains. Energy demands for agricultural processing and transformation within IGREENFIN scope of work in Burkina Faso have been estimated at 3580 MWh annually. These demands are for the following activities:

- Storage of vaccines to address growing livestock diseases due to climate change
- Powering drip irrigation to address declines in agricultural yields
- Powering processing techniques to reduce post-harvest losses

The energy demands will be fully covered by solar + storage solutions. In the absence of the GCF proceeds for renewable energy technologies these energy demands would be covered using diesel generators which would have led to an estimated 110,367 tCO2 eq emissions in Burkina Faso over the project´s lifetime.

Mali

Mali has limited domestic energy supply to address its growing demands. Electricity demands alone increased by 7.8% per year from 2005 to 2015[182] while climate variability is heavily affecting the energy supply which depends at 45% on hydroelectricity. Energy access is an additional challenge, with 48% of population in 2019 having access to electricity and only 15.3% in rural areas[183]. The government of Mali is aiming for 70% access rate to electricity by 2036. To date, approximately 10% of rural energy services are provided using Renewable Energy Systems, including mainly small-scale applications such as Solar Home Systems (SHS)[184].

The actors in the energy sector in Mali are both public and private. AER-Mali, the agency for renewable energy is one of the actors which has executed programmes funded by GEF – UNDP to promote a community-based model on mini-grids. Public efforts are also carried by the Agency for

[181] The role of the tasks assumed by the fermiers varies from one COOPEL to another, but may include extending the network, connecting customers, billing, collection, etc. The relationship between fermiers and COOPELs varies drastically from one case to another and may be regulated by contract or not.

[182] Access to electricity, rural (% of rural population) - Mali, Burkina Faso, Cote d'Ivoire, Ghana | Data (worldbank.org); gmg_mali_final.pdf (afdb.org)

[183] Mainly through the deployment of diesel-backed mini-grids operated by private local players (Climatescope, 2018).

[184] gmg_mali_final.pdf (afdb.org)

Domestic Energy and Rural Electrification (AMADER). AMADER which currently also serves as the energy regulatory authority outside of urban centers[185], has provided financial and technical support to communities and private companies for mini-grid projects since 2005. Both AER-Mali and AMADER are involved in developing rural electrification projects, an overlap which creates sometimes confusion with regards to the development of donor-funded mini-grids in the country. The private sector has also been active, investing and operating mini-grids in rural areas under the regulatory supervision of AMADER. Under this regulatory supervision, rural electrification concessions are granted to private operators. Local communities, farmers associations or SMEs can also apply for grants to supply isolated communities using mini-grids.

To date, much of the rural electrification has been achieved by donor-funded programmes through AMADER, which has implemented mainly diesel powered mini-grids in rural environments (96% of the total off-grid electricity generation corresponding to 100 mini-grid projects). Government of Mali however intends to decarbonize its electricity sector with the support of its partners. As part of this journey, a 2014 GEF-UNDP pilot programme executed by AER-Mali established a framework for community based mini-grid operations in Mali with the use of multi-functional platforms. The programme paved the way for scaling-up renewable energy based mini-grids in Mali with a community ownership model and electrified 8 localities using solar hybrid mini-grids and multi-functional platforms for productive use.

IGREENFIN will work with the National Agricultural Bank of Mali to provide concessional finance to small farmer cooperatives for owning mini-grids which will enable the adoption of Renewable Energy Technologies alongside agricultural value chains. Energy demands for agricultural processing and transformation within IGREENFIN scope of work in Mali have been estimated at 3580 MWh annually. These demands are for the following activities:

- Storage of vaccines to address growing livestock diseases due to climate change
- Powering drip irrigation to address declines in agricultural yields
- Powering processing techniques to reduce post-harvest losses

The energy demands will be fully covered by solar + storage solutions. In the absence of the GCF proceeds for renewable energy technologies these energy demands would be covered using diesel generators which would have led to an estimated 110,367 tCO2 eq emissions in Mali over the project´s lifetime.

Cote d'Ivoire

Although the national electricity access rate in Côte d'Ivoire is one of the highest in sub-Saharan Africa, access greatly differs between urban and rural populations: 93.9 percent for urban and only 41.9% for rural in 2019[186]. Rural penetration of the national grid and access to electricity are key issues for the country's electricity sector. While the official target is 100 percent electrification by 2025, so far, actual electrification rates have lagged[187].
The main provider of electricity is the state-owned energy company, Côte d'Ivoire Energies (CIE). To expand its business in rural areas, CIE created the Rural Electrification Master Plan (Plan Directeur d'Electrification Rurale - PDER) which investment needs are estimated at 575 billion FCFA (EUR

[185] e.g., verifying proposed tariffs for mini-grids, issuing permits for mini-grids, supplying electricity to rural areas through public-private partnerships (PPPs) etc.
[186] Access to electricity, rural (% of rural population) - Mali, Burkina Faso, Cote d'Ivoire, Ghana | Data (worldbank.org)
[187] PAOP Cote d'Ivoire Market Assessment (usaid.gov)

862.5 million) from 2015 through 2030. In addition to CIE masterplan, the National Program for Rural Electrification Program (Programme National d'Electrification Rurale -PRONER), managed directly by the Government of Cote d´Ivoire aims at expanding access to electricity to rural areas. As an outcome of PRONER, approximately 4,600 out of 8,000 villagers gained access to electricity at the end of 2017.

To date, Ministry of Energy in Cote d´Ivoire has identified about 79,000 sites that are eligible to off-grid rural electrification. The current regulatory framework however for the provision of mini-grids by the private sector in Cote d´Ivoire is administratively heavy. Mini-grids can be deployed for self-consumption by anyone, and capacities under 13 kW are exempt of authorization requirements. However, the sale of electricity to third parties requires Government licensing. Currently, the only private mini-grids operating in Côte d'Ivoire are from development projects supported by donor agencies (i.e., the Akwaba project in the Zanzan district), which resulted in solar mini-grids for seven remote villages and also included back-up diesel generators to resolve the storage requirements for 24-hour connectivity. IFAD conducted consultations with Ministry of Energy in Cote d´Ivoire for the implementation of IGREENFIN. Ministry has shown great interest in the programme and committed to support it given the contribution which IGREENFIN will bring to the Renewable Energy National Plan and the positive impacts for rural populations in Cote d´Ivoire.

The licensing process, access to adequate finance and low levels of consumer awareness of solar solutions have been the main barriers impeding the ability of solar companies to grow in Cote d´Ivoire. By working with the National Investment Bank of Côte d'Ivoire and providing concessional finance to eligible operators under a PPP framework as would be agreed with Ministry of Energy, IGREENFIN will enable the adoption of Renewable Energy Technologies alongside agricultural value chains in rural areas.

Energy demands for agricultural processing and transformation within IGREENFIN scope of work in Cote d'Ivoire have been estimated at 2680 MWh annually. These demands are for the following activities:

- Storage of vaccines to address growing livestock diseases due to climate change
- Powering drip irrigation to address declines in agricultural yields
- Powering processing techniques to reduce post-harvest losses

The energy demands will be fully covered by solar + storage solutions. In the absence of the GCF proceeds for renewable energy technologies these energy demands would be covered using diesel generators, which would have resulted in 82,790 tCO2eq emissions in Cote d´Ivoire over the lifetime of the programme.

Ghana

In 2019, 84 % of the population in Ghana had access to electricity. This figure falls to 70 % of the population in rural areas[188]. To tackle the electrification challenge, Government of Ghana has set two major plans, The Renewable Energy Master Plan (REMP) and the National Electrification Master Plan (NEMP).

The REMP of Ghana has a rural off-grid electrification component. The REMP largely relies on government entities to deploy, own, and operate energy systems. In the REMP, Government financed

[188] Access to electricity, rural (% of rural population) - Mali, Burkina Faso, Cote d'Ivoire, Ghana | Data (worldbank.org)

mini-grids are under the responsibility of the Volta River Authority, Power Distribution Service Ghana Ltd, and the Northern Electricity Distribution Company.

Under the NEMP however, communities may work through local leadership by applying to the Self-Help Electrification Programme (SHEP) to receive government support via the district assembly in realizing grid access. Communities applying for the SHEP must procure and erect all of the required distribution poles themselves and demonstrate that at least one-third of households are wired and prepared to be connected. In addition, two industry associations are relevant to off-grid solar: (i) the Association of Ghana Solar Industries (AGSI), which focuses exclusively on solar, and (ii) the Renewable Energy Association of Ghana, which covers a range of renewable technologies.

As of date, nearly all mini-grids built are donor-funded and government-owned such as the African Development Bank's (AfDB) Ghana Scaling up Renewable Energy Program.[189] Given Ghana's high electrification rate (84%) and national policies that prioritize government-led development, private-sector mini-grid development has been limited. Yet the regulation enables the Energy Commission in Ghana to provide licenses for power generation, transmission and distribution. To date, the country's only private operator of multiple mini-grids is Black Star Energy, which operates 17 mini-grids serving approximately 6,000 customers in the Ashanti and Brong-Ahafo Regions. Black Star Energy has been successful in raising impact equity investments, crowdfunding debt, and grants, such as the EDF Pulse Africa award[190]. Although Black Star Energy has been successful in operating its mini-grids, from an official standpoint, the company is only an installer, and its retail operations have merely been tolerated by the government.

In terms of financing the mini grid sector, Ghana's commercial banking sector does not actively lend to off-grid energy companies[191] and the banks involved in the country's renewable energy sector have high interest rates loans with short tenors. Ghana has 144 licensed rural banks, several of which offer consumer credit for products but not specifically to off-grid systems[192]. Several donors have developed local credit facilities that are, in theory, applicable to off-grid energy companies. These facilities include a US$ 10 million clean energy guarantee facility through the USAID Development Credit Authority (DCA) and Ecobank and the previously mentioned Rural Development Fund[193].

These facilities, however, are not explicitly designed for off-grid energy companies and have not been accessed by the off-grid sector. In fact, a DCA guarantee has never been used for a loan transaction in Ghana's energy sector. Investments in the off-grid sector are from international sources, predominately donor and impact funds (e.g.: PEG and ZOLA Electric, which are the main international SHS companies). Many local SHS distributors, such as Wilkins Engineering Ltd. or NorthLite Solar Ltd., are traditional suppliers of renewable energy equipment and are not set up to offer consumer credit. Furthermore, the energy companies that have considered entering the market in Ghana had often pursue lower risk opportunities such as captive power. The lack of local financing options has led to the emergence of crowd-funding as an important fundraising source for off-grid companies.

[189] The program's objectives are to install 55 mini-grids, as well as stand-alone solar systems for 33,000 households, 1,350 schools, 500 health centers, and 400 communities.
[190] Poindexter, "Black Star Energy."; JoyBusiness, "Black Star Energy Motivated to Produce Cheaper Sustainable Power - CEO."
[191] The banks involved in the country's renewable energy sector generally are Stanbic Bank, Ecobank Ghana, Fidelity Bank, and CalBank.
[192] Bank of Ghana, "List of Rural Banks."
[193] The Rural Development Fund managed by the Danish International Development Agency (DANIDA), which provides US$ 20 million to SMEs involved with the following: (i) agriculture and manufacturing, and (ii) energy (including SHS companies) on an 80/20 allocation, respectively. The scheme channels these funds through on-lending agreements with local banks to reduce collateral requirements for small borrowers. Lending rates are indexed to the Ghana Treasury Bill yield, allowing a maximum 10 percent margin.

The main barriers impeding the uptake of mini grids in Ghana are financial and regulatory. Financial barriers include unavailability of concessional finance in the market that matches the investment cycle for mini-grids. Regulatory barriers are mainly the lack of a licensing framework regarding private mini grid development. Yet Government of Ghana recognizes that an estimated 3 million out of the 5.8 unelectrified people in Ghana reside in remote Islands or are lakeside communities that are difficult to reach with main grid extension. IGREENFIN will work with the ARB Apex Bank Limited of Ghana to provide concessional finance to both private sector and small farmer cooperatives for owning solar mini-grids that will support agricultural value chains. A dedicated framework to underserved and far to reach areas will be set in partnership with Government of Ghana to provide solar energy for the following activities:

- Storage of vaccines to address growing livestock diseases due to climate change
- Powering drip irrigation to address declines in agricultural yields
- Powering processing techniques to reduce post-harvest losses

Energy demands for agricultural processing and transformation within IGREENFIN scope of work in Ghana have been estimated at 2680 MWh annually. These demands will be fully covered by solar + storage solutions. In the absence of the GCF proceeds for renewable energy technologies these energy demands would be covered using diesel generators, which would have resulted in 82,790 tCO2eq emissions in Ghana over the lifetime of the programme.

II- Business Model for Renewable Energy activities within IGREENFIN

1. Ownership of energy assets

Overall, the IGREENFIN programme will finance the installation of 14.4 MWp of solar + storage mini-grids across the 5 target countries with an average capacity of 8 kWp per system, leading to a total of 1800 mini-grids which will avoid diesel in agricultural value chains, enabling about 500,000 tCO2eq emissions reduction. Mini-grid assets will be own by the borrower who shall be either a cooperative or a private sector operator depending on the specific regulatory framework and arrangement in the country. The following table summarizes mini-grids assets ownership across the 5 target countries.

	Lender	Asset Owner	Regulatory Arrangement
Burkina Faso	Agricultural Bank of Burkina Faso	• COOPEL • Private Sector • Operator of Mini Grids	• COOPEL license from ARSE • Concession Agreement from ARSE
Mali	National Agricultural Bank of Mali	• Community Based Organization • Private sector Operator	• PPP with AER-Mali • License from AMADER
Senegal	Agricultural Bank of Senegal	Cooperatives of farmers in the area of undertaking	ERIL Framework

	Lender	Asset Owner	Regulatory Arrangement
Cote d´Ivoire	National Investment Bank of Côte d'Ivoire	Private sector	Tender of licensing by Ministry of Energy for serving agricultural areas with solar mini grids
		Single farmer	Small holder farmer not selling electricity to any third party and owning for own use.
Ghana	ARB Apex Bank Limited	PAYGO Operator with transfer to famers associations	System financed and installed by a PAYGO operator and transferred to farmers associations based on payments on installments. System is maintained by Operator during the initial phase.
		Single farmer	Small holder farmer not selling electricity to any third party and owning for own use.

2. Flow of funds and financial instruments

Proceeds from the GCF will be blended with IFAD proceeds and availed to National Agricultural Banks which will pass them downstream to future assets owners in forms of highly concessional loans. Asset's owners will have to justify bringing their own equity contribution for the solar equipment's. Other eligibility criteria for the loans include:

- System owner provides own equity contribution in the tune of 20% of system value
- System owner falls within the regulatory eligibility criteria in the country (has a license where required or is legally cleared by the relevant country authorities)
- Electrical assets are purchased to strictly support agricultural value chains as per IGREENFIN design

When the borrower is a farmer´s association or a single small holder farmer, repayments will be done as the borrower sells agricultural products.

When the borrower is a private sector operator of mini-grids, revenue is collected from end users with whom the operator will have long term energy supply agreements and repayment is done with collected proceeds. Exchange risks are handled by National Agricultural Banks which are the Delivery Partner of Executing Entity.

3. Energy Value Chain summary

Renewable energy sector	*Despite progress achieved in the past decade in increasing the electrification rates in the 5 target countries of IGREENFIN, rural areas are still widely underserved with electricity. In Senegal, 52.2% of the rural population in 2019 did not have access to electricity. On Burkina Faso, only 4.7% of the rural population had access to electricity the same year, while rural access electricity access rate stood at 70%, 41.5% and 15.3% in Ghana, Cote d´Ivoire and Mali respectively. Lack of electricity in the areas of agricultural undertaking could undermine efforts for improving agricultural yields including the efforts to minimize post-harvest losses as primarily envisaged by the IGREENFIN programme. Regulatory frameworks for off-grid electrification are not homogenous across the 5 countries. While some countries such as Burkina Faso and Mali have achieved important advancement in liberalizing their off-grid energy sector and thus attracting investments, regulatory frameworks for private sector investments in mini-grids are still heavy in Cote d´Ivoire for instance. Yet, whether for storage of vaccines to address growing livestock diseases amid climate change, or energizing drip irrigation to improve agricultural yields which are continuously being affected by climate change, or simply processing farmers agricultural products to reduce post-harvest losses, electricity will be required to support agricultural value chains in the IGREENFIN programme. Traditionally, cold storage, irrigation, and processing in rural off-grid areas of Africa are powered by fossil fuel with the use of Diesel generators. This Business-as-Usual approach is carbon intensive and does not align with the climate ambition of the beneficiary countries. IGREENFIN will finance in total the installation of 14.4 MWp of solar capacity which will be spread across 1800 mini-grid systems to support agricultural value chains in the 5 countries, resulting in 500,000 tCO2eq emission reduction over the project´s lifetime. The market assessment on Energy Value chain has identified specific business models in each country, given current regulatory advances, which will be used to support the uptake of these mini-grids.*
Technical support and best practices	*Small scale mini grids with capacity below 10 kWp are not highly attractive commercial undertakings especially when deployed in rural areas where end users' ability to pay is low. Recent years' experience by mini grid developers across Africa has demonstrated that the sale of electricity alone does not suffice to enable mini grids provide attractive returns on investments and thus productive use is an important component which can guarantee long term viability of mini grid operations. Building on these best practices, IGREENFIN will finance mini grids and enable energy access by smallholders' farmers, not energy access for just the sake of energy access, but energy access for the sake of improving climate adaptive capabilities of end beneficiaries and supporting productive use across agricultural value chains. By creating in partnership with Government a framework for such electrification as it will be the case in Cote d´Ivoire, IGREENFIN will be achieving Technical Assistance outcomes that pave the way for market transformation.*

Financial services	Access to concessional finance that mirrors the business cycle of mini-grids is a major barrier that has been impeding the off-take of solar projects in the rural areas of the 5 target countries. Lenders are still perceiving mini-grid operations as highly risky given the low ability to pay of end users. In more open markets such as Mali or Burkina Faso where mini grids are well known, lending terms by financial institutions are unfortunately still prohibitive to projects. IGREENFIN will bridge these market gaps by availing credit at concessional terms to mini-grid projects that support the identified agricultural value chains.
Climate vulnerability and other risks	Energy infrastructure that will be financed by IGREENFIN will primarily achieve climate mitigation outcomes. Climate vulnerabilities and risks in the business-as-usual scenario are heavy dependence on fossil fuel to support agriculture. These mitigation outcomes will be achieved by end users (small holders' farmers) whom livelihood generation is already reducing year to year due to climate change. Renewable Energy technologies will help strengthen smallholders' resilience to climate change by supporting the following activities: • Storage of vaccines to address growing livestock diseases due to climate change • Powering drip irrigation to address declines in agricultural yields • Powering processing techniques to reduce post-harvest losses
Key Barriers and Enablers	Key barriers include: i. Limited access to affordable loans and financial services to support Renewable Energy Technologies in rural areas. These include lack of concessional terms on pricing and lack of lenders appetite to provide credit for operations where off-takers ability to pay is low. ii. Business-as-usual practice where rural population turns first to fossil fuels and wood for energy sources. Renewable Energy Technologies are more capital intensive than diesel generators, which has led populations that do not easily have access to credit to naturally go for the most affordable solution. iii. Timelines for the licensing process for mini grids Key enablers include: i. Conducive regulatory frameworks for the case of Mali and Burkina Faso ii. Abundant solar resources across the 5 countries iii. Tax incentives for the import of solar products across the 5 countries iv. The on-ground experience of all 5 agricultural banks which will act on behalf of the Executing Entity to finance acquisition of solar installations.
Current extents and potential program adoption	The programme will finance the installation of 14.4 MWp solar capacity spread across 1800 mini-grids of average capacity of 8 kWp each. Target of programme adoption is across the 3 main adaptive outcomes which Renewable Energy. Technologies will support: • 20% of installed mini-grids support cold storage for livestock vaccines • 60% of installed min grids support drip irrigation activities • 20% of installed mini-grids support processing of agricultural products to reduce post-harvest losses.

Proposed intervention	Increase green financing (min. US$1,000) available to MSMEs, cooperatives, FOs and women and youth-led organizations for the implementation of viable innovative green businesses that use climate-resilient, low emission agricultural techniques and practices such as efficient irrigation techniques and solar-powered pumps and adoption of RETs to power processing facilities.
Mitigation activities and impacts	The use of solar energy instead of fossil fuels to power irrigation pumps and other equipment will also help reduce GHG emissions. Overall, the programme will avoid diesel in agricultural value chains, enabling about 500,000 tCO2eq emissions reduction over the lifetime.
Adaptation activities and impacts	*Access to solar energy for powering drip irrigation equipment will ensure better use of water resources, which could become scarcer in some parts of the region. In the end solar powered irrigation will improve farmers' productivity while insuring more stable water supply for crops and livestock. Given current state of rainfall variability, solar powered irrigation will also help increase small holder farmers' incomes, especially in off-season.* *Access to RETs to power processing will help reduce post-harvest losses, creating better value and improving the overall food security situation for farmers which climate variability is exposing to unpredictable seasons.* *Access to RETs for cold storage of vaccines will support survival of livestock given the devastating effects of climate change on livestock.*
Number and size of beneficiaries	IGREENFIN – Phase 1 aims to benefit 378,600 smallholder farmers organized around FOs, cooperatives, women and youth-led organizations and MSMEs directly, and over 2,494,000 people indirectly, of which 50 per cent will be women, 50 per cent youth. Other beneficiaries include: 1,500 MSMEs and 2,500 FOs, cooperatives or women- or youth-led organizations. It is important to note that this number is for all value chains.

ANNEX III: Preliminary inventory of relevant portals and tools

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
Online Tool	Conservation International	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Landscape monitoring	Projects, Stressors and shocks, Assets and capacities, SDG indicators, Market access, Food security, Water Consumption and Deficit	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder	Regional, Country, Local	Resilience Atlas	https://foodsecurityiap.resilienceatlas.org/
Portal	IFAD and GEF	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Project tracker and reporter	Themes, Documents, Projects	Technical specialist, Scientific advisor, Stakeholder, Food Security Experts	Regional	Resilient Food Systems	https://www.resilientfoodsystems.co/kc/resource_library
Portal	OSS	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Landscape monitoring	Land cover change, Country Profiles, Atlas of Land Cover Change	Technical specialist, Scientific advisor, Stakeholder, Food Security Experts	Regional	OSS Tools	http://www.oss-online.org/en/tools
Portal	OSS	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Landscape monitoring	Land cover change, Country Profiles, Atlas of Land Cover Change	Technical specialist, Scientific advisor, Stakeholder, Food Security Experts	Regional	OSS BRICKS	http://prod.oss-intra.org/bricks_se/login; http://delta-suivi-evaluation.com/sawap/#/login

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
Library	IFAD	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Photo Library, Monitoring and Verification	Photo repository, Monitoring and Verification	Technical specialist, Scientific advisor, Stakeholder	Regional	Photo repository	https://www.flickr.com/groups/14745171@N22/
Portal	WFP	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Landscape monitoring	Agriculture - productivity, Climate, Crops - distribution, Farming systems, Forestry, Landscape Monitoring, Asset Evaluation, GIS, Remote sensing, WebGIS Platform	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Asset Manager, Project Manager, Food Security Experts	Regional	AIMS	https://aims-unwfp.hub.arcgis.com/
Portal	CILSS	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Landscape monitoring	Agriculture - productivity, Climate, Landscape Monitoring	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder	Regional	CILSS portal	http://www.cilss.int/index.php/2017/03/08/atlas-sur-les-paysages-de-lafrique-de-louest/
M&E Approach	ESA	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Landscape monitoring	Essential Climate Variables, Climate Services Agriculture, Ecosystems, Infrastructure, Climate Change	Technical specialist, Scientific advisor, Stakeholder	Global, Regional, Country	Earth Observation for Sustainable Development	http://eo4sd-climate.gmv.com/#:~:text=Earth%20Observation%20for%20Sustainable%20Development%20(

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
				Risk, Extreme Events Monitoring, Agriculture, Atmosphere, Climate, Cultural Heritage, Education, Forestry, Marine, Public Health, Security			Consortium	EO4SD)%20is%20a%20new%20ESA,at%20national%20and%20international%20level.
Desktop Tool	FAO	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	GHG Emissions assessment	Climate, GHG Emission assessment, Mitigation, Adaptation, Agriculture Inputs, Energy, Management of Organic Soils, Aquaculture	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Country Focal Points, Country Reporting	Local	Ex-Ante Carbon Balance Tool	http://www.fao.org/in-action/epic/ex-act-tool/overview/en/
Desktop Tool	FAO	National, Sub-national/Province/District	Survey Design for Assessment of the resilience of farmer and pastoralist households to climate change.	Assessment of the resilience of farmer and pastoralist households to climate change.	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Country Focal Points, Country Reporting	Local, Country	Self-Evaluation and Holistic Assessment of climate Resilience of Farmers and	http://www.fao.org/in-action/sharp/sharp-application/en/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
							Pastoralists	
Desktop Tool	FAO	National, Sub-national/Province/District	Access to adequate food	Access to adequate food assessment	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Country Focal Points, Country Reporting	Local, Country	Food Insecurity Experience Scale (FIES)	http://www.fao.org/in-action/voices-of-the-hungry/fies/en/
Database	ICRAF, World Agroforestry Centre	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Landscape-level assessment of soil and ecosystem health	Systematic landscape-level assessment of soil and ecosystem health	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Country Focal Points, Country Reporting	Local, Country	Land Degradation Surveillance Framework	http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/
Desktop Tool	IFAD	National, Sub-national/Province/District	Local-level rural poverty assessment	Local-level rural poverty assessment	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Country Focal Points, Country Reporting	Country	Multidimensional Poverty Assessment Tool	https://www.ifad.org/en/web/knowledge/publication/asset/39631564#:~:text=The%20Multidimensional%20Poverty%20Assessment%20To

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
								ol%20(MPAT)%20is%20the%20result%20of,local%2Dlevel%20rural%20poverty%20assessment.
Desktop Tool	IFPRI	Regional, National	Aggregate index, reported at the country or regional level	Aggregate index, reported at the country or regional level	Technical specialist, Scientific advisor, Stakeholder, Country Focal Points, Country Reporting	Country	Women's Empowerment in Agriculture Index	https://weai.ifpri.info/versions/weai/
Online Tool	Biodiversity International and CIAT (IFAD)	National, Sub-national/Province/District	Assess and map crop varieties, livestock breeds, and aquatic farmed-types and their functional traits, where to get the crop seeds, animal breeds, and aquatic farmed types: from local communities to public and private companies	Map Crop seeds, animal breeds, and aquatic farmed types: from local communities to public and private companies	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Country Focal Points, Country Reporting	Country	Diversity Assessment Tool for Agrobiodiversity and Resilience	https://www.agrobiodiversityplatform.org/datar

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
Online Tool	Various	Regional, National	Planning and assessing projects	Planning and assessing projects	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Country Focal Points, Country Reporting	Country	Outcome mapping	https://www.researchtoaction.org/2012/01/outcome-mapping-a-basic-introduction/#:~:text=Outcome%20mapping%20(OM)%20is%20a,policy%20influence%20and%20research%20uptake.
Desktop Tool	CI	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Land Degradation Neutrality	Land Cover Change, Land Productivity, Soil Carbon, Land Degradation, SDG 15.3.1	Technical specialist, Scientific advisor, Stakeholder	Regional	Vital Signs, Resilience Atlas, Trends.Earth	http://vitalsigns.org/
Online Tool	USAID	Regional, National	Various socio-economic layers: various socio-economic layers	Various socio-economic layers	Technical specialist, Scientific advisor, Stakeholder	Country	Statcompiler	https://www.statcompiler.com/en/
Desktop Tool	FAO	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water	Agriculture - productivity, Climate, Crops - distribution, Farming systems, Forestry - statistics, Land degradation, Land evaluation,	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder	Local, Country, Regional	Collect Earth	http://www.openforis.org/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
				Land use/cover, Remote sensing				
Desktop Tool	FAO	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Early Warning and Early Action tools, Land, Soil, Crop, Water, Drought Monitoring	Agriculture - productivity, Climate, Crops - distribution, Farming systems, Land Cover, Crop Phenology, Drought Monitoring, GIS, Remote sensing	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Early Warning Expert, Land Use Planner, Drought Mitigation Planner, Extension Services, Food Security Experts	Sub-National	Agriculture Stress Index Country Toolbox	http://www.fao.org/giews/earthobservation/asistool.jsp?lang=en
Geoportal	FAO	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Early Warning and Early Action tools, Land, Soil, Crop, Water, Drought Monitoring	Agriculture - productivity, Climate, Crops - distribution, Farming systems, Land Cover, Crop Phenology, Drought Monitoring, GIS, Remote sensing, National Geospatial Platform	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder, Early Warning Expert, Land Use Planner, Drought Mitigation Planner, Extension Services, Food Security Experts	National	National Geospatial Platform for Agriculture Drought Monitoring	http://www.fao.org/giews/earthobservation/asistool.jsp?lang=en
Online Tool	FAO	Global, Regional, National, Sub-national/Province/District,	Assessment and mapping tools: Land, Soil, Crop, Water	Agriculture - productivity, Climate, Water Productivity, Water	Technical specialist, Scientific advisor, Modeler,	Global, Regional, Country	FAO WAPOR	https://wapor.apps.fao.org/home/WAPOR_2/1

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
		Watershed/Basin/Landscape		Scarcity, GIS, Remote sensing	Facilitator, Stakeholder			
Geoportal	CI and partners	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water	Land Cover Change, Monitoring	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder	Regional	Vital Signs	http://vitalsigns.org/
Geoportal	UNDP, CBD, GEF	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land, Soil, Crop, Water, Biodiversity, Ecosystem Services, Human Impacts	Aichi Biodiversity Targets, Biodiversity, Climate and Carbon, Ecosystem Services, Human Impact, Land Cover, Marine, Natural Hazards, Protected Areas, Restoration, Socio-Economic	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder	Global	UN Biodiversity Lab	https://www.unbiodiversitylab.org/
Geoportal	ESA	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land cover change	Land Cover change indicators, GIS, Remote sensing, WebGIS Platform	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder	Global	ESA-CCI Viewer	https://maps.elie.ucl.ac.be/CCI/viewer/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
Catalog	FAO	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Forestry, Fisheries, Climate, Livestock, Crops, Pasture	Agriculture - productivity, Agro-Ecology, Climate, Crops - distribution, Farming systems, Forestry, Land degradation, Land evaluation, Land use/cover, GIS, Mapping, Remote sensing	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder	Global, Regional, Country	FAO Geonetwork	http://www.fao.org/geonetwork/
Catalog	FAO	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Forestry, Fisheries, Climate, Livestock, Crops, Pasture	Agriculture - productivity, Agro-Ecology, Climate, Crops - distribution, Farming systems, Forestry, Land degradation, Land evaluation, Land use/cover, GIS, Mapping, Remote sensing	Technical specialist, Scientific advisor, Modeler, Facilitator, Stakeholder	Global, Regional, Country	Hand-in-hand	https://data.apps.fao.org/
Geoportal	FAO	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools: Land, Soil, Crop, Water, Biodiversity	Agriculture - productivity, Agro-Ecology, Climate, Crops - distribution, Farming systems, Forestry, Land degradation, Land	Technical specialist, Scientific advisor, Modeler, Stakeholder	Global, Regional, Country	EarthMap	https://earthmap.org/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
				evaluation, Land use/cover, GIS, Mapping, Remote sensing				
Geoportal	UNCCD	Global, Regional, National	Assessment and mapping tools, Land, Soil, Crop, Water, Land Degradation Neutrality	Land cover, Land cover changes, land cover change aggregated, land cover flows, land productivity dynamics, soil carbon, soil carbon change, land degradation	Technical specialist, Scientific advisor, Modeler, Stakeholder	Global	LDN Reporting Default Data	https://maps.unccd.int/ldi/main.html
Geoportal	UNCCD	Global, Regional, National	Assessment and mapping tools, Drought Monitoring	Agriculture - productivity, Climate, Drought assessment, Early Warning, GIS, Mapping, Remote sensing	Technical specialist, Scientific advisor, Stakeholder	Global	Drought Risk Assessment	https://maps.unccd.int/drought/
Geoportal	UNCCD	Global, Regional, National	Assessment and mapping tools, Drought Monitoring	Annual, Seasonal, Simple Sand and Dust Storms Index	Technical specialist, Scientific advisor, Stakeholder	Global	SDS Source Map	https://maps.unccd.int/sds/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
Geoportal	JRC	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land Degradation	Accessibility, Forest Loss, Aridity, Livestock, Climate-Vegetation trends, Population Density, Decreasing land Productivity, Irrigation, Income Level, Fire, Population change, Water Stress, Built-up, High-input agriculture, Low-input agriculture, convergence of evidence	Technical specialist, Scientific advisor, Modeler, Stakeholder	Global	WORLD ATLAS OF DESERTIFICATION	https://wad.jrc.ec.europa.eu/geoportal
Portal	USGS (SAWAP)	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land, Soil, Crop, Water	Land Cover Change	Technical specialist, Scientific advisor, Modeler, Stakeholder	Regional	West Africa: Land Use and Land Cover Dynamics	https://eros.usgs.gov/westafrica/data-downloads
Geoportal	Colombia University	Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land, Soil, Crop, Water	Soils profiles, soil database	Technical specialist, Scientific advisor, Modeler, Stakeholder	Regional	Africa Soils Information System	http://africasoils.net/
Catalog	ISRIC	Global, Regional, National, Sub-national/Provin	Assessment and mapping tools,	Soil profiles	Technical specialist, Scientific	Regional	ISCRIC World Soils	https://data.isric.org/geonetwork/srv/eng/catal

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
		ce/District, Watershed/Basin/Landscape	Land, Soil, Crop, Water		advisor, Modeler, Stakeholder		Information	og.search#/home
Portal	University of Nebraska & Wageningen University	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land, Soil, Crop, Water	Yield gaps	Technical specialist, Scientific advisor, Modeler, Stakeholder	Regional	Global Yield Gap Atlas	https://www.yieldgap.org/
Portal	WOCAT	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land, Soil, Crop, Water, SLM	Agriculture - productivity, Agro-Ecology, Climate, Crops - distribution, Farming systems, Forestry, Land degradation, Land evaluation, Sustainable Land Management, WOCAT, GIS, Mapping, Remote sensing	Technical specialist, Scientific advisor, Modeler, Stakeholder	Global	WOCAT	https://www.wocat.net/en/global-slm-database/
Portal	Colorado State University	National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land, Soil, Crop, Water, Carbon Benefits	Carbon Benefits	Technical specialist, Scientific advisor, Modeler, Stakeholder	Global	Carbon Benefits Project	https://banr.nrel.colostate.edu/CBP/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
Geoportal	FAO	Global, Regional, National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land, Soil, Crop, Water, Agro Ecological Zones	Agriculture - productivity, Agro-Ecology, Climate, Crops - distribution, GIS, Mapping, Remote sensing	Technical specialist, Scientific advisor, Modeler, Stakeholder	Global	Global AgroEcological Zones v4	https://un-fao-gaez-4-1-nycgov.hub.arcgis.com/
Desktop Tool	IFAD	National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, Land, Soil, Crop, Water, Impact Assessments	Climate-related risks in agricultural and rural development investments and strategies, including economic and financial analysis	Technical specialist, Scientific advisor, Modeler, Stakeholder	Country	The Climate Adaptation in Rural Development – Assessment Tool (CARD)	https://www.ifad.org/en/web/knowledge/publication/asset/41085709
Online Tool	ESRI	National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tool, Water Balance	Water balance assessment and trends	Technical specialist, Scientific advisor, Modeler, Stakeholder	Global	Water Balance App	https://livingatlas.arcgis.com/waterbalance/
Online Tool	OSS and partners	Regional, National, Sub-national	Information sharing	GGW projects and partners	Technical specialist, Stakeholder, Public	Regional	GGW Stakeholders Platform	https://panegmv.org/partners/map
Online Tool	UNEP and Google	National, Sub-national, Waterbasin	Assessment and mapping tools, freshwater ecosystems	Freshwater ecosystems	Technical specialist, Scientific advisor, Modeler, Stakeholder	National, Sub-National	Freshwater Ecosystems Explorer	https://www.sdg661.app/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
Online Tool	JRC and Google	National, Sub-national, Waterbasin	Assessment and mapping tools, surface water dynamics	Surface Water Dynamics	Technical specialist, Scientific advisor, Modeler, Stakeholder	National, Sub-National	Global Surface Water Explorer	http://global-surface-water.appspot.com/map
Online Tool	DHI GRAS	National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, wetlands	Wetland's monitoring	Technical specialist, Scientific advisor, Modeler, Stakeholder	Regional, Country	GlobWetland Africa	http://globwetland-africa.org/
Online Tool	BOKU	National, Sub-national, Waterbasin	Assessment and mapping tools, freshwater data	Freshwater monitoring	Technical specialist, Scientific advisor, Modeler, Stakeholder	National, Sub-National	Freshwater Information Platform - The Network for freshwater research	http://www.freshwaterplatform.eu/index.php/spatial-data-sources.html
Online Tool	CIFOR, USFS, USAID, FTA	National, Sub-national/Province/District, Watershed/Basin/Landscape	Assessment and mapping tools, assessment and validation of wetlands	Wetland mapping, validation and monitoring	Technical specialist, Scientific advisor, Modeler, Stakeholder	National, Sub-National	Sustainable Wetlands Adaptation and Mitigation Program (SWAMP)	https://www2.cifor.org/global-wetlands/
Online Tool	Griffith University and partners	National, Sub-national, Waterbasin	Assessment and mapping tools, explore water future	Water future mapping of options	Technical specialist, Scientific advisor, Modeler, Stakeholder	National, Sub-National	The Sustainable Water Future Programm	http://water-future.org/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
							e (Water Future) of Future Earth	
Online Tool	DHI, IWA, UNEP, GEF	Sub-national, Waterbasin	Assessment and mapping tools, Flood and Drought Management	Flood and Drought Management	Technical specialist, Scientific advisor, Modeler, Stakeholder	National, Sub-National	Flood and Drought Management Tools 2014 – 2018 GEF project	https://fdmt.iwlearn.org/about/pilot-basins/volta-basin
Portal	Max Planck Institute and partners	Global	Assessment and mapping tools, Carbon data	Carbon Benefits	Technical specialist, Scientific advisor, Modeler, Stakeholder	Global	Geocarbon data portal	https://www.bgc-jena.mpg.de/geodb/projects/Data.php
Online Tool	Landsale	Sub-national, Waterbasin	Assessment and guidelines, ecosystem restoration, landscape assessments and guidelines	Ecosystem restoration, landscape assessments	Technical specialist, Scientific advisor, Modeler, Stakeholder	National, Sub-National	Landscale	https://www.landscale.org/
Online Tool	ETH Zurich	Sub-national, Waterbasin	Assessment and mapping tools, Information sharing	Ecosystem restoration mapping	Technical specialist, Scientific advisor, Modeler, Stakeholder	National, Sub-National	Restor	https://www.crowtherlab.com/restoration/
Online Tool	World Bank Group	Country, Region, Watershed	Assessment and mapping tools,	Assessment and mapping tools, climate change	Technical specialist, Scientific	Country, Region, Watershed	Climate Change	https://climateknowledgeportal.worldbank.org/

Type	Agency / Institution	Scale	Sub-Category	Thematic areas	User Category	Geographic Scope	Name	URL
			climate change portal	portal, country profiles, impacts by sector	advisor, Modeler, Stakeholder		Knowledge Portal	

ANNEX IV - Geographic scope

1. Burkina Faso[194]

Data availabity, suitability and usability
For the four weather stations in the project area, gaps limit ability to rely on these datasets for the historical analysis for both precipitation and temperature (minimum and maximum).
Historical climates: a reanalyzed historical data (ERA-5) for monthly precipitation pointed to two main precipitation patterns in the project area. The rainy season starts in March-April for the Southern provinces and in April-May for the Northern regions. The rainy season ends for both clusters in October. The accumulated rainfall amount in the Southern provinces is higher than the one in the Northern provinces.

For monthly temperature, all clusters experience a similar pattern of high temperature, from March to May and also in the period of August to September. Cold months are recorded for the rest of year and especially in December and January. As a consequence of the early signs of global warming, all regions currently experience warmer temperature than in the reference period (1979-2008).

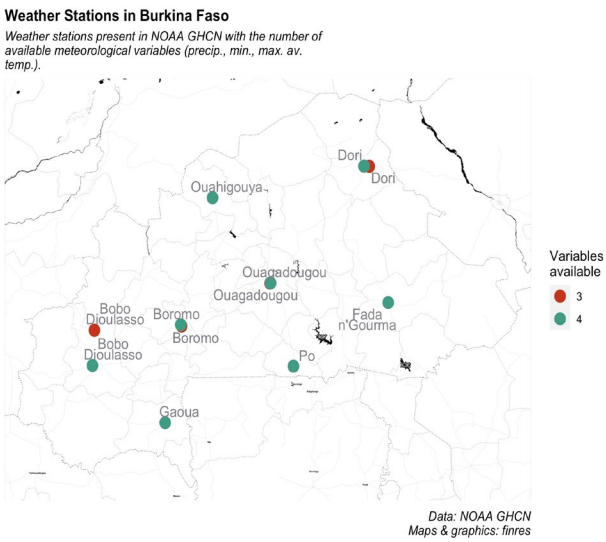


Figure 12. Weather station distribution in Burkina Faso

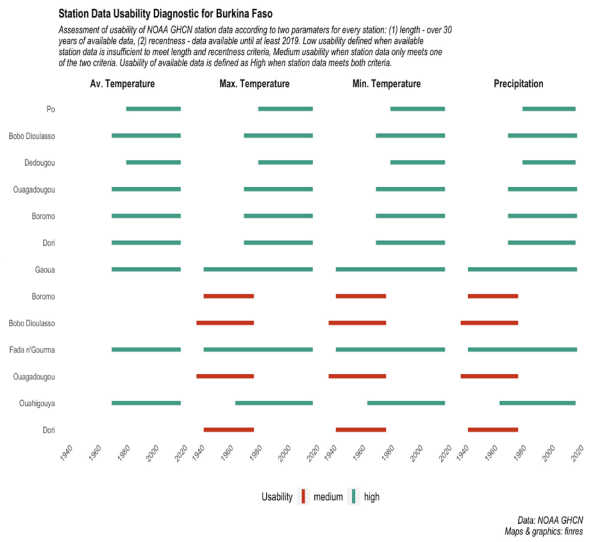


Figure 13. Station data usability diagnostic for BF

Climate projections (Climate Hotspots)
On the basis of the overall climate variability and change analysis, the provinces bordering Mali and in the Northern part of the country appear to be the most affected under a RCP4.5 scenario.

Precipitation

In the near future, the model ensemble mean precipitation is projected to fluctuate between -9.9% (MC) and 7.8% (LC) in the dry season and between -1.3% (MC) and 3.8% (MC) in the rainy season. By mid-century, the precipitation mean could fluctuate between -4.8% (LC) and 10.8% (MC) in

194 For the project area, four weather stations provided data on temperature and precipitation. Not all stations in the project area provide long-enough (over 30 years) record and data at least until 2019. For the stations ranked with high usability, assuming they do not display significant gaps in the time series, the data provided by the weather stations could be used for the historical analysis of the local climates.

the dry season and increase from 1.1% (MC) to 7.1% (HC) in the rainy season. In the project area, the regions can be analysed in three categories:

The first category, with the least change, consists of - for example - the regions of Zondoma and Kossi with an increase trend of mean precipitation of about 1.8% during the rainy season by mid-century (2026-2055). This group encompasses Nayala with 1.5% (MC) and Sourou with 2.0% (MC).
The second cluster, with moderate change, consists of - for example - the regions of Banwa at 3.3% (MC) and Kénédougou at 4.6% (HC). In this cluster the mean precipitation is projected to increase by 4.0%.
The third category facing the most change, consists of - among others - the regions of Sanmatenga with 6.8% (HC) and Balé with 5.2% (MC). In this cluster the mean precipitation is projected to increase by 6.1%.

Table 23. Variation trends in precipitation over Burkina Faso

	dry season	rainy season
near future	-9.9% (MC) and 7.8% (LC)	-1.3% (MC) and 3.8% (MC)
mid-century	-4.8% (LC) and 10.8% (MC)	1.1% (MC) to 7.1% (HC)

Table 24. Precipitation changes over the project areas in Burkina Faso

	least change	moderate change	most change
Area	Zondoma and Kossi with 1.8% Nayala with 1.5% (MC) Sourou with 2.0% (MC)	Banwa with 3.3% (MC) Kénédougou with 4.6% (HC)	Sanmatenga with 6.8% (HC) Balé with 5.2% (MC)

Consecutive Dry Days (CDD)

In the near future, the model ensemble mean shows that the consecutive dry days (precipitation below 1mm) in the rainy season is projected to fluctuate between -0.7 day (LC) and 1.4 days (MC) with respect to the reference period (1979-2008). By mid-century, the average number of the consecutive dry days (precipitation below 1mm) in the rainy season could fluctuate between -1.2 days (MC) and 0.4 day (MC). In the project area, the regions can be analysed in three clusters.

The first category, with the least change, consists of - for example - the regions of Sanmatenga and Zondoma with a mean number of days subject to dryness (precipitation below 1mm) in the rainy season increase of 0.1 day annually by mid-century (2026-2055). This category involves Sanmatenga at 0.1 day (LC) and Léraba at 0.1 day (LC).

With a mean number of days subject to dryness (precipitation below 1mm) in the rainy season decrease of -0.5 day, the second category, which faces moderate change, comprises - for example - the following regions: Comoé at -0.5 day (MC) and Sourou at -0.7 day (MC).
The third category facing the most change, gathers - among others - the regions of Namentenga with -0.8 days (HC) and Nayala at -1.2 days (MC). In this category the mean number of days subject to dryness (below 1mm) in the rainy season is projected to decrease by -1.1 days.

Table 25. Variation trends in consecutive dry days over Burkina Faso

	rainy season
near future	-0.7 day (LC) and 1.4 days (MC)
mid-century	-1.2 days (MC) and 0.4 day (MC)

Table 26. Changes of consecutive dry days over the Project areas in Burkina Faso

	least change	moderate change	most change
Area	Sanmatenga and Zondoma at 0.1 day Sanmatenga at 0.1 day (LC) Léraba at 0.1 day (LC)	Comoé at -0.5 day (MC) Sourou at -0.7 day (MC)	Namentenga with -0.8 days (HC) Nayala at -1.2 days (MC)

Extreme Wet Events (R95pTOT)

Extreme wet event patterns at the local level: for the Mid Warming Scenario (RCP4.5), in the near future, the model ensemble mean shows that the number of days subject to extreme wet events is projected to fluctuate between -1.5 days (MC) and 0.1 day (LC) in the dry season and fluctuate between -0.6 day (MC) and 0.5 day (MC) in the rainy season. By mid-century, average number of days subject to extreme wet events could fluctuate between -0.8 day (MC) and 0.5 day (MC) in the dry season and fluctuate between -0.3 day (LC) and 1.6 days (HC) in the rainy season. In the project area, the regions can be analysed in four categories:

With an absence of chance in the average number of days subject to extreme wet events during the rainy season within the 2026-2055 period, the first category, which faces the least change, is made up of for example the following regions: Loroum (LC), Passoré (LC) and Passoré (LC).
The second category facing lower change, gathers - for example - the regions of Soum and Tuy with 0.4 day (LC) and Kossi with 0.5 day (MC). In this category the average number of days subject to extreme wet events is projected to increase by 0.4 day.
The third cluster, with higher change, consists of - for example - the regions of Léraba at 0.7 day (MC) and Namentenga at 0.8 day (LC). In this category the average number of days subject to extreme wet events is projected to increase by 0.8 day.

With an average number of days subject to extreme wet events increase of 1.6 days, the fourth cluster, which faces the most change, comprises a single region: Comoé.

The temperature hotspot analysis below displays the area facing the most change with respect to temperature and temperature-related extremes. The temperature pattern and its associated extremes is similar with the Northern part of bordering Mali and the Southern part facing the most change compared to the Central part of the project area. In the near future, the model ensemble mean shows that the temperature is projected to increase from 1.1°C (HC) to 1.1°C (HC) in the dry season and increase from 0.7°C (HC) to 0.8°C (HC) in the rainy season. By mid-century, average temperature could increase from 1.7°C (HC) to 1.9°C (HC) in the dry season and increase from 1.3°C (HC) to 1.4°C (HC) in the rainy season. In the project area, the regions can be analysed in two categories:

The first category, facing the least change, consists of - for example - the regions of Sourou and Bam with an average temperature increase of 1.31°C during the rainy season by mid-century (2026-2055).
The second category facing the most change, gathers - for example - the regions of only Loroum and Soum at 1.39°C (HC). In this category the mean temperature is projected to increase by 1.39°C

Table 27. Variation trends in Extreme Wet Events over Burkina Faso

	the dry season	rainy season
near future	-1.5 days (MC) and 0.1 day (LC)	-0.6 day (MC) and 0.5 day (MC)
mid-century	-0.8 day (MC) and 0.5 day (MC)	-0.3 day (LC) and 1.6 days (HC)

Table 28. Changes of Extreme Wet Events over the Project areas in Burkina Faso

	least change	Lower change	Higher change	most change
Area	Loroum Passoré Passoré	Soum and Tuy with 0.4 day Kossi with 0.5 day	Léraba with 0.7 day (MC) Namentenga with 0.8 day (LC)	Comoé.

Heatwaves (TX90p)

In the near future, the model ensemble mean shows that the number of days subject to extreme heat events is projected to increase from 22.3 days (HC) to 28.0 days (HC). By mid-century, the average number of days subject to extreme heat events could increase from 38.0 days (HC) to 43.5 days (HC). In the project area, the regions can be analysed in four categories:

With an average number of days subject to extreme heat events increase of 38.4 days annually within the 2026-2055 period, the first category, which faces the least change, is made up of for example the following regions: Kossi and Passoré.
The second category facing lower change, gathers - for example - the regions of Zondoma with 40.0 days (HC) and Loroum with 40.3 days (HC). In this category the mean number of days subject to extreme heat events is projected to increase by 40.3 days.
The third cluster, with higher change, consists of - for example - the regions of Comoé at 41.3 days (HC) and Sanmatenga at 41.8 days (HC). In this category the average number of days subject to extreme heat events is projected to increase by 41.4 days.
With an average number of days subject to extreme heat events increase of 43.2 days, the fourth cluster, which faces the most change, comprises - among others - the subsequent regions: Tuy with 43.5 days (HC).

Table 29. Variation trends in Heatwaves over Burkina Faso

near future	22.3 days (HC) to 28.0 days (HC)
mid-century	38.0 days (HC) to 43.5 days (HC)

Table 30. Changes of Heatwaves over the project areas in Burkina Faso

	least change	Lower change	Higher change	most change
Area	Kossi and Passoré	Zondoma with 40.0 days (HC) Loroum with 40.3 days (HC)	Comoé with 41.3 days (HC) Sanmatenga at 41.8 days (HC)	Tuy with 43.5 days (HC).

Warm Nights (TN90p)

Extreme nighttime heat event patterns: In the Mid-Warming Scenario (RCP4.5), in the near future, the multi-model mean number of nights subject to extreme nighttime heat events is projected to increase from 7.2 nights (HC) to 12.4 nights (HC). By mid-century, the average number of nights subject to extreme nighttime heat events could increase from 14.7 nights (HC) to 28.0 nights (HC). In the project area, the regions can be analysed in three categories:

The first category, with the least change, consists of - among others - the regions of Nayala and Tuy with an average number of nights subject to extreme nighttime heat events increase of 15.5 nights annually by mid-century (2026-2055). This group includes Tuy with 16.1 nights (HC) and Balé with 14.7 nights (HC).
The second cluster, with moderate change, consists of - for example - the regions of Bam at 20.3 nights (HC) and Zondoma at 19.0 nights (HC). In this cluster the average number of nights subject to extreme nighttime heat events is projected to increase by 19.7 nights.
The third cluster facing the most change, gathers - for example - the regions of Oudalan at 24.4 nights (HC). In this category the average number of nights subject to extreme nighttime heat events is projected to increase by 26.4 nights.

Table 31. Variation trends in Warm Nights over Burkina Faso

near future	7.2 nights (HC) to 12.4 nights (HC).
mid-century	14.7 nights (HC) to 28.0 nights (HC)

Table 32. Changes of Warm Nights over the project areas in Burkina Faso

	least change	moderate change	most change
Area	Increase of extreme nighttime heat events: -Tuy with 16.1 nights (HC) - Balé with 14.7 nights (HC)	Increase of the extreme events: - Bam with 20.3 nights (HC) - Zondoma with 19.0 nights (HC)	Increase of extreme events: - Oudalan at 24.4 nights (HC)

Extreme Wind Events (Sf95TOT)

The maps below display the main hotspots of extreme wind. In both scenarios, the highest increase in the number of days of extreme wind is also projected to occur in the Eastern and Northern provinces bordering Mali. In the near future, the multi-model mean number of days subject to extreme wind events is projected to decrease from -2.2 days (HC) to -0.3 day (LC). By mid-century, the average number of days subject to extreme wind events could fluctuate between -2.1 days (MC) and 0.3 day (LC). In the project area, the regions can be analysed in three categories:

The first category, facing the least change, consists of - among others - the regions of Bam and Yagha with an average number of days subject to extreme wind events decrease of -0.1 day annually by mid-century (2026-2055).
With an average number of days subject to extreme wind events decrease of -0.6 day, the second cluster, which faces moderate change, is made up of - for example - the following regions: Balé at -0.8 day (LC) and Houet with -0.5 day (MC).
The third category facing the most change, consists of - among others - the regions of Léraba with -1.3 days (MC). In this cluster the mean number of days subject to extreme wind events is projected to decrease by -1.6 days.

Table 33. Variation trends in Extreme Wind Events over Burkina Faso

	the dry season	rainy season
near future	-1.5 days (MC) and 0.1 day (LC)	-0.6 day (MC) and 0.5 day (MC)
mid-century	-0.8 day (MC) and 0.5 day (MC)	-0.3 day (LC) and 1.6 days (HC)

Table 34. Changes of Extreme Wind Events the project areas in Burkina Faso

	least change	Lower change	Higher change	most change
Area	Loroum Passoré Passoré	Soum and Tuy with 0.4 day Kossi with 0.5 day	Léraba with 0.7 day (MC) Namentenga with 0.8 day (LC)	Comoé.

2. Mali

The main climates present in the project area are: Tropical savanna climate with dry-winter characteristics and Hot semi-arid climate.

1. Ansongo, Bafoulabé and Banamba are the circles where the Dry group of climate is affecting more than 33% of the area. With all its area under this group of climate, Ansongo displays the greatest domain. In this group, the present climates are the Hot desert climate and the Hot semi-arid climate.
2. Bougouni, Dioïla and Kadiolo are the circles where the Tropical group of climate is affecting more than a third of the area. With all its area under this group of climate, Kadiolo displays the greatest part. Within this group, the only climate present is the Tropical savanna climate with dry-winter characteristics.

Data availabity, suitability and usability

For the project area, 12 weather stations provided data on temperature and precipitation. Not all stations in the project area provide long-enough (over 30 years) record and data at least until 2019. For the stations ranked with high usability, assuming they do not display significant gaps in the time series, the data provided by the weather stations could be used for the historical analysis of the local climates.

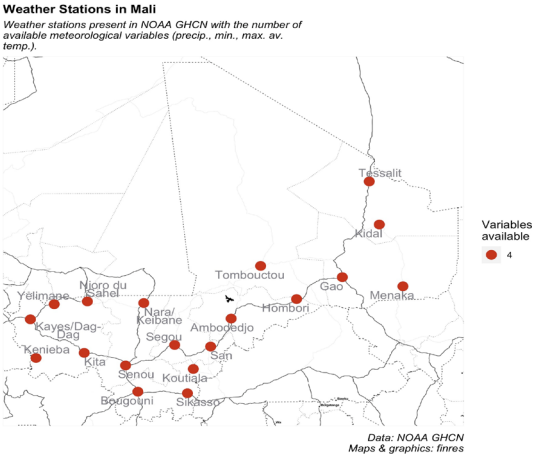


Figure 14. *Weather stations distribution in Mali*

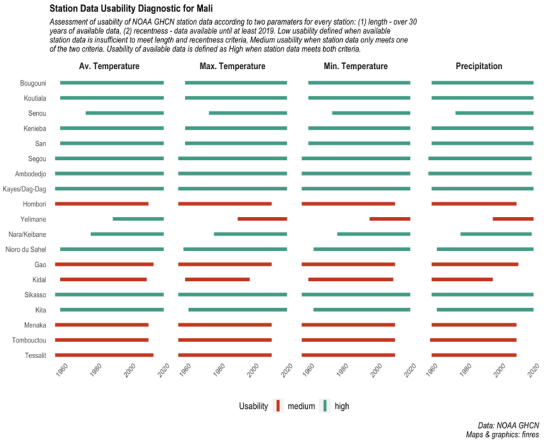


Figure 15. *Station data usability diagnostic for Mali*

For the project area, 12 weather stations provided data on temperature and precipitation. Not all stations in the project area provide long-enough (over 30 years) record and data at least until 2019. For the stations ranked with high usability, assuming they do not display significant gaps in the time series, the data provided by the weather stations could be used for the historical analysis of the local climates.

Specifically for the 12 weather stations in the project area, gaps limit our ability to rely on these datasets for the historical analysis for both precipitation, minimum and maximum temperatures. Reanalyzed historical data (ERA-5) outline three main precipitation patterns in Mali. The rainy season starts in all areas in May, and ends in in October, up to November for the Southern departments. All clusters experience a similar pattern of hot, from March to May and again a second warm season between August and September, and cold months for over the rest of year and especially in December and January. As a consequence of the early signs of global warming, all regions currently experience warmer temperature than in the reference period (1979-2008).

Climate projections (Climate Hotspots)

On the basis of the overall climate variability and change analysis, below a summary of areas which are projected to be the least to most affected by climate change. In the RCP4.5 scenarios, the circles bordering Mauritania and in the Northern part of the country appear to be the most affected.

Precipitation

The most severe changes in precipitation patterns and extremes are following a relatively similar progression for precipitation and dryness, while extreme wet events are mostly occurring in the Eastern and Southern part of Mali. Uncertainties are rather limited for precipitation and higher for both weather extremes.
The model ensemble mean precipitation is projected to fluctuate between -8.4% (MC) and 27.6% (MC) in the dry season and fluctuate between -5.0% (MC) and 7.0% (MC) in the rainy season. By mid-century, the mean precipitation could fluctuate between -5.6% (LC) and 31.6% (MC) in the

dry season and range from -0.9% (LC) and 19.9% (HC) in the rainy season. In the project area, the regions can be analysed in two clusters:

The first cluster, with the least change, gathers - for example - the regions of Niono and Koulikoro with an increase mean precipitation of 2.4% during the rainy season by mid-century (2026-2055). This category encompasses Kita at 2.5% (MC) and Kayes at 0.7% (LC). All the regions are located in the Southern part.
With a mean precipitation increase of 14.0%, the second cluster, which looks towards the most change, is composed of - for example - the following regions: Ménaka at 13.2% (MC). All the regions are located in the Northern Central part.

Table 35. Variation trends in precipitation over Mali

	the dry season	rainy season
near future	-8.4% (MC) and 27.6% (MC)	-5.0% (MC) and 7.0% (MC)
mid-century	-5.6% (LC) and 31.6% (MC)	-0.9% (LC) and 19.9% (HC)

Table 36. Precipitation changes over the project areas in Mali

	least change	most change
area	Niono and Koulikoro with 2.4% Kita with 2.5% (MC) Kayes with 0.7% (LC).	Ménaka with 13.2% (MC)

Consecutive Dry Days (CDD)

The model ensemble mean shows that the number of days subject to dryness (precipitation below 1mm) in the rainy season is projected to fluctuate between -0.9 day (LC) and 4.2 days (MC). By mid-century, the average number of days subject to dryness (precipitation below 1mm) in the rainy season could fluctuate between -2.6 days (HC) and 4.3 days (MC). In the project area, the regions can be analyzed under four clusters:

With an average number of days subject to dryness (below 1mm) in the rainy season decrease of -0.3 day annually within the 2026-2055 period, the first cluster, which faces the least change, comprises among others the following regions: Mopti with -0.4 day (MC) and Kéniéba at -0.5 day (MC). Most of the regions are located in the Central and Southern parts of the countries.
The second cluster facing lower change, gathers - for example - the regions of Kati at 1.0 days (MC) and Kangaba with 1.1 day (LC). In this cluster the average number of days subject to dryness (below 1mm) in the rainy season is projected to increase by 1.2 days. All the regions are located in the Southern part.
With an average number of days subject to dryness (below 1mm) in the rainy season decrease of -1.7 days, the third category, which looks towards higher change, is composed of - for example - the subsequent regions: Douentza at -1.4 days (HC) and Ansongo with -2.6 days (MC).
With a mean number of days subject to dryness (below 1mm) in the rainy season increase of 3.4 days, the fourth cluster, which faces the most change, is composed of - for example - the subsequent regions: Nioro with 4.3 days (MC) and Yélimané with 4.3 days (LC).

Table 37. Variation trends in consecutive dry days over Mali

	rainy season
near future	-0.9 day (LC) and 4.2 days (MC)
mid-century	-2.6 days (HC) and 4.3 days (MC)

Table 38. Variation trends in consecutive dry days over Mali

	least change	Lower change	higher change	most change
area	Mopti with -0.4 day (MC) Kéniéba at -0.5 day (MC)	Kati at 1.0 days (MC) Kangaba with 1.1 day (LC)	Douentza at -1.4 days (HC) Ansongo with -2.6 days (MC).	Nioro with 4.3 days (MC) Yélimané with 4.3 days (LC)

Extreme Wet Events (R95pTOT)

The near future, the model ensemble mean shows that the number of days subject to extreme wet events is projected to fluctuate between -1.1 days (MC) and 0.6 day (LC) in the dry season and fluctuate between -0.8 day (MC) and 0.8 day (HC) in the rainy season. By mid-century, average number of days subject to extreme wet events could range from -0.9 day (HC) and 1.1 days (MC) in the dry season and fluctuate between -0.3 day (MC) and 1.4 days (HC) in the rainy season. In the project area, the regions can be analysed under four categories:

With an average number of days subject to extreme wet events decrease of -0.2 day during the rainy season within the 2026-2055 period, the first category, which faces the least change, is composed of among others the following regions: Nioro and Diéma. All these regions are located in the Central part.
The second cluster facing lower change, gathers - among others - the regions of Ténenkou at 0.2 day (MC) and Ténenkou with 0.3 day (LC). In this cluster the mean number of days subject to extreme wet events is projected to increase by 0.2 day. The vast majority (more than 90%) of the regions affected by this change are located in the Southern part of the country.
With a mean number of days subject to extreme wet events increase of 0.5 day, the third category, which looks towards higher change, is composed of - for example - the following regions: Kita at 0.5 day (LC) and Kati at 0.6 day (MC). All the regions are located in the Southern part.
With an average number of days subject to extreme wet events increase of 1.1 days, the fourth cluster, which faces the most change, is made up of - among others - the subsequent regions: Dioïla at 0.9 day (MC) and Gao with 0.9 day (HC).

Table 39. Variation trends in Extreme Wet Events over Mali

	the dry season	rainy season
near future	-1.5 days (MC) and 0.1 day (LC)	-0.6 day (MC) and 0.5 day (MC)
mid-century	-0.8 day (MC) and 0.5 day (MC)	-0.3 day (LC) and 1.6 days (HC)

Table 40. Changes of Extreme Wet Events in the project areas in Mali

	least change	Lower change	Higher change	most change
area	Nioro and Diéma	-Ténenkou with 0.2 day (MC) - Ténenkou with 0.3 day (LC).	Kita with 0.5 day (LC) Kati with 0.6 day (MC).	Dioïla with 0.9 day (MC) Gao with 0.9 day (HC).

Temperature

The main hotspots of temperature change and temperature-related extremes. The temperature pattern and its associated extremes are similar with the Northern part of Mali facing the most change compared to the Southern part of the country. The model ensemble mean temperature is projected to increase from 1.0°C (HC) to 1.2°C (HC) in the dry season and increase from 0.7°C (HC) to 1.1°C (HC) in the rainy season. By mid-century, average temperature could increase from 1.7°C (HC) to 1.9°C (HC) in the dry season and increase from 1.3°C (HC) to 1.9°C (HC) in the rainy season. In the project area, the regions can be analyzed in four categories.

The first category, with the least change, consists of - for example - the regions of Koutiala and Kadiolo with a mean temperature increase of 1.33°C during the rainy season by mid-century (2026-2055). All the regions are located in the Southern part.
The second category facing lower change, gathers - for example - the regions of Kolokani at 1.47°C (HC) and Kita and Mopti at 1.51°C (HC). In this category the mean temperature is projected to increase by 1.44°C.
With an average temperature increase of 1.59°C, the third category, which looks towards higher change, is composed of - among others - the subsequent regions: Bourem with 1.57°C (HC) and Ménaka at 1.57°C (HC).
The fourth category facing the most change, consists of - for example - the regions of only Goundam with 1.77°C (HC). In this category the mean temperature is projected to increase by 1.84°C. All the regions are located in the Northern part of the country.

Table 41. Variation trends in temperature over Mali

	dry season	rainy season
near future	1.0°C (HC) to 1.2°C (HC	0.7°C (HC) to 1.1°C (HC)
mid-century	1.7°C (HC) to 1.9°C (HC)	1.3°C (HC) to 1.9°C (HC)

Table 42. Changes of temperature in the project areas in Mali

	least change	Lower change	Higher change	most change
Area	Increase of mean temperature of 1.33°C at Koutiala	Increase of temperature - Kolokani with 1.47°C (HC)	Increase temperature Bourem with 1.57°C (HC)	Increase temperature Goundam with 1.77°C (HC).

	Kadiolo	- Kita and Mopti with 1.51°C (HC).	and Ménaka at 1.57°C (HC)	

Heatwaves (TX90p)

The model ensemble mean shows that the number of days subject to extreme heat events is projected to increase from 21.6 days (HC) to 28.6 days (HC). By mid-century, the average number of days subject to extreme heat events could increase from 36.3 days (HC) to 54.8 days (HC). In the project area, the regions can be analyzed under three clusters.

With an average number of days subject to extreme heat events increase of 38.4 days annually within the 2026-2055 period, the first cluster, which faces the least change, is made up of for example the subsequent regions: Kayes at 36.3 days (HC) and Kati with 38.2 days (HC). All the regions are located in the Southern part.
The second category facing moderate change, consists of - for example - the regions of Mopti at 41.6 days (HC) and Barouéli at 42.5 days (HC). In this category the average number of days subject to extreme heat events is projected to increase by 42.1 days. The regions are located in the Central and Southern parts of the country.
The third cluster facing the most change, gathers - for example - the regions of Ansongo with 45.6 days (HC) and Nara at 47.0 days (HC). In this cluster the average number of days subject to extreme heat events is projected to increase by 48.4 days. All the regions are located in the North.

Table 43. Variation trends in Heatwaves over Mali

near future	21.6 days (HC) to 28.6 days (HC)
mid-century	36.3 days (HC) to 54.8 days (HC)

Table 44. Changes of Heatwaves over the project areas in Mali

	least change	Moderate change	most change
area	Kayes at 36.3 days (HC) Kati with 38.2 days (HC)	Mopti with 41.6 days (HC) Barouéli with 42.5 days (HC)	Ansongo with 45.6 days (HC) Nara with 47.0 days (HC)

Warm Nights (TN90p)

The multi-model mean number of nights subject to extreme nighttime heat events is projected to increase from 6.2 nights (HC) to 32.7 nights (HC). By mid-century, the average number of nights subject to extreme nighttime heat events could increase from 13.0 nights (HC) to 58.1 nights (HC). In the project area, the regions can be analysed under three clusters :
With an average number of nights subject to extreme nighttime heat events increase of 18.6 nights annually within the 2026-2055 period, the first cluster, which looks towards the least change, is made up of for example the subsequent regions: Nara with 17.7 nights (HC) and Kati at 15.9 nights (HC). All the regions are located in the Southern part.

The second category facing moderate change, consists of - for example - the regions of Gourma-Rharous at 37.8 nights (HC) and Niafunké at 40.0 nights (HC). In this category the average number of nights subject to extreme nighttime heat events is projected to increase by 32.9 nights. The majority (more than 80%) of the regions are located in the Central part.
The third category facing the most change, consists of - for example - the regions of Bourem and Tombouctou with 58.1 nights (HC). In this cluster the mean number of nights subject to extreme nighttime heat events is projected to increase by 53.2 nights. All the regions are located in the Northern part of the country.

Table 45. Variation trends in Warm Nights over Mali

near future	6.2 nights (HC) to 32.7 nights (HC)
mid-century	13.0 nights (HC) to 58.1 nights (HC)

Table 46. Changes of consecutive dry days over the project areas in Mali

	least change	Moderate change	most change
area	Increase of extreme events: Nara with 17.7 nights (HC) Kati with 15.9 nights (HC)	Increase of extreme nighttime heat events: Gourma-Rharous with 37.8 nights (HC) and Niafunké with 40.0 nights (HC)	Increase of extreme events: Bourem and Tombouctou with 58.1 nights (HC)

Extreme Wind Events (Sf95TOT)

The main hotspots of extreme wind. In both scenarios, the highest increase in the number of days of extreme wind is also projected to occur in the Northern circles of Mali. Climate change at the global level also translates in modifications in extreme wind event patterns at the local level in Mali. In this section, we describe changes in the annual number of days subject to extreme wind events in the project area, in the near future (2006-2035) and mid-century (2026-2055) in comparison with the reference period (1979-2008).

In the Mid-Warming Scenario (RCP4.5), in the near future, the multi-model mean number of days subject to extreme wind events is projected to fluctuate between -2.1 days (HC) and 1.2 days (LC). By mid-century, the average number of days subject to extreme wind events could fluctuate between -2.0 days (HC) and 2.1 days (HC). In the project area, the regions can be analysed under four clusters.

The first category, facing the least change, gathers - among others - the regions of Kati and Nara with a mean number of days subject to extreme wind events decrease of -0.1 day annually by mid-century (2026-2055). This category encompasses Nara and Koro at 0.1 day (MC). All the regions are located in the Southern part.
The second cluster, with lower change, gathers - for example - the regions Barouéli with 0.6 day (LC) and Diéma with 0.9 day (LC). In this category the average number of days subject to extreme wind events is projected to increase by 0.5 day. More than half of the regions are located in the Central part.

The third cluster facing higher change, consists of - for example - the regions of only Kadiolo with -2.0 days (HC). In this cluster the mean number of days subject to extreme wind events is projected to decrease by -1.3 days. All the regions are located in the Southern part.
With an average number of days subject to extreme wind events increase of 1.4 days, the fourth category, which looks towards the most change, comprises - among others - the subsequent regions: Gao at 1.4 days (MC) and Ménaka at 1.4 days (MC). All the regions are located in the Northern part.

Table 47. Variation trends in Extreme Wind Events over Mali

near future	-2.1 days (HC) and 1.2 days (LC)
mid-century	-2.0 days (HC) and 2.1 days (HC)

Table 48. Variation trends in Extreme Wind Events over Mali

	least change	Lower change	Higher change	most change
area	Nara and Koro: decrease of extreme wind events of 0.1 day	Increase of extreme wind events: Barouéli with 0.6 day (LC) Diéma with 0.9 day (LC)	Decrease of extreme wind events: Kadiolo with 2.0 days (HC)	Increase of extreme wind events: Gao with 1.4 days (MC) Ménaka with 1.4 days (MC).

3. Senegal

The main climates present in the project area are: Tropical savanna climate with dry-winter characteristics and Hot semi-arid climate.
Bakel, Bambey and Birkilane are the departments where the Dry group of climates is affecting more than a third of the area. With 100% of its area under this group of climates, Bambey displays the most significant part. Under this group, the present climates are the Hot semi-arid climate and the Hot desert climate.
Bignona, Bounkiling and Goudomp are the departments where the Tropical type of climate is occurring over more than a third of the area. With 100% of its area under this group of climates, Bignona displays the greatest part. Within this type, the present climates are the Tropical savanna climate with dry-summer characteristics and the Tropical savanna climate with dry-winter characteristics.

Elevation above sea level: Altitude in the project area ranges from -13 meters in Fatick and Foundiougne (for example), to 279 meters in Tambacounda. Coastal or landlocked is a key characteristic distinguishing the departments of the project area. The mean altitude of the landlocked departments is about 30 meters above sea-level, while coastal departments reach 30 meters on average.
Data availabity, suitability and usability

For the project area, nine weather stations provided data on temperature and precipitation. All stations in the project area provide long-enough (over 30 years) record and data at least until

2019. Assuming they do not display significant gaps in the time series, the data provided by the weather stations could be used for the historical analysis of the local climates.

Reanalyzed historical data (ERA-5) suggests that there are two main precipitation patterns in Senegal. In the Southern departments of Casamance, the rainy season provides about twice as much precipitation as in the regions located North of the Gambia. However, the rainy season starts in both areas in May, and ends in in October, up to November for the Southern departments. Historical climate

Monthly Temperature: Three key temperature clusters can be distinguished in the analysis, from East to West, the coastal zone. In the Eastern-most department of Senegal, temperature reaches up to 33-34°C in the warmer months, on average, while this temperature is limited to about 28°C (coastal zones) and 30°C in the zone located between the coast and the Eastern departments. The minimum monthly temperature is about 24°C by the coast and 25-26°C in the warmest part of the country. All departments and clusters have experienced an increase in mean monthly temperatures over the last decades.

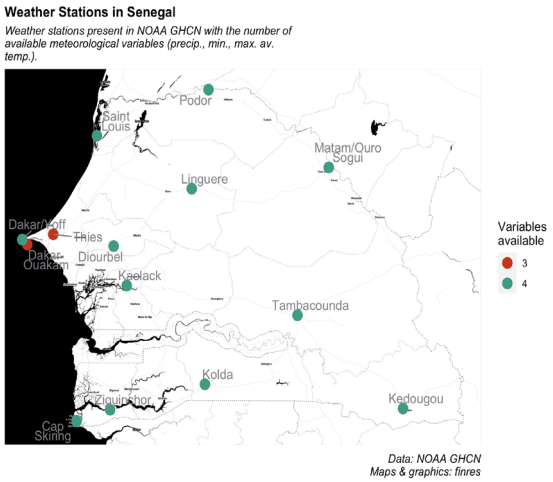


Figure 16. Weather stations distribution in Senegal

Figure 19. Station data usability diagnostic for Senegal

Climate projections

On the basis of the overall climate variability and change analysis, An analysis of areas which are projected to be the least to most affected by climate change picture emergence of no clear geography, even though the Northern and Eastern bordering departments present higher exposure but not consistently.

Precipitation

The main hotspots of precipitation change and precipitation-related extremes. The most severe changes in precipitation patterns and extremes are following a relatively similar progression for precipitation and dryness, while extreme wet events describe an opposite pattern to this of dry days. Uncertainties remain high for all indicators. The multi-model mean precipitation is projected to fluctuate between -19.6% (HC) and 7.3% (LC) in the dry season and fluctuate between -9.7% (MC) and 0.8% (LC) in the rainy season. By mid-century, average precipitation could fluctuate between -22.0% (HC) and 3.9% (LC) in the dry season and fluctuate between -10.7% (MC) and 3.7% (MC) in the rainy season. In the project area, the regions can be analyzed in two categories.

With a mean precipitation increase of 0.8% during the rainy season within the 2026-2055 period, the first cluster, which faces the least change, is composed of among others the following regions: Ranérou Ferlo at 1.4% (MC), Birkilane at 1.4% (MC) and Ranérou Ferlo at 3.7% (MC). All the regions are landlocked, more than half of the regions are located in the Central part, more than half of the regions are located in the Western part and also more than half of them are located in the Southern part of the country.
With a mean precipitation decrease of -5.7%, the second cluster, which looks towards the most change, is made up of - for example - the subsequent regions: Mbour with -2.6% (MC), Matam with -2.6% (MC) and Louga with -2.8% (LC). More than 80% of the regions are landlocked, more than half of the regions are located in the Western part and also more than three-forth (75%) of them are located in the Northern part of the country.

Table 49. Variation trends in precipitation over Senegal

	the dry season	rainy season
near future	-19.6% (HC) and 7.3% (LC)	-9.7% (MC) and 0.8% (LC)
mid-century	-22.0% (HC) and 3.9% (LC)	-10.7% (MC) and 3.7% (MC)

Table 50. Precipitation changes over the project areas in Senegal

	least change	most change
Area	Ranérou Ferlo with 1.4%(MC) Birkilane with 1.4%(MC) Ranérou Ferlo with 3.7% (MC)	Mbour with -2.6% (MC) Matam with -2.6% (MC) Louga with -2.8% (LC)

Consecutive Dry Days (CDD)

The model ensemble mean shows that the number of days subject to dryness (below 1mm) in the rainy season is projected to increase from 1.2 days (MC) to 5.0 days (HC). By mid-century, the average number of days subject to dryness (below 1mm) in the rainy season could fluctuate between -0.8 day (LC) and 4.2 days (HC). In the project area, the regions can be analysed under two clusters:

With an average number of days subject to dryness (below 1mm) in the rainy season increase of 0.7 day annually within the 2026-2055 period, the first cluster, which faces the least change,

comprises among others the subsequent regions: Guinguinéo with 0.0 days (MC), Tambacounda with 0.0 days (MC) and Kaffrine with 0.5 day (LC). All the regions are landlocked, more than 90% of the regions are located in the Central part and also more than half of them are located in the Southern part of the country.

The second cluster, with the most change, gathers - for example - the regions of Sédhiou with 2.5 days (MC), Goudiry and Ziguinchor at 2.5 days (MC) and Saint-Louis with 4.2 days (LC). In this cluster the mean number of days subject to dryness (below 1mm) in the rainy season is projected to increase by 3.0 days. More than 90% of the regions are landlocked and also more than half of them are located in the Western part of the country.

Table 51. Variation trends in consecutive dry days over Senegal

	rainy season
near future	1.2 days (MC) to 5.0 days (HC)
mid-century	-0.8 day (LC) and 4.2 days (HC)

Table 52. Changes of consecutive dry days over the project areas in Senegal

	least change	most change
Area	Guinguinéo with 0.0 days (MC) Tambacounda with 0.0 days (MC) Kaffrine with 0.5 day (LC)	Sédhiou with 2.5 days (MC) Goudiry and Ziguinchor at 2.5 days (MC) Saint-Louis with 4.2 days (LC)

Extreme Wet Events (R95pTOT)

The multi-model mean number of days subject to extreme wet events is projected to fluctuate between -1.2 days (HC) and 0.6 day (LC) in the dry season and fluctuate between -0.7 day (LC) and 0.5 day (LC) in the rainy season. By mid-century, average number of days subject to extreme wet events could fluctuate between -1.9 days (HC) and 0.5 day (LC) in the dry season and fluctuate between -1.2 days (MC) and 0.8 day (MC) in the rainy season. In the project area, the regions can be analysed in two categories:

With a mean number of days subject to extreme wet events increase of 0.4 day during the rainy season within the 2026-2055 period, the first cluster, which faces the least change, is composed of among others the following regions: Koupentoum with 0.3 day (MC), Malème Hodar at 0.3 day (MC) and Sédhiou at 0.1 day (MC). All the regions are landlocked, more than half of the regions are located in the Central part, more than half of the regions are located in the Western part and also more than half of them are located in the Southern part of the country.
With a mean number of days subject to extreme wet events decrease of -0.4 day, the second cluster, which looks towards the most change, is made up of - for example - the subsequent regions: Thiès with -0.1 day (LC), Tivaouane with -0.1 day (LC) and Saint-Louis with -0.5 day (LC). More than 80% of the regions are landlocked, more than half of the regions are located in the Western part and also more than 80% of them are located in the Northern part of the country.

Table 52. Variation trends in Extreme Wet Events over Senegal

	the dry season	rainy season
near future	-1.2 days (HC) and 0.6 day (LC)	-0.7 day (LC) and 0.5 day (LC)
mid-century	-1.9 days (HC) and 0.5 day (LC)	-1.2 days (MC) and 0.8 day (MC)

Table 53. Changes of Extreme Wet Events over the project areas in Senegal

	least change	moderate change	most change
Area	Koupentoum with 0.3 day (MC), Malème Hodar wth 0.3 day (MC) Sédhiou with 0.1 day (MC).	Bafing at 1.0 days (MC), Worodougou at 1.0 days (MC) and Worodougou at 1.0 days (MC)	Thiès with -0.1 day (LC), Tivaouane with -0.1 day (LC) Saint-Louis with -0.5 day (LC).

Temperature

The most severe increase describes similar patterns for temperature and extreme heat (mostly affecting landlocked areas), while on the opposite side, warm nights could primarily affect the coastal zone. The multi-model mean temperature is projected to increase from 0.7°C (HC) to 1.1°C (HC) in the dry season and increase from 0.6°C (HC) to 1.0°C (HC) in the rainy season. By mid-century, average temperature could increase from 1.3°C (HC) to 1.9°C (HC) in the dry season and increase from 1.2°C (HC) to 1.6°C (HC) in the rainy season. In the project area, the regions can be analyzed under three clusters:

The first cluster, facing the least change, gathers - for example - the regions of Oussouye and Saint-Louis and Mbour with an average temperature increase of 1.30°C during the rainy season by mid-century (2026-2055).
The second category facing moderate change, gathers - for example - Kébémer at 1.36°C (HC), Goudomp and Sédhiou with 1.36°C (HC). In this cluster the mean temperature is projected to increase by 1.39°C.
The third cluster, with the most change, consists of - for example - the regions of Goudiry with 1.63°C (HC) and Ranérou Ferlo with 1.63°C (HC). In this cluster the mean temperature is projected to increase by 1.54°C.

Table 54. Variation trends in temperature over Senegal

	dry season	rainy season
near future	0.7°C (HC) to 1.1°C (HC)	0.6°C (HC) to 1.0°C (HC
mid-century	1.3°C (HC) to 1.9°C (HC)	1.2°C (HC) to 1.6°C (HC)

Table 55. Changes of temperature in the project areas in Senegal

	least change	Moderate change	most change
Area	Increase of mean temperature of 1.30°C at - Oussouye - Saint-Louis - Mbour	Kébémer with 1.36°C (HC), Goudomp and Sédhiou with 1.36°C (HC)	Goudiry with 1.63°C (HC) Ranérou Ferlo with 1.63°C (HC)

Heatwaves (TX90p)

The multi-model mean number of days subject to extreme heat events is projected to increase from 13.6 days (HC) to 27.9 days (HC). By mid-century, the average number of days subject to extreme heat events could increase from 28.4 days (HC) to 55.0 days (HC). In the project area, the regions can be analysed in four categories.
With an average number of days subject to extreme heat events increase of 31.7 days annually within the 2026-2055 period, the first cluster, which looks towards the least change, is composed of among others the subsequent regions: Kaolack at 32.4 days (HC) and Thiès with 31.6 days (HC).
With a mean number of days subject to extreme heat events increase of 36.9 days, the second category, which looks towards lower change, is composed of - for example - the subsequent regions: Tivaouane at 36.6 days (HC) and Malème Hodar at 38.3 days (HC).
The third category facing higher change, consists of - for example - Bignona at 42.0 days (HC). In this category the average number of days subject to extreme heat events is projected to increase by 42.3 days.
The fourth cluster, with the most change, gathers the region of only Oussouye with 55.0 days (HC). All the regions are landlocked.

Table 56. Variation trends in Heatwaves over Senegal

near future	13.6 days (HC) to 27.9 days (HC).
mid-century	28.4 days (HC) to 55.0 days (HC)

Table 57. Changes of Heatwaves over the project areas in Senegal

	least change	Lower change	Higher change	most change
Area	-Kaolack with 32.4 days (HC) -Thiès with 31.6 days (HC)	Tivaouane with 36.6 days (HC) Malème Hodar with 38.3 days (HC).	Bignona with 42.0 days (HC)	Oussouye with 55.0 days (HC)

Warm Nights (TN90p)

The multi-model mean number of nights subject to extreme nighttime heat events is projected to increase from 10.5 nights (HC) to 29.4 nights (HC). By mid-century, the average number of nights subject to extreme nighttime heat events could increase from 18.6 nights (HC) to 66.8 nights (HC). In the project area, the regions can be analyzed in two categories:

With a mean number of nights subject to extreme nighttime heat events increase of 29.4 nights annually within the 2026-2055 period, the first cluster, which faces the least change, is composed of among others the following regions: Koupentoum and Ranérou Ferlo. All the regions are landlocked.
With a mean number of nights subject to extreme nighttime heat events increase of 57.9 nights, the second cluster, which looks towards the most change, is made up of - for example - the subsequent regions: Kaolack with 62.1 nights (HC) and Koungheul with 61.5 nights (HC).

Table 58. Variation trends in Warm Nights over Senegal

near future	10.5 nights (HC) to 29.4 nights (HC)
mid-century	18.6 nights (HC) to 66.8 nights (HC)

Extreme Wind Events (Sf95TOT)

In both scenarios, the highest increase in the number of days of extreme wind is projected to occur in the Eastern part of the project area. The model ensemble mean shows that the number of days subject to extreme wind events is projected to fluctuate between -1.8 days (MC) and 0.8 day (MC). By mid-century, the average number of days subject to extreme wind events could fluctuate between -2.1 days (MC) and 2.1 days (MC). In the project area, the regions can be analysed in three categories:
The first cluster, facing the least change, gathers - among others - the regions of Bounkiling and Kaolack with a mean number of days subject to extreme wind events decrease of -0.3 day annually by mid-century (2026-2055). This category encompasses Foundiougne at -0.4 day (MC) and Bignona with -0.8 day (LC). All the regions are landlocked.
The second cluster, with moderate change, consists of - for example - the regions of Koungheul with 2.1 days (LC) and Sédhiou with 0.9 day (LC). In this category the average number of days subject to extreme wind events is projected to increase by 1.0 day.
The third cluster, with the most change, gathers - among others - the regions of Tivaouane with -1.3 days (MC) and Thiès at -1.5 days (MC). In this cluster the average number of days subject to extreme wind events is projected to decrease by -1.5 days.
Despite the countries of Cote d'Ivoire and Ghana are not part of the areas of the Green Great Wall band, they are taken into account in this project since the selected areas are facing the same climate conditions compared to others.

Table 60. Variation trends in Extreme Wind Events over Senegal

near future	-1.8 days (MC) and 0.8 day (MC)
mid-century	-2.1 days (MC) and 2.1 days (MC)

Table 61. Extreme Wind Events the project areas in Senegal

	least change	Moderate change	most change
Area	Decrease of extreme wind events: - Foundiougne with -0.4 day (MC)	Increase of extreme wind events: Koungheul with 2.1 days (LC)	Decrease projection of extreme wind events: - Tivaouane with -1.3 days (MC)

	- Bignona with -0.8 day (LC).	Sédhiou with 0.9 day (LC).	- Thiès with -1.5 days (MC))

4. Cote d'Ivoire

IFAD GCF funding proposal targets the regions located in the Northern part of Côte d'Ivoire. From Gontougo in the South-Eastern part to Folon in the North-Western part. The project area, located in the Northern part of the country is only exposed to the Tropical Savanna climate (Aw). The project area displays relatively homogenous elevation with altitude ranging from about 400 to 800 meters above sea-level.
Data availabity, suitability and usability

In the GHCN database, Côte d'Ivoire provides access to 20 weather station data. In the project area, which is located in the Northern part, there are four stations available. Out of these four stations, one provides a limited number of climate-related indicators (instead of four for the other ones). Assessment of station data usability indicated that the station of Ferkessedougou, in the North presents limited usability due to (1) limited temporal coverage and (2) limited recentness. The precipitation and temperature data for the four stations available in the project area are displayed here for the period ranging from 2000 to nowadays. For the stations in Bouake, Korhogo and Odienne, a significant gap in availability prevents the use of this data for this historical analysis of the local climate. Considering the limited coverage of the available weather station data, the analysis provided in the feasibility study relies on ERA-5 data (see glossary for details). The analysis first investigates precipitation and then temperature in the period ranging from 1979 to 2018.

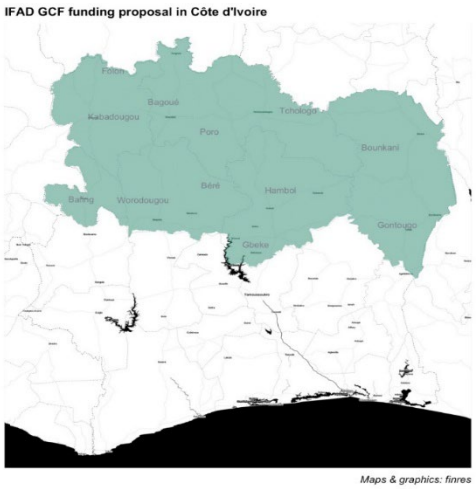


Figure 17*. Map of Cote d'Ivoire showing the targeted areas shaded in green*
Historical climate

Monthly precipitation: According to the clustering method applied for this analysis, the regions of the project area can be gathered under three categories ranging from East, with the lowest precipitation to the West with the highest temperature. The temporal pattern of precipitation is rather similar across the clusters with the July, August and September being the wettest.
Monthly Temperature: According to the same clustering method, the regions of the project area can be gathered under four categories. The warmest months of the year in all four clusters appear to be February, March and April while the coldest months coincide with the wettest months.

Average monthly temperatures in the clusters range from 24°C to 30°C. A recent increase in temperature for all months and all clusters can be observed (dark green).

Climate projections (Climate Hotspots)

Precipitation

Analysis show that in both mid and high climate scenario, the most severe changes in precipitation patterns and extremes are following a similar progression for the respective indicators. Uncertainties remain high.
The model ensemble mean precipitation is projected to fluctuate between -5.7% (MC) and 0.2% (LC) in the dry season and fluctuate between -0.5% (MC) and 2.6% (HC) in the rainy season. By mid-century, average precipitation could fluctuate between -4.3% (MC) and 0.8% (MC) in the dry season and increase from 1.0% (MC) to 5.4% (HC) in the rainy season. In the project area, the regions can be analysed under four categories:
With an average precipitation increase of 1.0% during the rainy season within the 2026-2055 period, the first cluster, which faces the least change, is composed of only one region: Gontougo.
With an average precipitation increase of 2.8%, the second cluster, which faces lower change, is composed of - among others - the following regions: Hambol with 2.8% (HC), Bafing with 2.8% (HC) and Bafing at 2.8% (HC).
The third category facing higher change, consists of - among others - the regions of Poro with 4.0% (MC), Gbeke at 4.0% (MC) and Béré at 4.1% (MC). In this cluster the mean precipitation is projected to increase by 3.9%.
The fourth category, with the most change, consists of - for example - the regions of only Tchologo with 5.3% (HC). In this category the average precipitation is projected to increase by 5.4%.

Table 62. Variation trends in precipitation over Cote d'Ivoire

	the dry season	rainy season
near future	-5.7% (MC) and 0.2% (LC)	-0.5% (MC) and 2.6% (HC)
mid-century	-4.3% (MC) and 0.8% (MC)	1.0% (MC) to 5.4% (HC)

Table 63. Precipitation changes over the project areas in Cote d'Ivoire

	least change	lower change	higher change	most change
area	Gontougo with 1.0%	Hambol with 2.8% (HC) Bafing with 2.8% (HC)	Poro with 4.0% (MC) Gbeke with 4.0% (MC) Béré with 4.1% (MC)	Tchologo with 5.3% (HC)

Consecutive Dry Days (CDD)

In the near future, the multi-model mean number of days subject to dryness (below 1mm) in the rainy season is projected to fluctuate between -0.3 day (MC) and 1.4 days (MC). By mid-century, the average number of days subject to dryness (below 1mm) in the rainy season could fluctuate between -0.7 day (MC) and 1.2 days (LC). In the project area, the regions can be analyzed under three clusters.

The first cluster, facing the least change, consists of - among others - the regions of Béré and Hambol with a mean number of days subject to dryness (below 1mm) in the rainy season increase of 0.3 day annually by mid-century (2026-2055).
The second cluster facing moderate change, gathers - for example - the regions of only Poro with -0.7 day (MC). In this category the mean number of days subject to dryness (below 1mm) in the rainy season is projected to decrease by -0.4 day.
With a mean number of days subject to dryness (below 1mm) in the rainy season increase of 0.9 day, the third category, which faces the most change, is made up of - for example - the subsequent regions: Worodougou at 0.7 day (MC), Bafing at 0.7 day (MC) and Kabadougou at 1.2 day (MC).

Table 64. Variation trends in consecutive dry days over Cote d'Ivoire

	rainy season
near future	-0.3 day (MC) and 1.4 days (MC)
mid-century	-0.7 day (MC) and 1.2 days (LC)

Table 65. Changes of consecutive dry days over the project areas in Cote d'Ivoire

	least change	moderate change	most change
Area	Béré and Hambol with 0.3 day	Poro with -0.7 day (MC)	Worodougou at 0.7 day (MC) Bafing at 0.7 day (MC) Kabadougou at 1.2 day (MC).

Extreme Wet Events (R95pTOT)

The multi-model mean number of days subject to extreme wet events is projected to decrease from -1.0 days (HC) to 0.0 day (LC) in the dry season and increase from 0.2 day (LC) to 0.7 day (MC) in the rainy season. By mid-century, average number of days subject to extreme wet events could decrease from -1.4 days (HC) to -0.1 day (MC) in the dry season and increase from 0.5 day (LC) to 1.7 days (MC) in the rainy season. In the project area, the regions can be analysed under four clusters.
The first cluster, facing the least change, consists of the region of Bagoué with an average number of days subject to extreme wet events increase of 0.5 day during the rainy season by mid-century (2026-2055).
With an average number of days subject to extreme wet events increase of 0.8 day, the second category, which faces lower change, is made up of - for example - the subsequent regions: only Poro and Folon with 0.8 day (LC).

With a mean number of days subject to extreme wet events increase of 1.1 days, the third cluster, which looks towards higher change, is made up of - for example - the subsequent regions: Bafing at 1.0 days (MC), Worodougou at 1.0 days (MC) and Worodougou at 1.0 days (MC).
With a mean number of days subject to extreme wet events increase of 1.7 days, the fourth cluster, which looks towards the most change, is composed of - for example - the subsequent regions: only Bounkani at 1.7 days (MC).
Temperature assessments display the main hotspots of temperature change and temperature-related extremes. In both scenarios mid and high, the most severe increase describes similar patterns.

Table 66. Variation trends in Extreme Wet Events over Cote d'Ivoire

	the dry season	rainy season
near future	-1.0 days (HC) to 0.0 day (LC)	0.2 day (LC) to 0.7 day (MC)
mid-century	-1.4 days (HC) to -0.1 day (MC)	0.5 day (LC) to 1.7 days (MC)

Table 67. Changes of Extreme Wet Events over the project areas in Cote d'Ivoire

	least change	lower change	higher change	most change
Area	Bagoué with an average number of days subject to extreme wet events increase of 0.5 day	Poro with 0.8 days Folon with 0.8 day (LC).	Bafing with 1.0 days (MC), Worodougou with 1.0 days (MC) Worodougou with 1.0 days (MC)	Bounkani with 1.7 days (MC).

Temperature

The multi-model mean temperature is projected to increase from 0.9°C (HC) to 1.1°C (HC) in the dry season and increase from 0.7°C (HC) to 0.8°C (HC) in the rainy season. By mid-century, average temperature could increase from 1.5°C (HC) to 1.7°C (HC) in the dry season and increase from 1.3°C (HC) to 1.3°C (HC) in the rainy season. All measured against temperature in the reference period (1979-2008). In the project area, the regions can be analysed under two categories.
The first category, facing the least change, gathers - among others - the regions of Bagoué and Gbeke and Bafing and Worodougou and Folon and Kabadougou with an average temperature increase of 1.28°C during the rainy season by mid-century (2026-2055).
The second category facing the most change, gathers - for example - the regions of only Hambol at 1.31°C (HC). In this cluster the average temperature is projected to increase by 1.32°C.

Table 68. Variation trends in temperature over Cote d'Ivoire

	dry season	rainy season
near future	0.9°C (HC) to 1.1°C (HC)	0.7°C (HC) to 0.8°C (HC)

mid-century	1.5°C (HC) to 1.7°C (HC)	1.3°C (HC) to 1.3°C (HC)

Table 69. Changes of Heatwaves over the project areas in Cote d'Ivoire

	least change	most change
Area	Increase on mean temperature increase of 1.28°C at Bagoué, Gbeke, Bafing, Worodougou, Folon and Kabadougou	Increase of 1.31°C at Hambol

Heatwaves (TX90p)

The multi-model mean number of days subject to extreme heat events is projected to increase from 27.4 days (HC) to 33.3 days (HC). By mid-century, the average number of days subject to extreme heat events could increase from 46.6 days (HC) to 58.3 days (HC). In the project area, the regions can be analyzed under three categories.

With an average number of days subject to extreme heat events increase of 47.7 days annually within the 2026-2055 period, the first cluster, which faces the least change, is composed of for example the subsequent regions: Tchologo, Bagoué.
With a mean number of days subject to extreme heat events increase of 53.4 days, the second category, which looks towards moderate change, comprises - for example - the subsequent regions: Gontougo at 54.6 days (HC), Folon at 54.6 days (HC) and Gontougo with 54.2 days (HC).
The third category facing the most change, gathers - among others - the regions of only Worodougou with 58.2 days (HC). In this category the mean number of days subject to extreme heat events is projected to increase by 57.6 days.

Table 70. Variation trends in Heatwaves over Cote d'Ivoire

near future	27.4 days (HC) to 33.3 days (HC)
mid-century	46.6 days (HC) to 58.3 days (HC).

Table 71. Changes of Heatwaves over the project areas in Cote d'Ivoire

	least change	moderate change	most change
Area	Tchologo Bagoué	Gontougo with 54.6 days (HC) Folon at 54.6 days (HC) Gontougo with 54.2 days (HC)	Worodougou with 58.2 days (HC).

Warm Nights (TN90p)

The multi-model mean number of nights subject to extreme nighttime heat events is projected to increase from 14.8 nights (HC) to 40.5 nights (HC). By mid-century, the average number of nights

subject to extreme nighttime heat events could increase from 43.2 nights (HC) to 100.7 nights (HC). In the project area, the regions can be analysed under two clusters.
With a mean number of nights subject to extreme nighttime heat events increase of 54.6 nights annually within the 2026-2055 period, the first cluster, which faces the least change, is composed of for example the following regions: Poro with 48.7 nights (HC) and Tchologo with 51.4 nights (HC).
With an average number of nights subject to extreme nighttime heat events increase of 91.7 nights, the second cluster, which faces the most change, is composed of - for example - the following regions: Gontougo at 93.2 nights (HC) and Béré with 93.2 nights (HC).

Table 72. Variation trends in Warm Nights over Cote d'Ivoire

near future	14.8 nights (HC) to 40.5 nights (HC)
mid-century	43.2 nights (HC) to 100.7 nights (HC)

Table 73. Changes of Warm Nights over the project areas in Cote d'Ivoire

	least change	most change
Area	Increase of nighttime extreme heat events: - Poro with 48.7 nights (HC) - Tchologo with 51.4 nights (HC).	Increase projection of extreme nighttime heat events: - Gontougo with 93.2 nights (HC) - Béré with 93.2 nights (HC).

Extreme Wind Events (Sf95TOT)

This assessment displays the main hotspots of extreme wind. In both scenarios, the highest increase in the number of days of extreme wind is projected to occur in the Eastern part of the project area. The model ensemble mean shows that the number of days subject to extreme wind events is projected to fluctuate between -1.2 days (MC) and 1.3 days (MC). By mid-century, the average number of days subject to extreme wind events could fluctuate between -1.1 days (LC) and 1.8 days (MC). In the project area, the regions can be analysed under three clusters.
The first category, facing the least change, consists of - among others - the regions of Gbeke and Tchologo with a mean number of days subject to extreme wind events increase of 0.6 day annually by mid-century (2026-2055).
With a mean number of days subject to extreme wind events decrease of -0.8 day, the second category, which faces moderate change, is made up of - for example - the subsequent regions: Bagoué at -1.0 day (MC), Poro at -1.0 day (MC) and Worodougou at -0.7 day (LC).
With an average number of days subject to extreme wind events increase of 1.7 days, the third category, which faces the most change, comprises - for example - the subsequent regions: only Gontougo at 1.8 days (LC).

Table 74. Variation trends in Extreme Wind Events over Cote d'Ivoire

near future	-1.2 days (MC) and 1.3 days (MC)
mid-century	-1.1 days (LC) and 1.8 days (MC)

Table 75. Changes of Extreme Wind Events the project areas in Cote d'Ivoire

	least change	moderate change	most change
area	Gbeke and Tchologo with an increase of extreme wind events by 0.6 day annually by mid-century	Decrease of extreme wind events: - Bagoué with -1.0 day (MC) - Poro with -1.0 day (MC) - Worodougou with -0.7 day (LC).	Increase of extreme wind events at Gontougo with 1.8 days (LC).

5. Ghana

The IGREENFIN funding proposal targets the regions located in the Northern and Middle Belts of Ghana. Ghana has one dominant climate regime: A tropical savanna climate with dry-winter characteristics (in pink on the map) that represents more than 95% of the country's area. The project area, located in the Northern part of the country is only exposed to the Tropical Savanna climate (Aw).
Data availabity, suitability and usability

In the GHCN database, Ghana provides access to 20 weather station data. In the project area, which is located in the Northern and Central parts, there are four stations available. Out of these seven stations, all seven stations provide data on temperature (min., mean and max.) as well as precipitation.

The assessment of the extent to which the data from the weather stations provided to GHCN provide a solid enough basis to elaborate a detailed climate risk analysis indicate that the data from all stations available in GHCN have both satisfactory temporal coverage (more than 30 years) and recentness (available until at least 2019).

Reanalyzed historical data (ERA-5): Monthly precipitation: According to the clustering method applied for this analysis, the regions of the project area can be gathered under three categories ranging from North (Cluster 3), with the lowest precipitation to the Southern part of the project area with the highest precipitation (Cluster 2). The temporal pattern of precipitation is relatively different across clusters with the July, August and September being the wettest in the Northern regions, while the rainy season last from March-April to September in the Southern part of the project area. The regions part of the cluster 1 appear as transition zone.

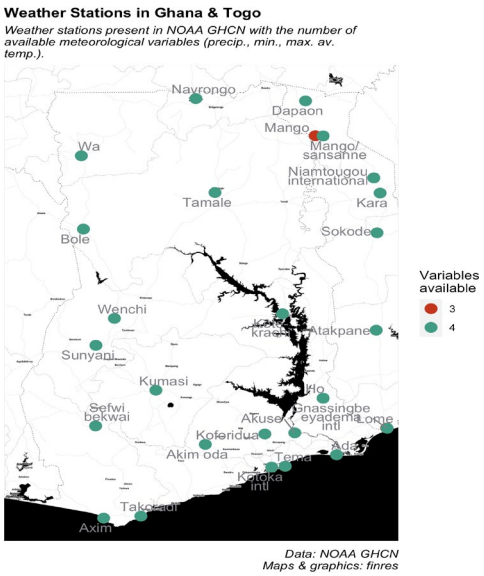


Figure 18*. Weather stations map in Ghana*

Historical climate

Monthly Temperature: According to the same clustering method, the regions of the project area can be gathered under two categories, with a clear divide between Northern and Southern parts of the project area. The warmest months of the year in all four clusters appear to be February, March and April while the coldest months coincide with the wettest months. Average monthly temperatures in the clusters range from 24°C to 28°C in the Southern part and from 25°C to 31°C in the Northern regions. A recent increase in temperature for all months and all clusters can be observed (dark green) in comparison to temperature in the reference period (light green).

Climate projections

On the basis of the overall climate variability and change analysis, a summary of areas which are projected to be the least to most affected by climate change indicate that in both scenarios, RCP4.5 (left) and RCP8.5 (right) the Middle Belt of Ghana is projected to be the most affected.

Precipitation (main hotspots of precipitation change and precipitation-related extremes). In both scenarios, the most severe changes in precipitation patterns and extremes are following a similar progression for the respective indicators. Uncertainties remain high, particularly for the frequency of consecutive dry days.

Mid-warming scenario (RCP4.5): The near future, the multi-model mean precipitation is projected to fluctuate between -6.3% (MC) and 3.8% (MC) in the dry season and fluctuate between -2.1% (LC) and 2.9% (MC) in the rainy season. By mid-century, average precipitation could fluctuate between -7.2% (LC) and 7.3% (MC) in the dry season and fluctuate between -0.6% (MC) and 8.1% (HC) in the rainy season. In the project area, the regions can be analyzed under two categories:

The first cluster, with the least change, gathers - among others - the regions of Sunyani and Obuasi Municipal with a mean precipitation increase of 1.2% during the rainy season by mid-century (2026-2055). This category involves Obuasi Municipal with 0.9% (LC), Techiman with 0.9% (LC) and Atwima at 2.4% (LC).

With a mean precipitation increase of 6.1%, the second category, which faces the most change, comprises - for example - the subsequent regions: Sene with 5.6% (MC), Sawa-Tuna-Kalba at 5.6% (MC) and Kintampo North with 4.9% (MC).

Table 76. Variation trends in precipitation over Ghana

	the dry season	rainy season
near future	-6.3% (MC) and 3.8% (MC)	-2.1% (LC) and 2.9% (MC)
mid-century	-7.2% (LC) and 7.3% (MC)	-0.6% (MC) and 8.1% (HC)

Table 77. Precipitation changes over the project areas in Ghana

	least change	most change
area	Obuasi Municipal with 0.9% (LC) Techiman with 0.9% (LC) Atwima at 2.4% (LC)	Sene with 5.6% (MC) Sawa-Tuna-Kalba at 5.6% (MC) Kintampo North with 4.9% (MC).

Consecutive Dry Days (CDD)

The near future, the multi-model mean number of days subject to dryness (below 1mm) in the rainy season is projected to fluctuate between -1.8 days (MC) and 3.9 days (MC). By mid-century, the average number of days subject to dryness (below 1mm) in the rainy season could fluctuate between -3.5 days (MC) and 2.2 days (LC). In the project area, the regions can be analysed in four clusters:

The first cluster, facing the least change, gathers - among others - the regions of Bolgatanga and Ejura Sekyedumase with a mean number of days subject to dryness (below 1mm) in the rainy season decrease of -0.2 day annually by mid-century (2026-2055). This group involves Atebubu-Amantin and Manya Krobo with -0.1 day (LC), Gushiegu at -0.1 day (LC) and Bosomtwe-Kwanwoma with -0.1 day (LC).
The second cluster facing lower change, consists of - among others - the regions of Amansie East and East Akim at 0.5 day (LC), Saboba Chereponi at 0.5 day (LC) and Kwabre with 0.3 day (LC). In this category the mean number of days subject to dryness (below 1mm) in the rainy season is projected to increase by 0.7 day.
The third cluster facing higher change, consists of - among others - the regions of Atwima Mponua at 1.7 days (LC), Amansie Central with 1.7 days (LC) and Obuasi Municipal with 1.3 days (LC). In this cluster the mean number of days subject to dryness (below 1mm) in the rainy season is projected to increase by 1.6 days.
With a mean number of days subject to dryness (below 1mm) in the rainy season decrease of -2.7 days, the fourth cluster, which faces the most change, comprises - among others - the subsequent regions: only Asuogyaman at -1.8 days (MC).

Table 78. Variation trends in consecutive dry days over Ghana

	rainy season
near future	-1.8 days (MC) and 3.9 days (MC)
mid-century	-3.5 days (MC) and 2.2 days (LC)

Table 79. Changes of consecutive dry days over the project areas in Ghana

	least change	Lower changer	higher change	most change
area	Bolgatanga and Ejura Sekyedumase -0.2 day Atebubu-Amantin and Manya Krobo with -0.1 day (LC) Gushiegu at -0.1 day (LC) Bosomtwe-Kwanwoma with -0.1 day (LC).	Amansie East and East Akim at 0.5 day (LC), Saboba Chereponi at 0.5 day (LC) Kwabre with 0.3 day (LC)	Atwima Mponua at 1.7 days (LC) Amansie Central with 1.7 days (LC) Obuasi Municipal with 1.3 days (LC)	Asuogyaman at -1.8 days (MC)

Extreme Wet Events (R95pTOT)

The multi-model mean number of days subject to extreme wet events is projected to fluctuate between -1.2 days (HC) and 0.6 day (MC) in the dry season and fluctuate between -0.4 day (MC) and 1.1 days (HC) in the rainy season. By mid-century, average number of days subject to extreme wet events could fluctuate between -1.6 days (HC) and 0.6 day (MC) in the dry season and increase from 0.4 day (MC) to 2.4 days (HC) in the rainy season. In the project area, the regions can be analysed in two clusters.

The first category, with the least change, consists of - for example - the regions of East Mamprusi and Garu Tempane and Kassena Nankana with an average number of days subject to extreme wet events increase of 0.9 day during the rainy season by mid-century (2026-2055). This category encompasses Adansi South and Akwapim South and Atiwa at 0.8 day (MC), Asunafo North and Asunafo South and Nanumba South at 0.8 day (MC) and Atwima Mponua with 1.2 day (MC).
With a mean number of days subject to extreme wet events increase of 1.6 days, the second cluster, which faces the most change, comprises - for example - the subsequent regions: Atebubu-Amantin and Afram Plains at 2.4 days (MC), Tamale with 2.4 days (MC) and Sekyere East and Manya Krobo at 1.9 days (LC).

Table 80. Variation trends in Extreme Wet Events over Ghana

	the dry season	rainy season
near future	-1.2 days (HC) and 0.6 day (MC)	-0.4 day (MC) and 1.1 days (HC)
mid-century	-1.6 days (HC) and 0.6 day (MC)	0.4 day (MC) to 2.4 days (HC)

Table 81. Changes of Extreme Wet Events over the project areas in Ghana

	least change	most change
area	Adansi South and Akwapim South and Atiwa with 0.8 with (MC) Asunafo North and Asunafo South and Nanumba South at 0.8 day (MC) and Atwima Mponua with 1.2 day (MC).	Atebubu-Amantin and Afram Plains with 2.4 days (MC), Tamale with 2.4 days (MC) Sekyere East and Manya Krobo at 1.9 days (LC).

Temperature

In both scenarios, the most severe increase describes similar patterns (main hotspots of temperature change and temperature-related extremes).
Change in Temperature: The multi-model mean temperature is projected to increase from 0.8°C (HC) to 1.2°C (HC) in the dry season and increase from 0.7°C (HC) to 0.8°C (HC) in the rainy season. By mid-century, average temperature could increase from 1.4°C (HC) to 1.8°C (HC) in the dry season and increase from 1.2°C (HC) to 1.4°C (HC) in the rainy season. In the project area, the regions can be analysed in three clusters:
With a mean temperature increase of 1.26°C during the rainy season within the 2026-2055 period, the first category, which faces the least change, is composed of for example the subsequent regions: Adansi North.
With an average temperature increase of 1.30°C, the second category, which looks towards moderate change, comprises - for example - the subsequent regions: Berekum and Sawa-Tuna-Kalba with 1.29°C (HC).
The third cluster facing the most change, gathers - among others - the regions of Afigya Sekyere and Nanumba North with 1.36°C (HC) and Kintampo South and Tain and Bole with 1.37°C (HC). In this category the mean temperature is projected to increase by 1.35°C.

Table 82. Variation trends in temperature over Ghana

	dry season	rainy season
near future	0.8°C (HC) to 1.2°C (HC)	0.7°C (HC) to 0.8°C (HC)
mid-century	1.4°C (HC) to 1.8°C (HC)	1.2°C (HC) to 1.4°C (HC)

Table 83. Changes of Heatwaves over the project areas in Senegal

	least change	most change
Area	Increase on mean temperature increase of 1.28°C at Bagoué, Gbeke, Bafing, Worodougou, Folon and Kabadougou	Increase of 1.31°C at Hambol

Heatwaves (TX90p)

The multi-model mean number of days subject to extreme heat events is projected to increase from 23.1 days (HC) to 44.4 days (HC). By mid-century, the average number of days subject to extreme heat events could increase from 35.3 days (HC) to 75.4 days (HC). In the project area, the regions can be analyzed in three clusters:
With a mean number of days subject to extreme heat events increase of 42.6 days annually within the 2026-2055 period, the first category, which looks towards the least change, is composed of for example the following regions: Asunafo South with 44.5 days (HC), Savelugu Nanton at 44.5 days (HC) and Asunafo North with 45.6 days (HC).
The second cluster, with moderate change, gathers - for example - the regions of Bosomtwe-Kwanwoma with 51.9 days (HC), Amansie East at 51.9 days (HC) and Berekum with 54.8 days (HC). In this cluster the average number of days subject to extreme heat events is projected to increase by 53.7 days.
With a mean number of days subject to extreme heat events increase of 66.7 days, the third cluster, which looks towards the most change, is made up of - for example - the subsequent regions: Sene at 61.1 days (HC), Sekyere East at 61.1 days (HC) and Nkoranza at 62.7 days (HC).

Table 84. Variation trends in Heatwaves over Ghana

near future	23.1 days (HC) to 44.4 days (HC)
mid-century	35.3 days (HC) to 75.4 days (HC)

Table 85. Changes of Heatwaves over the project areas in Ghana

	least change	moderate change	most change
area	Asunafo South with 44.5 days (HC) Savelugu Nanton at 44.5 days (HC) Asunafo North with 45.6 days (HC).	- Bosomtwe Kwanwoma with 51.9 days (HC) Amansie East with 51.9 days (HC) - Berekum with 54.8 days (HC)	Sene at 61.1 days (HC) Sekyere East with 61.1 days (HC) Nkoranza with 62.7 days (HC)

Warm Nights (TN90p)

The multi-model mean number of nights subject to extreme nighttime heat events is projected to increase from 8.1 nights (HC) to 53.1 nights (HC). By mid-century, the average number of nights subject to extreme nighttime heat events could increase from 16.0 nights (HC) to 106.9 nights (HC). In the project area, the regions can be analyzed in two clusters:

With a mean number of nights subject to extreme nighttime heat events increase of 26.3 nights annually within the 2026-2055 period, the first category, which faces the least change, is composed of for example the subsequent regions: Kintampo North and Saboba Chereponi.
The second cluster, with the most change, consists of - among others - the regions of Jaman South with 80.5 nights (HC) and Atwima Mponua and Tano South with 86.0 nights (HC). In this category the mean number of nights subject to extreme nighttime heat events is projected to increase by 88.6 nights.

Table 86. Variation trends in Warm Nights over Ghana

near future	8.1 nights (HC) to 53.1 nights (HC)
mid-century	16.0 nights (HC) to 106.9 nights (HC)

Table 87. Changes of Warm Nights over the project areas in Ghana

	least change	most change
Area	Increase of nighttime extreme heat events: - Kintampo North - Saboba Chereponi.	Increase projection of extreme nighttime heat events: - Jaman South with 80.5 nights (HC) - Atwima Mponua and Tano South with 86.0 nights (HC)

Extreme Wind Events (Sf95TOT)

In both scenarios, the highest increase in the number of days of extreme wind is projected to occur in the South-Western part of the project area (main hotspots of extreme wind).

Extreme Wind Events (Sf95TOT): The multi-model mean number of days subject to extreme wind events is projected to fluctuate between -1.4 days (MC) and 3.4 days (LC). By mid-century, the average number of days subject to extreme wind events could fluctuate between -1.4 days (MC) and 4.8 days (MC). In the project area, the regions can be analysed under three clusters:

The first cluster, facing the least change, gathers - among others - the regions of Savelugu Nanton and West Gonja and Gushiegu and Dormaa with a mean number of days subject to extreme wind events decrease of -0.4 day annually by mid-century (2026-2055). This category includes Bunkpurugu Yunyoo at 0.1 day (MC), Karaga and Nadowli at 0.1 day (MC) and Dormaa with 0.5 days (MC).
With a mean number of days subject to extreme wind events increase of 1.8 days, the second category, which looks towards moderate change, comprises - for example - the following regions: Kwabre and Zabzugu Tatale with 1.1 days (LC), Offinso at 1.1 days (LC) and Bosomtwe-Kwanwoma with 1.3 day (LC).
With a mean number of days subject to extreme wind events increase of 3.9 days, the third cluster, which faces the most change, is made up of - among others - the following regions: Adansi North with 3.1 days (MC), Asante Akim South and Asante Akim North with 3.1 days (MC) and Ejisu-Juabeng and Pru at 3.8 days (LC).

Table 88. Variation trends in Extreme Wind Events over Ghana

near future	-1.4 days (MC) and 3.4 days (LC)
mid-century	-1.4 days (MC) and 4.8 days (MC)

Table 89. Changes of Extreme Wind Events the project areas in Ghana

	least change	moderate change	most change
area	Decrease events: Bunkpurugu Yunyoo with 0.1 day (MC), Karaga Nadowli with 0.1 day (MC) Dormaa with 0.5 days (MC).	Increase of extreme wind events: -Kwabre and Zabzugu Tatale with 1.1 days (LC) - Offinso with 1.1 days (LC) - Bosomtwe-Kwanwoma with 1.3 day (LC).	Increase of extreme wind events: Adansi North with 3.1 days (MC) Asante Akim South and Asante Akim North with 3.1 days (MC) Ejisu-Juabeng and Pru with 3.8 days (LC).