Intensification of Agriculture and Agroforestry Technologies (IAAT) for Climate Resilient Food and Nutrition Security: Tombouctou, Gao, Mopti, Koulikoro and Segou Regions of Mali

Annex 2: Feasibility Study

Accredited Entity: Save the Children Australia

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Contents

I. INTRODUCTION

1.1 Objective of the Feasibility Study

This study provides background information for the Green Climate Fund funding proposal for the feasibility of "Intensification of Agriculture and Agroforestry Techniques (IAAT) to build climate-resilient food and nutrition security: Tombouctou, Gao, Mopti, Koulikoro and Segou regions of Mali", prepared by Save the Children International Mali, in partnership with the Government of Mali.

The objective of the feasibility study is to present the explanation of the underlying logic of the project structure and activities, the reasons why interventions have been chosen for the IAAT, and the technological options analyzed for this proposed project scope. As a result, this feasibility study provides a detailed explanation of the contextual background of the project as well as the logical processes and conclusions that have been utilized, and the corresponding project design that is the most feasible and sound for the project. In addition, the feasibility study provides a summary of the economic and financial viability of the project, how the project will be implemented, and how the impacts of the project will be maintained due to its exit strategy.

1.2 Problem Statement

Mali is highly exposed to the impacts of climate change with ND-GAIN ranking it as the 11th most vulnerable to climate change and the 23rd least ready for climate change out of 192 countries.[1] With erratic rainfall (which is largely associated with floods and droughts), and mean temperatures of 28ºC that have experienced an average of 0.15°C increase per decade since the 1960s (associated with droughts and hotter days and nights and extreme heatwaves), Mali's climatic conditions negatively impact the country's agricultural suitability and productivity and ultimately contribute to increasing food insecurity.[2,3] In October-December 2022, 3.4 million people were food insecure (15% of the population) of which 617k were in the "crisis" phase; with overall food insecurity forecast to increase to 18% of Mali's population during June-August 2023.[4] Extreme poverty is also widespread throughout the Mail and has recently increased to reach 19.1% of the population in 2022 (up from 15.9% in 2021).[5]

Mali has a high dependence on small-scale, rainfed, subsistence agriculture and agropastoralism with agriculture the main source of livelihood for 80% of the population.[6] However, agriculture is threatened by increasingly adverse climatic conditions (72% of Mali's population lives in medium to high climate vulnerability), further compounded by challenges from political instability and armed conflict in some communities in eastern regions of the Mali.[7] Although there is a long tradition of adaptive techniques amongst smallholder farmers adjust to climatic hazards, there remain many tec to adaptation including limited access to finance for adaptation investments, limited educational channels for adaptation information, and additional systematic barriers for women and youth farmers. In addition, as climate hazards in Mali are forecast to increase, (primarily the severity of droughts and floods), they are predicted to generate losses of up to USD 300 million per year from 2030 onwards (around 15% of the value created by agriculture and breeding).[8] The adaptation priorities of Mali in agriculture and allied sectors include integrated soil fertility management, development of adaptive livestock systems, sustainable management of agroecology and implementation of climate-smart agriculture[9].

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[1] ND-GAIN Matrix, (2021), Available here
[2] Climate change / Mali: Interactive country fiches. Available here
[3] World Bank Climate Knowledge Portal, (2021), Mali profile. Available here
[4] Food Security Cluster (2022), November 2022 Harmonized Framework Results, Available here
[5] World Bank, (2023), Mali Presentation, Available here
6 N'Diaye, I., Aune, J.B., Synnevåg, G., Yossi, H., & Hamadoun, A. (Eds.). (2020) Adaptation de l'Agriculture et de l'Élevage au Changement Climatique au Mali: Résultats et leçons apprises au Sahel. Available here
[7] FAO (2017), "Country fact sheet on food and agriculture policy trends. Socio-economic context and role of agriculture." *Food and Agriculture Policy Decision Analysis.* Available here
[8] Makougoum C. T. P., (2020), Changement climatique au Mali : Impact de la sécheresse sur l'agriculture et stratégies d'adaptation, Available here
[9] Ministry of The Environment, Sanitation and Sustainable Development, (2021), Revised Nationally Determined Contributions, Available here

Mali's updated NDC indicated that country has large gap in technical and financial capacities to implement priority adaptation and mitigation actions in the country and requires external support.

In parallel, Mali is considered one of the world's "Least Developed Countries" with a GNI of $842 per capita and a Human Assets Index score of 45.6 against the LDC average of 57.6, making low-carbon pathways to sustainable development critical for the country.[10] Although Mali's current GHG emissions are very low in comparison to developed markets (4% of the global average per capita), in light of forecast economic development baseline scenarios forecast an increase in Mali's GHG emissions[11,12]. With agriculture responsible for approximately 70-80% of Mali's total GHG emissions, low-carbon agricultural livelihoods are crucial within this sector in order to achieve the government of Mali's 2021 commitment to reducing its GHG emissions in agricultural, energy, land use, and forest management (as part of its Nationally Determined Contribution submitted to UNFCCC).[13,14,15]

1.3 The proposed project

The IAAT project seeks to increase the adaptive capacity of smallholder farmers to climate change in Mali (both sedentary pastoralists and sedentary crop farmers) whilst also increasing the prevalence of low-carbon livelihood options. IAAT will do this by increasing smallholder farmer awareness and understanding of incentives for, and access to climate-smart agricultural (CSA) practices, techniques, technologies, and services, ultimately resulting in resilient and low-carbon agricultural production systems. To achieve this, the project will seek to overcome barriers to CSA adoption at all core levels of Mali's agricultural system, including directly with smallholder farmers and agri-entrepreneurs; agro-extension services; private sector businesses in CSA-compatible value chains; local financial providers and local and national government bodies.

The project will effectively contribute to low-emission and climate-resilient development pathways in Mali by increasing the long-term capacity of smallholder communities and their surrounding environment to recognize and respond to climate risks, increasing sustainable and low-carbon crop and livestock production and land management by smallholder farmers, and hence, both increase the resilience and reduce the GHG emissions of the agricultural system. IAAT will also facilitate building a strong partnership between private solar and biodigester technology suppliers through a Pay-As-You-Go (PAYG) financial and technology transfer model in the IAAT locations. This approach will bring a large amount of private sector finance from technology suppliers and financial institutions. The private sector will continue scaling up and replicating this business model in and beyond IAAT locations during and after the project completion.

IAAT's approach is consistent with Mali's existing policy priorities and devolved governance approach increasing its long-term paradigm shift potential as well as its support within the country. For example, the project's emphasis on Climate Smart Agriculture, that is directly aligned with NDC, NAPA, and PDESC. IAAT also has strong institutional foundations for scale-up within Mali. The USAID Albarka project, IAAT's co-funder and co-implementing partner, has existing field infrastructure and already established relationships with the Environment and Sustainable Development Agency (AEDD – known nationally in French as the AEDD) - the Executing Entity, the Ministry of Agriculture, other governmental and non-governmental entities, and vulnerable communities. These existing relationships will provide a platform for the project to scale up actions effectively and efficiently both during and after the project implementation. Replication examples include the establishment of CACs

[10] UN LDC (2021), Mali Profile, Available here
[11] Our World in Data using Global Carbon Project 2023 data , (2021), Mali: CO2 profile, Available here. Land use is not included in the estimation.
[12] Ministry of The Environment, Sanitation and Sustainable Development, (2021), Revised Nationally Determined Contributions, Available here
[13] Ministry of The Environment, Sanitation and Sustainable Development, (2021), Revised Nationally Determined Contributions, Available here
[14] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[15] Estimated FAO total emissions from agriculture (Available here) as a percentage of the World Bank (2023) Total greenhouse gas emissions. (Available here). NB that there will be some discrepancy due to differing methodologies employed.

and development of Community Action Plans, the development process for contingency plans for EWS information dissemination and response, extension officer curriculum, national land use database, youth and women business and financial training, guidelines for financial institutions (including microfinance), establishment and capacity building of private sector to engage and provide services to smallholder farmers.

IAAT seeks to enhance the knowledge and data environment around climate-smart agriculture and agroforestry at the community, regional, and national levels in Mali. The project will also enhance the local knowledge network including communities, public and private extension agents, and market agents. This knowledge exchange directly supports the scale-up climate-resilient agricultural practices and reinforces the resilience of farmers' livelihoods. For example, the CSA curriculum, social mobilization, and integration of traditional knowledge and experience in climate change adaptation are key tools for scaling up CSA and agroforestry. Agroforestry activity in IAAT will only include a) in private crop land – integration of fodder and fruit trees in the existing crop and livestock farming system for better soil and land management, b) in public land – plantation of fodder, fruits and other useful trees in degraded lands for sustainable rehabilitation without land transferring to crop cultivation and other structural changes. At the regional and national level, IAAT explicitly targets knowledge exchange and the sharing of lessons learned through yearly forums for all key actors (national, regional, and local bodies, other agricultural and climate change projects, researchers, and traditional knowledge groups) to share and discuss the key technical learnings of the project and how these could be broadened to additional areas.

The IAAT project will also create an enhanced land use database and deliver training on the interpretation of land use data to extension services. By increasing access to reliable information at the extension service level, the project will facilitate improved climate adaptation by improving the tailoring of adaptive techniques to the circle level. In addition, the land use database will enhance the national data environment for future mitigation and adaptation planning and research at the local and national levels, including for policies, research, and interventions. In support of this knowledge sharing, the Monitoring and Evaluation Plan (see Annex 11) will also develop a detailed view of the realized outputs of the project during implementation to support the ongoing development of implementation insights and "lessons learned". The project's knowledge management and learning activities will therefore develop and enhance knowledge availability and knowledge resource management competence at the national level, as well as farmers' ability to propose solutions to changing climate circumstances.

IAAT will contribute to the creation of an enabling environment for a low-carbon and climate-resilient agricultural system in Mali by i) addressing existing systemic barriers to adaptation and mitigation at the farm and community levels, ii) closing market-level knowledge gaps on how private sector businesses can serve smallholder farmers with low-carbon and climate resilient products and services and iii) building institutional capacity for long-term adaptation and mitigation planning and implementation. The project will address a broader range of systemic barriers as outlined and shown in the ToC diagram, including financial, informational, social, market, and technical as discussed in section B. 2 (a). Addressing these barriers will also help to create the enabling environment for scaling up CSA and agroforestry. IAAT will significantly contribute to institutional capacity building. The institutional capacity building at the community, regional and national level for mitigation and adaptation planning and implementation will contribute to the shift in the institutional priorities to address climate change challenges across the country.

IAAT has three components with eight outputs.

Component 1: Improving Extension Services and Increasing On-farm CSA Adoption. This component will focus on i) increasing the awareness of climate risks and ii) the understanding and technical

capacity of smallholder farmers to adopt CSA techniques by firstly building the capacity of agro-advisory services, the key educational service for smallholder farmers, and secondly by supporting the on-farm adoption of CSA techniques. This ccomponent will also enhance on-farm adoption of low-carbon CSA technologies and agroforestry to reduce the carbon emissions of the agricultural system whilst simultaneously supporting increased productivity in the regions targeted by the project. It will therefore achieve outputs 1.1 *"Improved technical capacities and inclusivity of extension services in climate-smart agriculture and agroforestry production* ", output 1.2 "*Increased use of climate resilient practices in the production of CSA crops, livestock, and agroforestry by smallholder farmers", and output 1.3 "Increased land area under agroforestry".*

Component 2: Supporting the development of CSA and agroforestry value chains: This aims to create sustainable markets for CSA and agroforestry products and ultimately more diverse and sustainable livelihoods for the target communities by fostering the development of connected value chains (from the input stage, including financing and technologies, to product sales and distribution) and lifting the barriers disproportionately faced by women and youth entrepreneurs for starting and running businesses, including access to finance. This will also encompass distributing solar irrigation and biodigester systems, supporting agricultural activities, as well as strengthening the associated value chains, infrastructure, and operational capacities. Component 2 will achieve outputs 2.1 *"CSA and agroforestry VCs are more connected and reach more smallholder farmers"*, 2.2 *"Smallholder farmers, especially youth and women, can more easily overcome barriers to entrepreneurship in CSA and agribusiness", and 2.3 "Increased adoption of low-carbon agriculture technologies by smallholder farmers".*

Component 3: Increasing institutional capacity and knowledge: This component will work to strengthen the institutional capacities of government entities at the local, regional, and national levels, as well as communities through Community Action Cycles (CACs), improving their adaptation planning capacities and management systems and procedures. It will also enhance stakeholder collaboration for knowledge-sharing for scaling out CSA, enhancing the impacts and reach of Components 1-2. Component 3 will achieve outputs 3.1 "Increased institutional capacity in climate change adaptation and mitigation planning and best practices to address agriculture-related climate risks" and 3.2 "Enhanced knowledge sharing and coordination of best practices in CSA and agroforestry across stakeholders".

The project activities will result in the following 2 co-benefits:

- **Co-benefit 1 Gender and social inclusion:** Increased gender equality and economic empowerment for women. Outcomes 1 and 2 will together deliver gender co-benefits. Output 2.2 will specifically seek to reduce barriers to entrepreneurship with a focus on women by increasing access to finance, delivering training on entrepreneurship, and making connections to other value chain actors. In component 1, the improved extension services targeted in output 1.1 will include a provision to increase the gender inclusivity of the existing services, and output 1.2 will target to reach 50% of women to ensure women are equally able to benefit from the new training (in contrast to their existing reduced access). In addition, the biodigester systems installed and promoted in component 2 will increase gender equality by reducing the time taken for households to collect wood for existing energy sources, a task often conducted by women. Taken together, these outcomes will deliver increased gender equality and empowerment by supporting women to have access to services and inputs currently more easily accessible by men, increasing the capacity of women beneficiaries and the time available to generate a sustainable income. In addition, increased gender equality and economic empowerment will also generate economic co-benefit by improving women's participation in food value chain and business activities. The promotion of the solar pumping system from Outcome 3 will improve women's access to water for household and agriculture use which reduces women's time to fetch water which can result in more time available for other productive or non-productive activities.

- Co-benefit 2 Environmental: Improved soil conditions and water resources from land use improvements. Outcomes 1 and outcome 3 will alter land use by smallholder farmers and together result in improved soil and water quality as a result of i) the adoption of improved water and soil management practices by smallholder farmers during crop and livestock production (output 1.2), and ii) the soil and water benefits provided by agroforestry such as improve soil biota and water flow (output 1.3). These activities will enhance healthy ecosystem services and create public goods for the communities. Several recent studies show that sustainable intensification of agroforestry and agriculture systems has positive impacts on diversification of pollination, pest control, nutrient cycling, GHG emissions reductions, water regulation, and soil health.[16, 17]

[16] Snapp et al. 2021. Agroecology and climate change- rapid evidence review. Agroecology and climate change rapid evidence review: Performance of agroecological approaches in low- and middle- income countries. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

[17] Biswas et al. 2022. Agroforestry offers multiple ecosystem services in degraded lateritic soils. Journal of Cleaner Production, 365: 132768

II. DESIGN APPROACH

2.1 Introduction to the design approach

The design of the GCF IAAT lays its foundation in a co-creation approach with multiple stakeholders contributing to the agriculture, agroforestry, and social ecosystems in Mali (incl. government, private sector, communities, research institutes, civil society organizations, international NGOs, etc.), placing the beneficiaries in the center of project design. This co-creation approach materialized through ongoing consultation of and collaboration with key stakeholders to iterate the project concept, define activities tailored to the needs of the communities, and elaborate strategies to achieve optimal impact.

The following key principles have guided this approach:

- Targeting long-term sustainable change through the project's activities, with impacts that will endure after the close of the project.
- Ensuring that project design and implementation are both informed and guided by stakeholder insights, particularly with beneficiaries in mind to ensure that the project addresses the intrinsic needs of communities/households and meaningfully contributes to enhanced adaptation and resilience capacities of Malian agriculture and natural resource-dependent communities.
- Building upon the climatic conditions and economic and sociocultural realities of Mali and adopting an inclusive and bottom-up approach in project design and implementation, to calibrate the activities optimally so they benefit the most vulnerable locations and beneficiaries.
- Ensuring alignment of GCF IAAT with government priorities regarding agriculture, agroforestry, and climate change to meaningfully contribute to Mali's sustainable development objectives, create ownership from authorities, and ensure the sustainability of key achievements beyond project implementation.
- Ensuring complementarity of GCF IAAT with existing initiatives in Mali to collaboratively leverage synergies and generate economies of scale.

The feasibility study and the funding proposal are built on the GCF-approved concept note and have been driven by analysis, stakeholder engagement, and GCF inputs to the concept note.

2.2 Structure and logical flow of the feasibility study

The feasibility study starts with context chapters that help understand the existing legal, financial and political context in Mali (*Chapter III Mali Context*), as well as climatic context which discusses current and future exposure to climatic risks (*Chapter IV Mali's Climate and Recent* Trends).

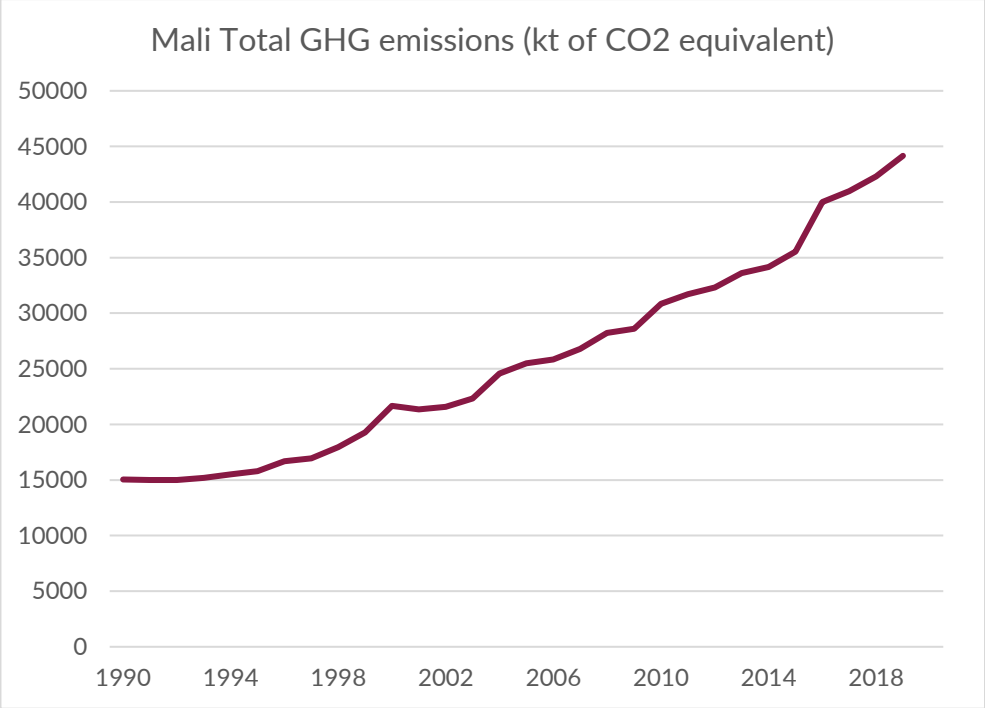
The study highlights the need for financing to promote adaptation and mitigation in Mali, discussing the projected exposure to climate hazards (*Chapter V Climate Change Projections and Hazards*), the causes of climate change (*Chapter 0*

5.3 The Causes of GHG emissions in Mali and **Mitigation Options**

5.3.1 Current emissions levels in Mali and the breakdown by sector

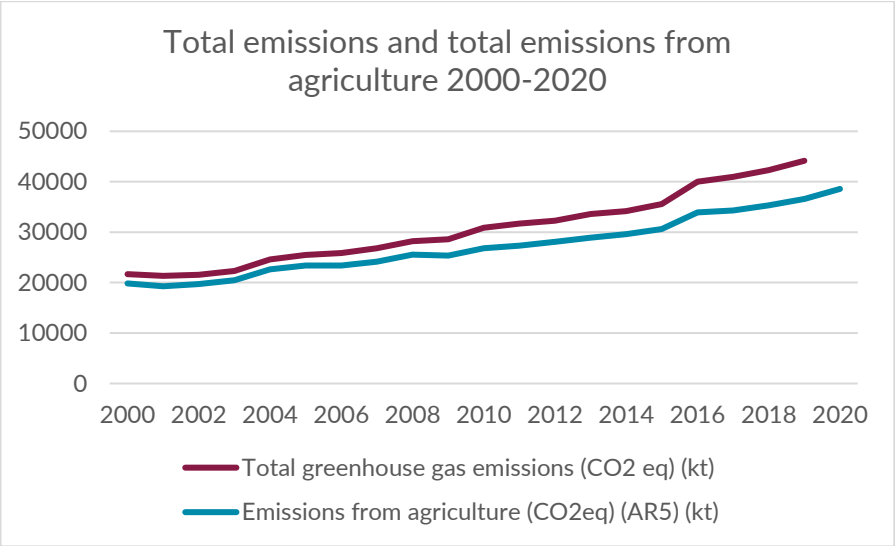
Mali's total greenhouse gas (GHG) emissions are rising but remain low relative to global averages. Since records began, emissions have been rising steadily with total emissions estimated at 44 million tons CO2eq per annum according to the World Bank's most recent estimates, as shown in Figure . However, Mali's emissions represent only 0.01% of total CO2 emissions worldwide and Mali's per capita emissions (0.19 t per capita) are approximately only 4% of the global average (4.69 t per capita).

Figure 25: Greenhouse gas emissions Mali



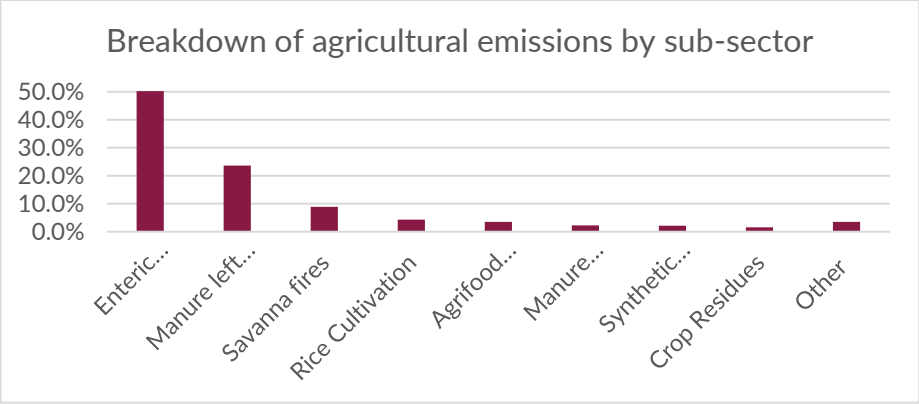
Agriculture is the dominant source of GHG emission in Mali, with CGIAR and FAO estimating it accounts for 70% to 80% of total GHG emissions. Agriculture is the key driver of emissions for two main reasons: i) it is one of Mali's largest economic sectors and the largest employer and ii) emissions from energy production (often the largest source of emissions in other countries) are relatively low due to the use of hydropower.As a result, emissions from agriculture have largely driven the trend in total emissions as evident in Figure .

Figure 26: Total emissions and total emissions from agriculture 2000-2020



Within agriculture, the two largest contributors of GHG emissions are from the rearing of livestock: enteric fermentation (CO2 and methane) and manure left on pastures (methane and nitrous oxide) which represent 50% and 24% total emissions from agriculture respectively. Other important sources of agricultural emission are savanna fires (which are in part employed to prevent the risk of further fires), and rice cultivation representing 9% and 4% of agricultural emissions.[1] All other sources of agricultural emissions contributing greater than 1% of the total are outlined in Figure .

Figure 27: Percentage of agricultural emissions by sub-sector



5.3.2 Emissions projections and mitigation potential

Due to high population growth (3.2% from 2020 to 2021), and factors associated with Mali's socioeconomic development (such as increasing access to electricity), Mali's GHG emissions are forecast to increase. Considering this, the government of Mali has committed to reducing its GHG emissions under its Nationally Determined Contribution (NDC) submitted to UNFCCC in 2021 for which it developed a 'baseline' and 'mitigation' scenario. The relative emissions levels under these two scenarios set against a baseline of 2020 emissions can be seen in Figure . The level of ambition for GHG emissions reductions in the 'mitigation' scenario compared to the 'baseline' scenario for 2030 represents a 31% decrease in the energy sector, a 25% decrease for the agriculture sector, a 39% decrease for the forestry sector and a 31% decrease for the waste sector.

Figure 28: Total GHG emissions under NDC base and mitigation scenarios (indexed to 2020)

5.4 Mitigation techniques in Mali and barriers for adoption

Under both the baseline and the mitigation scenarios laid out in the NDCs, Mali will continue to play a minor role in global emissions. However, mitigation techniques are significant as they have the potential to not only reduce GHG emissions in line with the NDC, but also to promote sustainable, green growth. Considering this, techniques that target the key emissions areas within agriculture (such as livestock - enteric fermentation, manure left on pastures), and increase the climate resilience of the agricultural sector should be prioritized. These fall into three themes that have been identified through desk research and expert interviews: animal production practices, crop production practices, and land use change and intensification. These are in line with the government's NDC submission which committed to promoting CSA including improving irrigation, managing fertilizer use, improving animal husbandry, and promoting reforestation. Below the three key areas have been outlined, alongside a summary of current adoption rates and the barriers to further adoption.

Most of the emissions result from livestock production, which represents a dominant livelihood in Mali. Therefore, emissions reduction through animal production practices must be considered alongside sustainable livelihood development. Without curbing livestock rearing, measures that target the livestock food consumption and grazing, as well as measures that reduce GHG emissions from manure can produce positive results in Mali.

For example, biodigesters enable households or communities (depending on size) to transform organic waste, principally livestock manure into productive outputs including biogas, as well as digestates including organic fertilizer. The primary mitigation opportunity results from the energy produced by biogas which can displace energy from firewood, charcoal, and other non-renewable sources. In Mali, burning firewood and charcoal account for about 78% of energy use in Mali's households. The second mitigation opportunity results from the emissions avoided through the management of organic waste, which could reduce the emissions from 'manure left on pastures' which represents 24% of agricultural emissions. The third mitigation opportunity also results from the increased supply of organic fertilizer, which could, in some circumstances, reduce GHG emissions from synthetic fertilizer use.

At present, the biogas system market is Mali is very early stage, with a complementary project (ABC, Sahel) stating that the "foundations of the market" still need to be developed. The primary barriers that constrain the biodigester market result principally from the high cost of the high capital costs and low levels of both local and international investments, the lack of access to waste, and the high labour demand required. In addition, lack of technical information on use as well as access to the technologies and poor implementation of biodigesters that focus exclusively on the energy production and not on the other outputs e.g. fertilizer have skewed public perception on the return on investment of the technique.

5.4.1 Land use change and intensification: agroforestry

To manage land use change and intensification, and increase carbon sequestration, reforestation is a key policy objective in Mali, highlighted by its prominence in the NDCs and the Climate-Smart Agriculture Investment Plan (CSAIP). Agroforestry has been included as a component to deliver the reforestation policy aims and is defined as carbon sequestration from adding above ground woody carbon storage (tree cover) in crops and grasslands. This practice increases carbon in agricultural landscapes by supporting the planting and natural regeneration of trees on crops and grasslands.

Agroforestry performs three functional roles: *productive*, *protective*, and *socioeconomic.* Firstly, as a practice it can support crop production, provide a source of fodder, provide fuel, provide shade for animals etc., this makes agricultural activities more *productive*. Secondly, there are potential environmental benefits e.g. reduced soil erosion, restoring soil health, carbon sequestration etc., which serves to *protect* land. Thirdly, agroforestry can be used as a means of income diversification and to increase farm yields, this emphasizes the *socioeconomic* benefits.

The *productive*, *socioeconomic*, and to some extent *protective* benefits of agroforestry serve as drivers to adopt agroforestry at a household level, with tangible benefits for farmers evident. A notable feature of agroforestry is that, because of the time required to cultivate mature trees, there is a delay between adopting agroforestry and the time to obtain the benefits. This delay, especially associated with the longer-term environmental benefits, means that clarity on land ownership, and coordination is often required from local authorities to implement the practice. As explored below, this can provide a barrier to agroforestry adoption.

5.4.2 Land use change and intensification: Irrigation to improve crop production practices

To both improve crop production and target land use change and intensification, irrigation has been identified as a key policy objective by the government of Mali. Irrigation could play a key role in reducing GHG emissions from rice cultivation which is the agricultural sub-sector that has the fourth highest emissions. In the CSAIP for Mali rice intensification is one of eight CSA investment areas, and the only one that highlights emissions reduction potential. This intensification will partially be delivered in the form of improved and increased irrigation systems.

Irrigation was identified as a primary constraint that inhibits farmers agricultural production in IAAT field data, cited as the second most important barrier to productivity (33% of all respondents) and making efficient and productive irrigation key for Mali's sustainable development.

There are two main options to reduce emissions associated with irrigation: crop intensification and replacing diesel pumps with solar pumps. Irrigation pumps in Mali typically run on diesel and electricity as sources of energy meaning that whilst increasing adoption of diesel and electricity fueled irrigation pumps can increase crop resilience and farmer adaptation to climate change, it also contributes to increased emissions. As well as potential increased costs for the farmer. Solar irrigation pumps have therefore been identified by IWMI as a technology that can create both mitigation and adaptation benefits for smallholder farmers, by increasing access to irrigated land and providing a renewable source of energy for farmers. However, similarly to biogas systems, barriers remain to solar irrigation pump adoption including: high upfront cost (an initial investment of anywhere between USD 840 and 4,700 is often needed), limited access to information for farmers, limited marketing attempts targeted at resource-poor and resource-limited farmers and underdeveloped markets for other items in irrigation value chain (e.g. for inputs (such as seeds and fertilizer) and outputs (irrigated agricultural products).[,]

In addition, improved irrigation practices can play a particularly key role in rice cultivation, which is the fourth highest emitting agricultural sub-sector. In the CSAIP for Mali the system for rice intensification (SRI) is one of eight CSA investment areas, and the only one that highlights emissions reduction potential. SRI fields adapt better to climate change, give off fewer greenhouse gas emissions, and allow farmers to increase productivity while using less seed, water and purchased agrochemical inputs. One practice within SRI is alternate wetting and drying (AWD), also known as "intermittent irrigation" which involves providing water intermittently to rice paddies and results in reduced methane emissions. Further, SRI trials in the Tombouctou region in 2008 showed average yield increases of 66% (ranging from 34-87%), with water savings of at least 32%. However, there is still low uptake for SRI across Mali as a whole which is reported at only 29,180 farmers across Mali in 2022.[,]

5.4.3 Summary

As Mali's contribution to global emissions is minor, adaptation is the primary focus in Mali. However, to align with the NDCs and to promote the development of a long-term resilient agricultural sector, mitigation techniques are an important additional consideration. The barriers to low-carbon and mitigation technologies and practices have been summarised into a barrier that will be targeted to be overcome by the project: "Immature markets (for relevant inputs and outputs) for low-carbon agriculture technologies/ practices such as agroforestry, solar irrigation, and biodigesters, alongside cultural barriers."

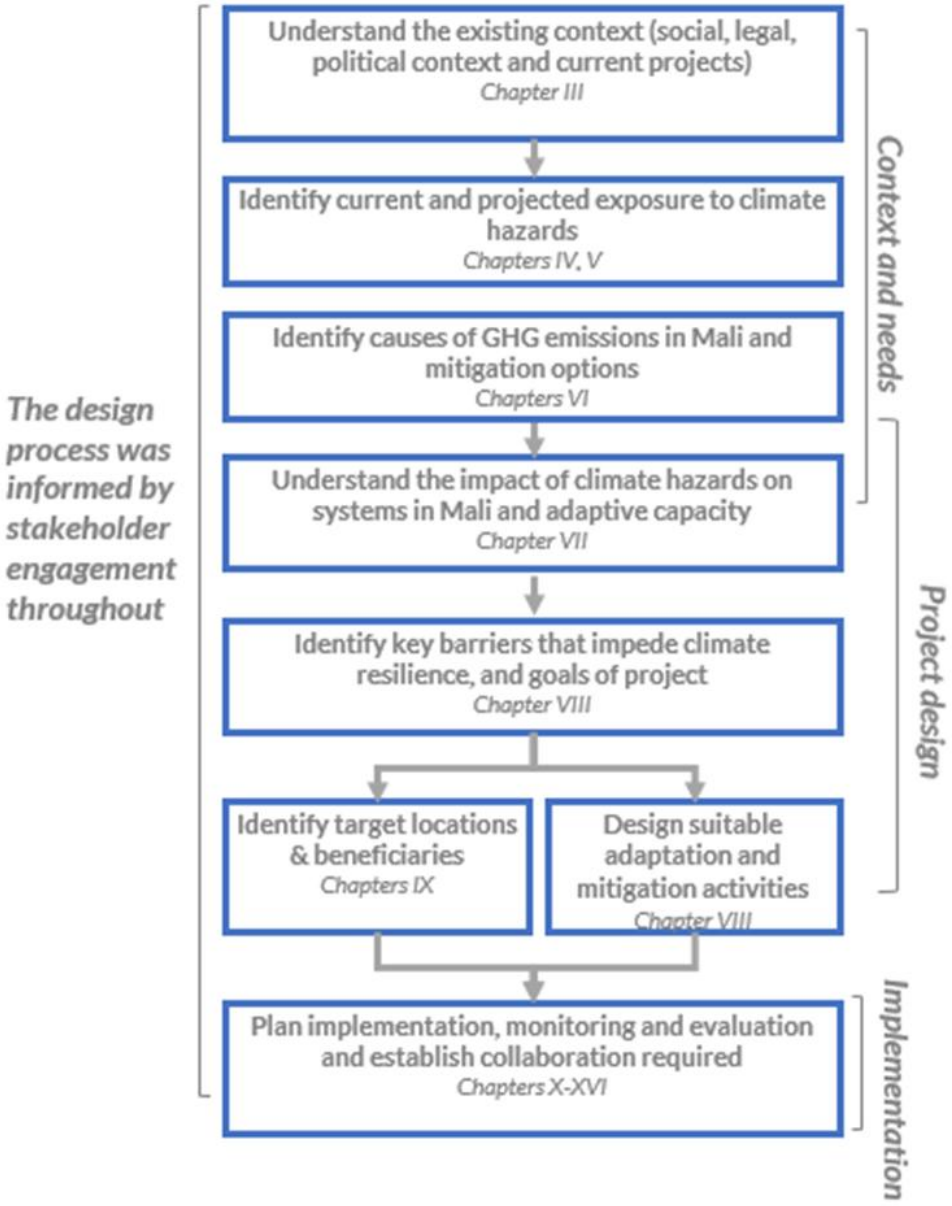
) as well as the inability in the current system to withstand the increasing pressures from climate hazards (*Chapter 0*

Climate Change Adaptation Gaps in Agriculture and Agroforestry).

The key elements of project design identify the barriers the project will address through the project activities to ultimately deliver impact (*Chapter VII Addressing Climate Change Vulnerability*), as well as the intervention locations and the people the project aims to support (*Chapter* ***Error! Reference source not found. Error! Reference source not found.***). Please see

Figure 1: Design approach for a visual representation of this logical flow.

Figure 1: Design approach



2.3 Summary of Stakeholder Engagement Conducted

This feasibility study is strongly rooted in community engagement and integrates insights from community members in the five target regions (Gao, Koulikoro, Mopti, Segou, and Tombouctou) as well as stakeholders with a nation-wide scope of work, identifying the most pressing needs and designing relevant activities to enhance adaptive and resilience capacities of smallholder farmers and reduce the GHG emissions of in agriculture and agroforestry in Mali. The document includes the result of a field study that was conducted to collect insights from communities and ensure alignment of planned interventions with their priorities. During the field data collection phase, an extensive range of methods was employed to gather information. This encompassed conducting surveys with a diverse group of participants, including 124 farmers (average farm size of <6 Ha) and 220 rural households, distributed across 27 circles within the five target regions.

In addition, valuable insights were gathered through interviews conducted with 92 key stakeholders across the Malian government, private sector, communities, research institutes, civil society organizations, and international NGOs. See *Table 1* for more information.

Workshops were held at the concept note stage to guide the initial project design, with a Regional Workshop, in each of the 5 regions of the project, and a National Validation Workshop held in May and June 2023 to support the finalisation of the project design.

Table 1: Stakeholders Segments Engaged and Key Objectives

Stakeholder Segment	**Government Organizations**	**Research Institutes**	**Private Sector**	**NGOs**	**Farmers**	**Households**
Number Engaged	31	2	20	39	124	220
Objective	Confirm the consistency of GCF IAAT with government priorities Learn from their experience and identify potential risks Identify key challenges and areas for institutional strengthening Assess financial management capacities of key government institutions	Discuss the results of their latest research into climate trends in Mali, as well as best practices for promoting climate-smart agriculture and building capacity for adaptation and resilience	Develop a better understanding of the market for climate-smart farming solutions Identify opportunities to work collaboratively on solutions to accelerate market development	Identify and confirm potential synergies and/or areas of duplication Learn from their experience and identify potential risks Discuss potential areas of collaboration Assess the financial capacity of potential implementation partners (Local NGOs)	Develop an improved understanding of their needs and challenges Identify together the most appropriate means of providing effective solutions to the challenges faced by farmers	Develop a better understanding of the vulnerability of households and the challenges that exist regarding overall living conditions

Please refer to Annex 7 “Summary of consultations and stakeholder engagement plan” for a full list of all stakeholders consulted during the project design phase.

III. MALI CONTEXT

3.1 Mali Context Overview

Mali is one of Africa's largest countries by land mass, its low population density results in a relatively low total population of approximately 22 million people. [18] However, Mali has seen continued population growth since 1955, with growth of 3.2% from 2020 to 2021, and resulting in predominantly young population with approximately 47% of the population less than 15 years old.[19,20] Although in the last two decades migration has led to the rapid growth of urban populations, most people still live in rural areas (56%) and agriculture remains the country's largest sector.[21]

Regarding governance, Mali is divided into regions,[22] which are further divided into administrative units called cercles (circles), which are in turn subdivided into communes.[23] Since 1991, Mali has adopted a decentralized approach to governance to reconfigure the institutional landscape and provide local communities the opportunity to participate in public affairs.[24]Municipalities own their economic, social, and cultural development and are responsible for planning, in particular through the preparation and implementation of Economic, Social and Cultural Development Plans (PDESC).[25]

The Government of Mali has defined key strategies, policies, and interventions to promote Climate Smart Agriculture and confront existing and future food security challenges exacerbated by climate change. Since 1994, Mali has ratified several international agreements including The UNFCC Convention in 1994, the UN Convention on Biological Diversity (CBD) in 1995, the Kyoto Protocol in 1999, and the Paris Agreement in 2015.[26] In 2021, under its revised Nationally Determined Contributions (NDCs), Mali pledged to achieve a 31% reduction in greenhouse gas emissions in the energy sector, 25% in agriculture, 39% in land use and forestry, and 31% in the waste sector by the year 2030, compared to business-as-usual.[27]

Approximately 80% of households in Mali have access to a formal financial institution, although for many it is provided through mobile network operators; only 17% of the population have a formal bank account.[28,29] Access to finance is particularly limited amongst smallholder farmers with smallholder farmers on average denied a loan seven out of ten times.[30] With the support of development partners, a cooperative/associative approach has been set up to reduce the financial exclusion of low-income populations with key institutions including Cooperative networks and Village Savings and Loan Associations (VSLAs).

Agriculture, defined as the practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food and other products, is the dominant livelihood in Mali, with 75% of the population depending on agriculture.[31] The agricultural sector is predominantly based on subsistence farming, with smallholder farmers working on small parcels of land (officially defined as less than 10 ha) representing over 86% of farmers.[32]

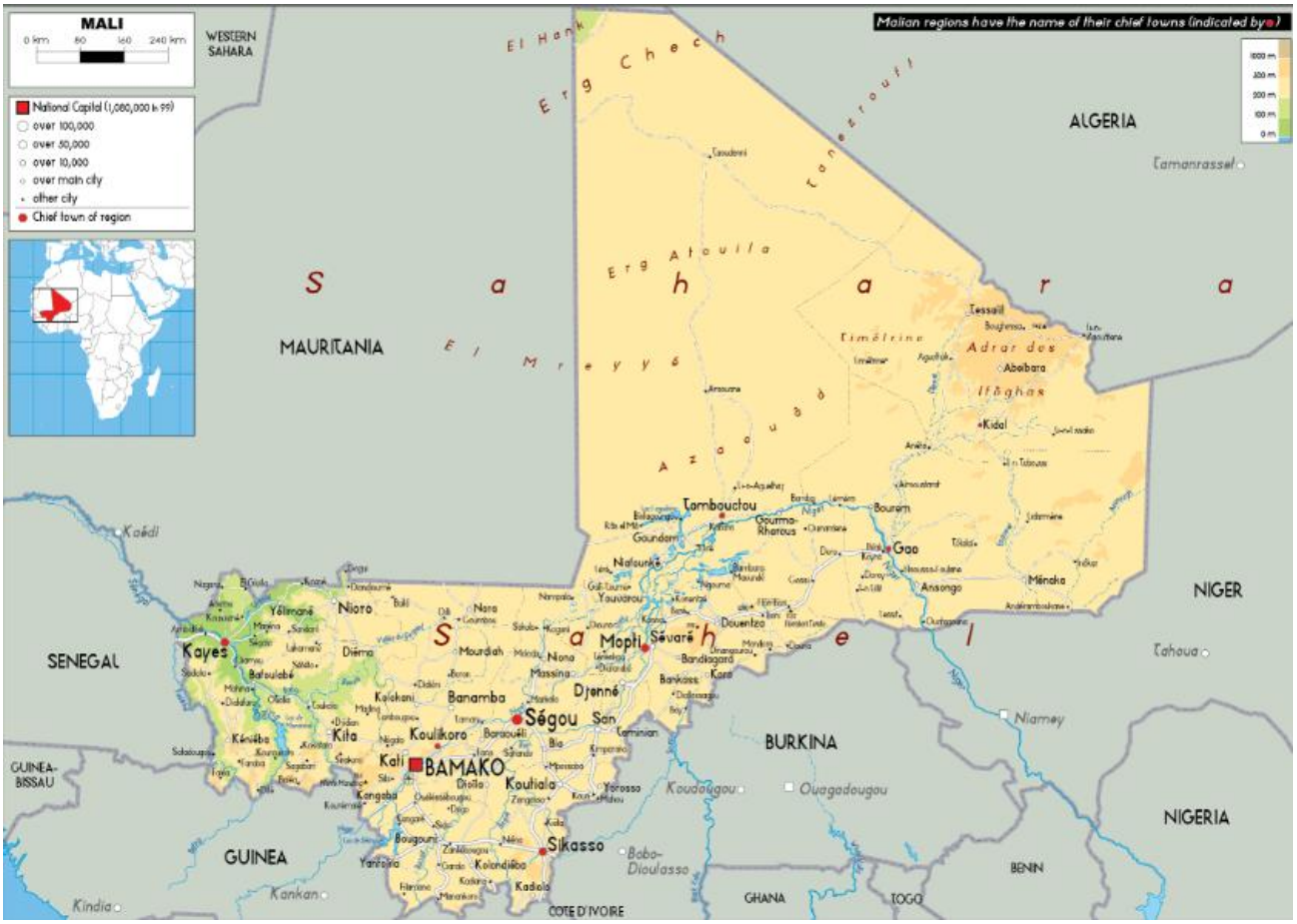
[18] Britannica (2023), Country Profile: Mali, Link
[19] Statista, (2023), Mali: Age structure from 2011 to 2021, Link
[20] World Bank, (2022) Population growth (Annual percentage – Mali), Link
21 N'Diaye, I. et al., (2020), Adaptation de l'Agriculture et de l'Élevage au Changement Climatique au Mali: Résultats et leçons apprises au Sahel. Available here
[22] Mali Actu, (2022) Organisation administrative du territoire malien, Link
[23] Britannica (2023), Country Profile: Mali, Link
[24] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link
[25] IBID
[26] UNDP, (2023) Country Profile: Mali, Link
[27] IBID
[28] BCEAO (2022), Financial Inclusion in Mali, Available here
[29] IBID
[30] IBID
[31] CGIAR, (2019), Solar Irrigation to counter climate-vulnerability and improve food security in Mali. Available here
[32] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here

3.2 Mali's Location and Government

3.2.1 Geography and socio-economic context

Mali is a landlocked country in the Saharan and Sahelian regions in West Africa, sharing its borders with seven countries: Algeria on the North, Niger and Burkina Faso on the East, Senegal and Mauritania on the West, and Côte d'Ivoire and Guinea on the South. [33] The country covers over 1,240,000 km^2, with a landscape largely arid and flat, composed of two main basic relief features: plains, and plateaus.[34] Mali's drainage system mostly consists of the Senegal and Niger rivers and their tributaries.[35] While the Senegal River system flows in a northwesterly direction across Western Mali, the Niger River meanders from the South-West towards the Center, following a northeasterly trajectory, and functions as the main trading and transport artery in the country.[36] The seasonal floods in some sections of the Niger River and the rich alluvial soil in the central delta provide fertile agricultural soil and pasture for livestock.[37] Soils outside the Niger valley in Mali are barren, often ferruginous in the South or covered by the desert in the North.[38]

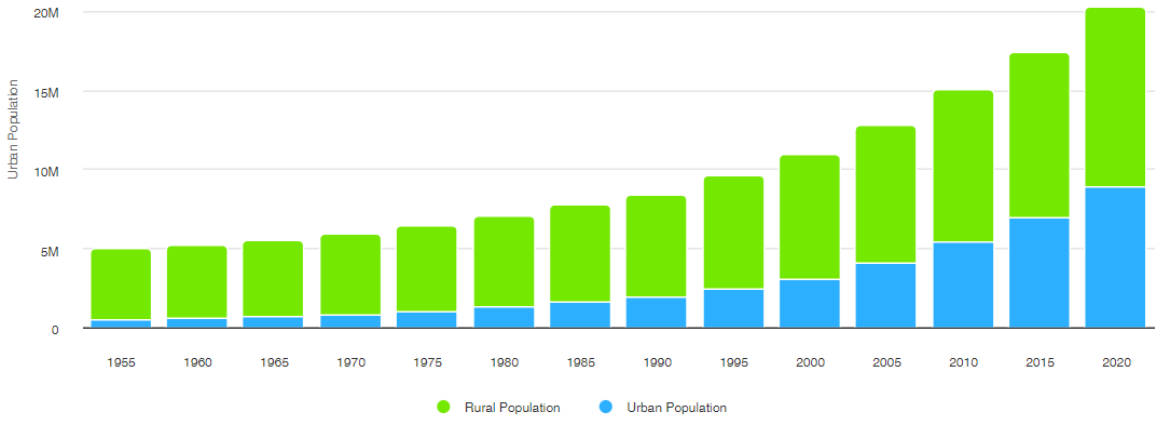
Figure 2: Physical map of Mali[39]



[33] Britannica (2023), Country Profile: Mali, Link
[34] IBID
[35] IBID
[36] IBID
[37] IBID
[38] IBID
[39] Worldometers, Mali Map (Physical), Link

Despite being one of the largest countries in Africa, Mali has a relatively small population, mainly living in rural areas. The country has 22 million inhabitants, for a density of 17 people per km^2,[40] reaching as low as one person per km^2 in the most remote eastern and north-eastern areas.[41] These regions have historically been characterized by a sparse population, but recurring droughts have led to increased migration towards the South, especially from herders.[42] The population is heavily centered along the Niger River, due to the area providing more opportunities for agriculture and livelihood.[43] 56% of Malians live in rural areas, dwelling in villages of between 150 and 600 inhabitants and surrounded by cultivated fields and grazing lands.[44] However, increased migration has led to a rapid growth of the urban population, growing from 28% in 2000 to 44% in 2020.[45]

Figure 3: Mali urban vs Rural population from 1955 to 2020[46]



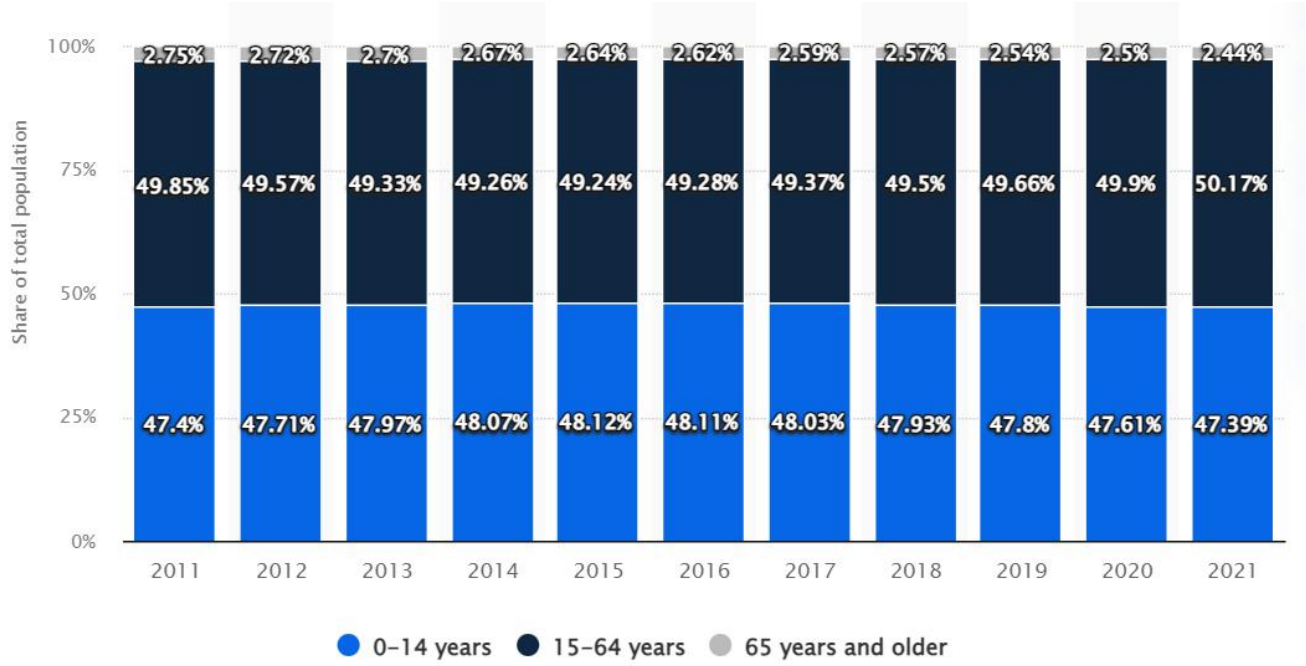
Mali has a predominantly young and vulnerable population that lacks opportunities to improve their livelihoods. The population is growing rapidly (3.2% from 2020 to 2021), leading to a large share of youth.[47] More than 47% of the population are less than 15 years old[48] (see *Figure 4: Age structure from 2011 to 2021 in Mali*) and 40% are aged between 15 and 40[49], resulting in a median age of 16.3 years in 2023.[50] Young people are highly exposed to employment challenges, especially those aged 15 to 24 years, due to job creation increasing at a significantly slower pace than population growth.[51] As a result, less than 50% of the workforce in this age group are employed. The overall unemployment rate among youth in Mali is estimated at 15% and could be as high as 50% when underemployment is considered.[52] This is a major vector of poverty and represents a threat to social cohesion and food security within communities.[53]

The population, especially those living in rural area, are highly exposed to poverty and vulnerable to shocks and stressors, including security and climate change. The livelihood resilience of rural populations is challenged by creeping insecurity[54] and a highly variable and changing climate context[55]. Extreme poverty has accelerated to reach 19.1% in 2022, from 15.9% in 2021, further

[40] Worldometers, (2020), Mali Population, Link
[41] Britannica (2023), Country Profile: Mali, Link
[42] IBID
[43] IBID
[44] IBID
[45] Worldometers, (2020), Mali Demographics, Link
[46] Worldometers, (2020), Mali Demographics, Link
[47] World Bank, (2021) Population growth (Annual percentage – Mali), Link
[48] Statista, (2021), Mali: Age structure from 2011 to 2021, Link
[49] FAO, (2017), Youth employment in Mali, Link
[50] Worldometers, (2020), Mali Population, Link
[51] ICCO Cooperation, (2018) Youth employment in Mali, Link
[52] ARCO, (2020) Market analysis to foster employment of young people in Mali, Link
[53] FAO, (2017), Youth employment in Mali, Link
[54] World Bank, (2023), Mali Presentation, Available here
[55] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link

emphasized by decreasing purchasing power.[56] Rural areas in the densely populated Southern regions account for 90% of the country's poverty.[57] Rural populations are under constant pressure to cope with and adapt to an unpredictable environment, for further information please see *chapter* V and 0 below. [58]

Figure 4: Age structure from 2011 to 2021 in Mali[59]



3.2.2 Administrative division

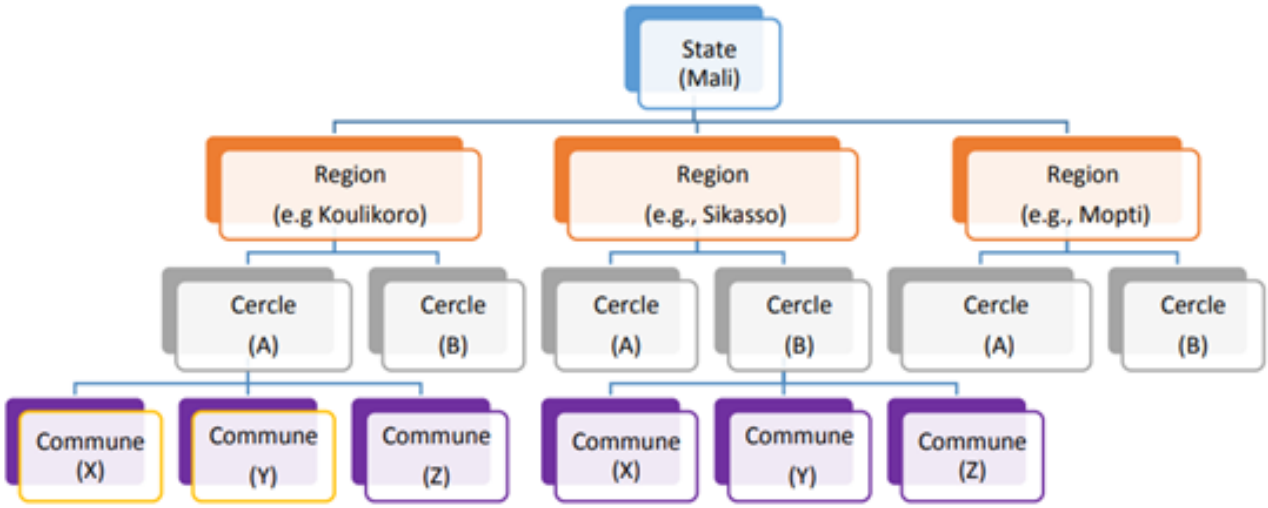
Mali is divided into regions,[60] which are further divided into administrative units called circles, which are in turn subdivided into communes.[61] The country is currently implementing a new administrative division, which will increase the number of circles and communes.[62] Each region is administered by a governor and a regional council. While the governor is appointed by the government and is in charge of overseeing the implementation of national policies,[63] the regional council, headed by a President, deliberates on the region's affairs particularly those relating to economic, social, and cultural development.[64] The circles serve as central hubs for key government services, with their diverse headquarters serving as focal points for health services, the army, the police, local courts, and other government agencies.[65] The communes, as the fundamental administrative unit, typically accommodate a school and a dispensary at its center and consist of multiple villages, each headed by chiefs and elected village councils.[66]

Mali adopted a decentralized approach to reconfigure the institutional landscape and provide local communities the opportunity to participate in public affairs.[67] In 1991, decentralization was initiated in Mali to reject the centralized government structure inherited from the colonial era, which lacked

[56] World Bank, (2023), Mali Presentation, Available here
[57] World Bank, (2023), Mali Presentation, Available here
[58] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link
[59] Statista, (2021), Mali: Age structure from 2011 to 2021, Link
[60] Mali Actu, (2022) Organisation administrative du territoire malien, Link
[61] Britannica, (2023) Country Profile: Mali, Link
[62] IBID
[63] Britannica, (2023), Country Profile: Mali, Link
[64] Droit Afrique, (2012), Malian Code of Territorial Authorities, Link
[65] IBID
[66] Droit Afrique, (2012), Malian Code of Territorial Authorities, Link
[67] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link

meaningful local authority. Malian decentralization was primarily a political endeavor to redistribute power to newly formed local politico-administrative entities, setting it apart from other West African countries, where it was often perceived as a technical adjustment of territorial administration to fulfill donor requirements. Decentralization in Mali aims to enhance participation of local communities in the public affairs of state, transfer key forms of decision-making power to the local level, and tailor development policy and national investment to the needs of local communities.[68] In that regard, the government set up the Ministry of Territorial Administration and Decentralization to oversee the design and effective implementation of decentralization policies.[69]

Figure 5: Decentralized politico-administrative structure in Mali[70]



3.3 Mali's Agricultural and Climate Change Regulatory and Policy Landscape

3.3.1 Institutions and Governance Structure for Climate Change and Agricultural Policies, National level

The Government of Mali relies on a collaborative framework between development actors to improve the adaptive and resilience capacities to climate change, especially in agriculture and agroforestry. The country established a national science-policy dialogue platform for climate change and food security (CCASA Platform) regrouping several stakeholders and aiming to facilitate dialogue between experts and decision-makers to create a common vision for agriculture and food security in the context of climate change.[71] The CCASA Platform was established in 2012 and is now participating in regional and international fora related to CSA, such as ECOWAS, NEPAD, UNFCCC, and GACSA.[72] The committee is chaired by the National Directorate of Agriculture (DNA), coordinated by the Agency for Environment and Sustainable Development (AEDD), and facilitated by the Malian Association of Awakening to Sustainable Development.[73] The National Directorate of Agriculture sits in the Ministry of Rural Development, which oversees the design and implementation of national agricultural policy, including the provision of training and technical support to farmers.[74]

Mali has also established a national committee specifically dedicated to climate change. The National Climate Change Committee (CNCCM) was set up in 2011 to provide a platform to coordinate Mali's response to climate change, including: (i) facilitate the implementation of commitments under the

[68] IBID
[69] Government of Mali, (2019), Official Journal of the Republic of Mali, Link
[70] USAID, (2017) Decentralized Governance And Climate Change Adaptation, Link
[71] IBID
[72] USAID, (2017) Decentralized Governance And Climate Change Adaptation, Link
[73] IBID
[74] Ministry of Rural Development (2023), Mission, Link

United Nations Framework Convention on Climate Change (UNFCCC) and any multilateral or bilateral climate change agreements, (ii) promote the development of synergies with other conventions, notably the Convention on Biological Diversity and the Convention to Combat Desertification, (iii) promote national capacity building on climate change, and (iv) provide a platform to discuss and design sustainable solutions to climate change.[75] Under the chairmanship of the Ministry of Environment, Sanitation, and Sustainable Development (MEADD), the CNCCM regroups members from the public sector, the private sector, local authorities and professionals from research centers, the farming community, and civil society. [76] The Ministry of Environment, Sanitation, and Sustainable Development is the primary institutional entity responsible for climate change initiatives within the country and serves as the focal point for both the Global Environment Fund (GEF) and the Green Climate Fund (GCF). The National Climate Change Committee (CNCCM) plays a consultative role and facilitates the mobilization of resources and stakeholders for climate-related projects in Mali. Mandated by the MEADD, the Agency for Environment and Sustainable Development (AEDD) coordinates climate mitigation and adaptation efforts and acts as the secretariat for the CNCCM.[77]

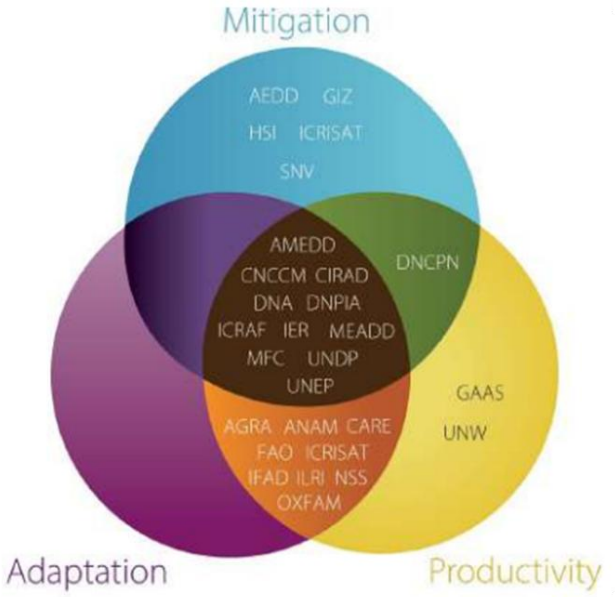
The Agency for Environment and Sustainable Development (AEDD), which sits in the Ministry of Environment, is the National Designated Authority in Mali, and the Executing entity of the GCF IAAT project (along with SCUS and SCI Mali). Established in 2010, the agency plays a central role in the definition and implementation of climate and environment related strategies in Mali.[78] AEDD coordinates the implementation of the National Environmental Protection Policy, oversees the integration of climate change considerations in all policies, including land-use planning, and actively participates in the management and coordination of several national platforms dedicated to climate change adaptation and mitigation, including the national science-policy dialogue platform for climate change and food security (CCASA),[79] and the National Climate Change Committee (CNCCM).[80] It also coordinates the implementation of international agreements and conventions on environmental issues.[81] AEDD works closely with development partners to strengthen the capacity of stakeholders involved in environmental management, desertification control, climate change, and sustainable development by developing modules, disseminating information, providing training, leading awareness campaigns, etc.[82] The key roles of AEDD include environmental data collection and analysis, collecting data, producing statistics, and disseminating research results on biotechnology relevant to environmental preservation, desertification control, climate change, and sustainable development.[83] AEDD also monitors financial mechanisms and funding related to environmental protection and sustainable development.[84]

The Institute for Rural Economy (IER), which is the government's research arm in agriculture, strongly contributes to the definition and implementation of agricultural policies and collaborates closely with other international research institutes. Created in 1960 to lead the research in agriculture in Mali and improve agricultural productivity and food security, the Institute for Rural Economy plays a central role in the ecosystem, working closely with stakeholders at the local, national, and international levels.[85] IER drives innovation in climate-smart technologies in Mali through continuous research and takes ownership of several interventions critical to the promotion of CSA, which include developing improved crop varieties adapted to local conditions, providing capacity building to farmers and agricultural extension workers, and raising awareness on CSA technologies.[86] IER collaborates closely with various international research institutions to fulfill its mission, including: the International

[75] Government of Mali, (2011), National decree for the creation of the National Climate Change Committee, Link
[76] IBID
[77] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[78] UNDP, Agency for Environment and Sustainable Development (AEDD), Ministry of Environment and Sanitation, Government of Mali, Link
[79] USAID, (2017) Decentralized Governance And Climate Change Adaptation, Link
[80] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[81] Agence de l'environnement et du développement durable, Link
[82] We Adapt, Agence de l'environnement et du développement durable, Link
[83] Agence de l'environnement et du développement durable, Link
[84] IBID
[85] Institute for Rural Economy, History and mission, Link
[86] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here

Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the Agricultural Research Centre for International Development (CIRAD), the World Vegetable Center (AVRDC), the International Livestock Research Institute (ILRI), and the World Agroforestry Centre (ICRAF).[87] Through these collaborations, IER and other research institutions develop tailored solutions for the development of CSA in Mali and carry out several projects and initiatives, such as the Climate-Smart Village program in Segou. Climate-smart villages allow research institutions to work closely with farmers to test a range of climate-smart technologies and practices, gather evidence on their effectiveness, and learn valuable lessons about mechanisms for scaling up these innovations.[88]

Figure 6 : Institutions for CSA in Mali[89]



AEDD Environment and Sustainable Development Agency **AGRA** Alliance for a Green Revolution in Africa **AMEDD** Malian Association of Awakening to Sustainable Development **ANAM** Mali National Meteorological Agency **CIRAD** Agricultural Research Centre for International Development **CNCCM** Mali National Climate Change Committee **DNA** National Directorate of Agriculture **DNCPN** National Directorate for Conservation and Protection of Nature **DNPIA** National Directorate of Animal Production and Industries **FAO** Food and Agriculture Orgnaization of the United Nations **GAAS** Groupe d'Animation Action au Sahel **GIZ** German Agency for International Cooperation **HSI** Helvetas Swiss Intercooperation **ICRAF** World Agroforestry Centre **ICRISAT** International Crops Research Institute for the Semi -Arid Tropics **IER** Institute for Rural Economy **IFAD** International Fund for Agricultural Development **ILRI** International Livestock Research Institute **MEADD** Ministry of the Environment, Sanitation, and Sustainable Development **NSS** National Seeds Service **SNV** Netherlands Development Organisation **UNDP** United Nations Development Programme **UNEP** United Nations Environment Programme **UNW** UN Women

3.3.2 Institutions and Governance Structure for Climate Change and Agricultural Policies, Local level

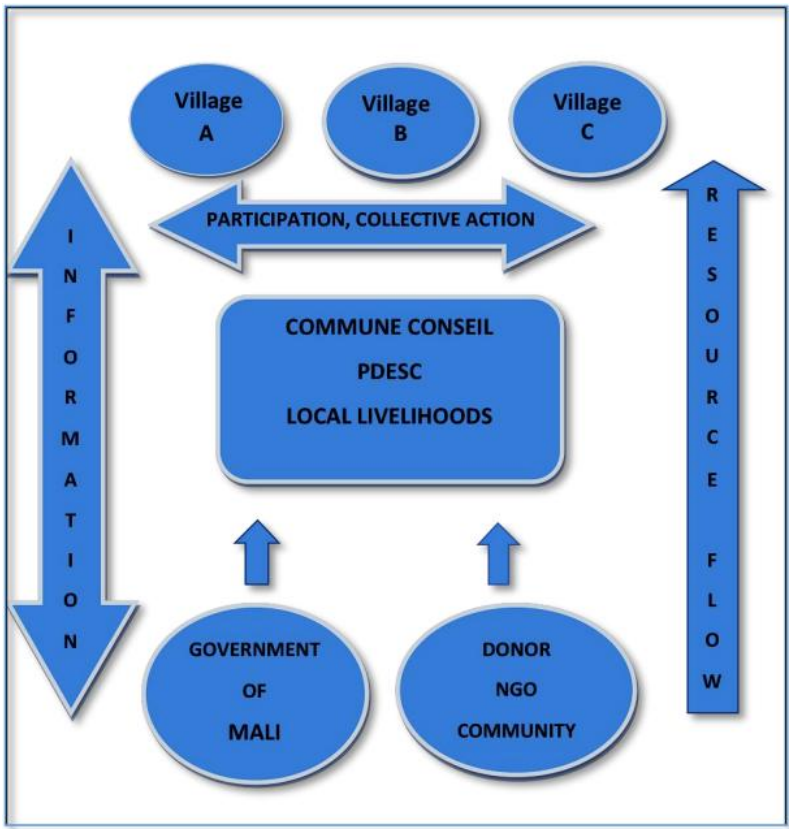
Decentralization in Mali has evolved towards "integral communalization" which confers autonomy on commune level municipalities to define priorities and implement national policies and programs within their territory.[90] The municipalities own their economic, social, and cultural development and are responsible for planification, in particular through the preparation and implementation of an Economic, Social and Cultural Development Plan (PDESC).[91] The conseil communal is the locally elected body which, with their executive components, are the central retainers of local-level power and decision making, while appointed government authorities are mostly in charge of supervision and advisory.[92] The villages are headed by a village chief, supported in their mission by other local bodies such as the village development committees. Local authorities at the village level closely collaborate with elected bodies and are mainly in charge of mediating the distribution of customary land rights.[93]

The existence of governance institutions at the commune and village level provides a distinct adaptive advantage by serving as intermediaries or gatekeepers and facilitating access to information.[94]

[87] IBID
[88] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[89] IBID
[90] Ministry of Environment, (2018), Proposed tool for integrating conventions for implementing of the Rio Conventions in Mali, Link
[91] IBID
[92] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[93] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link
[94] IBID

Decentralization in Mali empowers communal leadership to serve as a crucial mediator, facilitating horizontal communication among villages and vertical coordination with external actors across different levels (See Figure 7 for an illustration of adaptation-oriented governance in Mali). The Economic, Social and Cultural Development Plan (PDESC) materializes the strategic direction at the local level over five years and results from a participatory approach involving both authorities and communities. The conseil communal holds the responsibility for development planning, implementation, and evaluation, as reflected in the creation of the PDESC. This five-year plan is legally mandated and falls under the purview of the newly elected council. The preparation process typically follows standardized procedures across all communes and aims to foster participatory development.[95] Social capital is a valuable resource in villages, fueling collective action and collaborative problem-solving. Challenges related to natural resource management, optimal water utilization, and agricultural technology adoption are shared concerns that can be effectively addressed through collaboration. Effective decentralized governance has had a beneficial impact on the widespread adoption of adaptation technologies, through information sharing and establishment of linkages with external actors who introduce these technologies. In some communes, local authorities have strongly contributed to the enhancement of adaptation capacities, enforcing laws, creating small reserves, promoting local reforestation, establishing livestock corridors and instituting local rules for collective natural resource management. [96]

Figure 7: Framework for adaptation-oriented governance under Malian decentralization[97]



Despite theoretically playing a central role in the promotion of adaptation, most communes lack technical and financial resources to mitigate the increasing pressures of climate and environmental change. The development of the PDESC is not guided by a widespread adaptation vision and is

[95] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link
[96] IBID
[97] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link

mostly focused on solving specific, concrete, and immediate problems. Low literacy among communities is a key constraint to effective participation in the design of the PDESC, leading to little to no knowledge of the document from the majority of people. The contribution of women to the design and implementation of the plan is nearly non-existent. There is also limited participation of the government technical staff responsible for key sectors of agriculture, livestock, and natural resource management in the design of the PDESC. The very little awareness and understanding of climate change and its impacts by communal and village-level leadership leads to the lack of consideration of an adaptation lens in the planning of activities. The lack of local-level source of revenue to fund projects in the PDESC also provides limited implementation capacity from local authorities. However, the local presence of an active NGO allows to overcome the major resource and technical barriers faced in the implementation of the PDESC. [98]

The development of Community Action Cycles (CACs) is facilitated at the village level to enhance the contribution of communities in decision-making processes. CACs are mechanisms based on a systematic and iterative approach to engage communities and support them to autonomously identify, plan, implement, and evaluate actions to address specific needs or challenges relating to their village/neighborhood.[99] This approach allows to empower communities and involve them in decision-making, problem-solving, and implementation of activities to improve their social, economic, and/or environmental conditions.[100] The CAC approach, designed by Save the Children, is implemented by several organizations in Mali to empower social change, enhance decision-making, address diverse community needs, build sustainable mechanisms and linkages, bring additional resources, apply political pressure for service quality improvement, and challenge social structures and norms to benefit marginalized groups, especially women and youth.[101]

Additional platforms, such as Rural Resource Centers, are leveraged at the community level to foster collaboration between stakeholders and enhance adaptation and mitigation capacities in Mali. Rural Resource Centers (CRRs) are training and demonstration sites managed by grassroots organizations in Mali, providing opportunities for farmers to receive tailored technical advice and services.[102] Their local integration and the trust gained from producers facilitate the adoption of new techniques, making CRRs a valuable approach to empower rural communities and achieve sustainable development goals.[103] They serve as platforms for collaboration between producers and the private sector, ensuring the sustainability of supply sources and the quality of raw materials.[104] They offer accessible and relevant innovations, better service quality, increased participation of women and youth, and improved networking with other development actors.[105] CRRs go beyond agriculture in Mali, addressing socio-economic and environmental aspects such as community development, governance, nutrition and health, and entrepreneurship, contributing to increased income and job creation in rural areas.[106]

3.3.3 Policy landscape

The Government of Mali has defined key strategies, policies, and interventions to promote Climate Smart Agriculture and confront existing and future food security challenges exacerbated by climate change. Since 1994, Mali has ratified several international agreements including The UNFCC Convention in 1994, the UN Convention on Biological Diversity (CBD) in 1995, the Kyoto Protocol in 1999, and the Paris Agreement in 2015.[107] In 2021, under its revised Nationally Determined Contributions (NDCs), Mali pledged to achieve a 31% reduction in greenhouse gas emissions in the energy sector, 25% in agriculture, 39% in land use and forestry, and 31% in the waste sector by the

[98] USAID, (2017) Decentralized Governance And Climate Change Adaptation, Link
[99] Communication initiative Networks (2011), Community Mobilisation: The Community Action Cycle, Link
[100] MCLD, (2016), The Save the Children approach, Link
[101] IBID
[102] World Agroforestry, (2019), Rural Resource Centers, Link
[103] IBID
[104] IBID
[105] IBID
[106] IBID
[107] UNDP, (2023), Country Profile: Mali, Link

year 2030, compared to business-as-usual.[108] The government has developed and is currently leveraging several instruments both at the national and local levels to reach their declared objectives.

Climate Smart Agriculture plays a central role in Mali's strategy to thwart climate change impacts and improve adaptive and resilience capacities. The country's NDC highlights the importance of "climate-smart and resilient agriculture" practices to mitigate climate change and mentions forestry, energy, and agriculture as the priority areas to improve adaptation and resilience capacities.[109] Agriculture is also identified by the National Adaptation Programme of Action (NAPA) as a priority sector for investments, especially for the promotion of CSA technologies, including the adoption of climate-resilient inputs and livestock species, the development of irrigation infrastructures as well as agro-meteorological advisory systems.[110] The government aims to leverage CSA practices and technologies to increase productivity and incomes of Malian farmers and improve the livelihood of populations.[111]

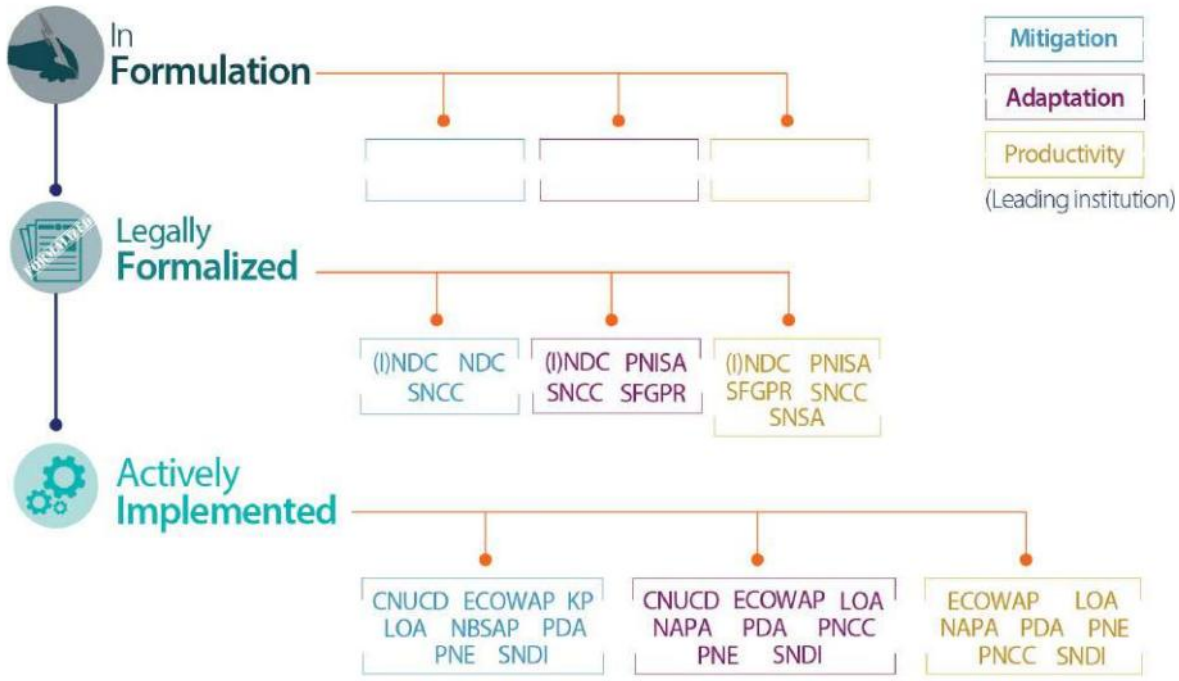
Mali has developed several strategies and programs to improve livelihoods through the development of agriculture and agroforestry and the improvement of adaptation and resilience capacities. Climate change is a core component of national planning and programming, as demonstrated by several policies aligned with the Strategic Framework for Growth and Poverty Reduction (SFGPR). These strategies and policies encompass among others. Figure 8 illustrates a collection of policies, strategies, and programs that pertain to agriculture and climate change:

- National Policy for the Protection of the Environment (1998), which focuses on combating desertification, sustainable management of natural resources, and food security;
- National Agricultural Policy (2013);
- National Climate Change Policy (2011);
- National Climate Change Strategy (2011);
- National Policy for Land Use Planning (2016);
- National Water Policy (2006), which emphasizes agricultural adaptation and productivity through water usage;
- Mali National Agricultural Investment Plan (2014);
- National Food Security Plan (2019)
- National Strategy for the Prevention and Management of Disaster Risk (2015)
- Strategic Framework for Economic Recovery and Sustainable Development in Mali (2019)

The National Agricultural Sector Investment Plan (PNISA), developed in 2014, materializes Mali's endeavor to draw on the agricultural sector as an engine for economic development. The plan outlines the conditions to improve food security and stimulate economic growth through more productive and sustainable agriculture, forestry and fishing.[112] The PNISA revolves around five key priority programs, highlighting natural resource management and agricultural mechanization.[113] The Plan's provisions include natural resource management and biodiversity preservation; soil defense and restoration and water and soil conservation; forest and wildlife reserve management and preservation; and river and watershed protection.[114] Several programs have already been implemented, including initiatives promoting agricultural diversification. Mali's agricultural development strategy further centers on the concept of "agropoles," which focuses on regional agricultural development akin to agro-processing zones, presenting an opportunity for the establishment of climate-smart value chains and climate-smart agropoles.[115]

[108] IBID
[109] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[110] IBID
[111] IBID
[112] Government of Mali, (2023) National Agricultural Sector Investment Plan, Link
[113] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[114] Government of Mali, (2023), National Agricultural Sector Investment Plan, Link
[115] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here

Figure 8: Policies for the promotion of CSA in Mali[116]



Since 2011, the National Climate Change Policy (PNCC) and the National Climate Change Strategy (SNCC) have provided the overarching framework for guiding climate action.[117] The PNCC and SNCC encourage participatory and decentralized management of natural resources, facilitating planning, implementation, and coordination across sectors and stakeholders.[118] The SNCC comprises eight strategic pillars, which include mainstreaming climate change into sectoral policies, capacity building, climate finance, and private sector engagement in climate change mitigation efforts. Various actions are outlined within these pillars, including reforestation, the establishment of a research program on agriculture and climate change, enhancement of weather and climate information systems for agriculture, climate resilience in the agriculture and forestry sectors, agricultural diversification, sustainable land management, and livestock intensification, among others.[119]

In 2019, Mali developed its national Climate-Smart Agriculture Investment Plan (CSAIP) to guide the country's action for the promotion of CSA technologies and strengthen farmers' resilience to climate change. The CSAIP builds on existing national programs, policies, and strategic plans to lay the foundation to scale-up CSA in Mali and aligns with national initiatives and priorities, including the NDC and other international commitments.[120] The plan outlines key interventions drawing on the NDC and national agricultural strategy to increase agricultural productivity, build adaptive and resilience capacities of farmers, pastoralists and fisher people to climate change, and reduce greenhouse gas emissions in agriculture.[121] These interventions are designed to attract investments from public and private sector partners in four main areas: sustainable land management, climate-smart crops and livestock, value chain development, and institutional strengthening. [122] The plan is also expected to

[116] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[117] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[118] IBID
[119] IBID
[120] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[121] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[122] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here

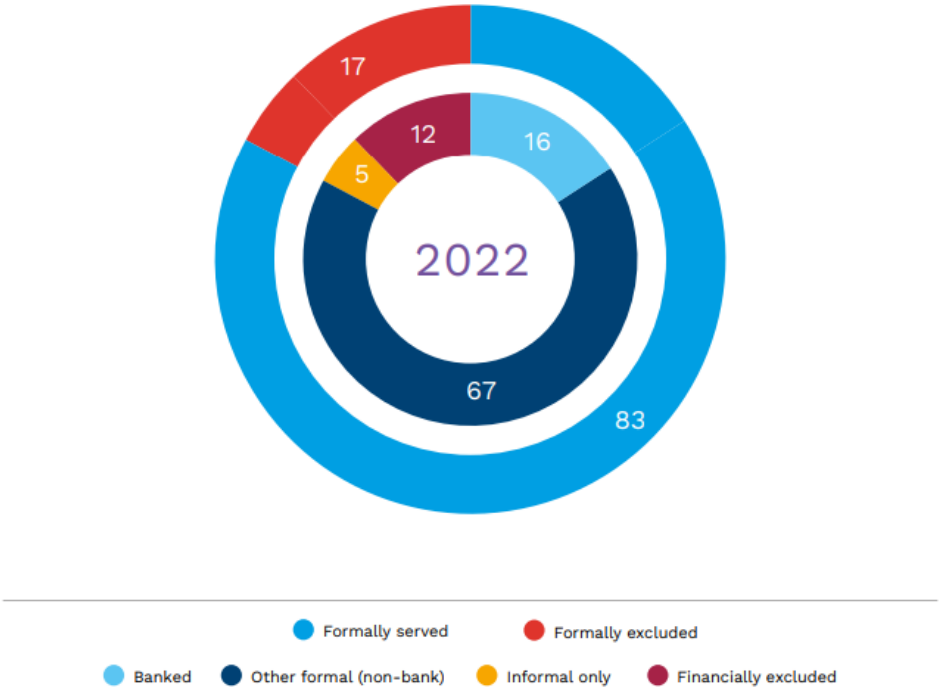
generate significant economic and social benefits, such as increased food security and employment opportunities. [123]

However, government priorities are constrained by budgetary challenges, which creates risks for both policy implementation, as well as the priority of agricultural policies. For example, in 2023, due to budgetary pressures, the government was not able to fully finance the National Response Plan (NRP), which is the main state response to support households in the areas most affected by food and nutrition insecurity[124]. This leads to uneven policy implementation across the country, with the most vulnerable often excluded from reform. At a national level, this is evidence both of the resources available to promote adaptation and the barriers to deploying said resources.

3.4 Mali's Financial Institutions

83% of households in Mali have access to a formal financial institution (See Figure 9 for a breakdown of the Malian population based on the type of financial institutions they have access to).[125] The formal supply of financial services in Mali mainly comprises three types of operators: banks, microfinance institutions (MFIs) and mobile network operators (MNOs). However, access to formal financial institutions has mostly been driven by the rise of MNOs in the past decade.[126]

Figure 9: Access strand (% of households)[127]



Banks are the most prominent financial institutions in Mali, representing 95% of total financial sector assets in 2017.[128] 14 banks are operating in the country and most of them include the Government as a shareholder.[129] However, these banks are mostly influenced by international investors, while the government has minimal interference in their management.[130] The banking system in Mali has significant growth potential due to a low penetration rate (only 17% of the population has a formal

[123] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[124] Handicap International, (2022), Breaking the Spiral of the Food and Nutrition Crisis in Mali, Link
[125] BCEAO, Financial Inclusion in Mali
[126] Fowowe B., Financial Inclusion, Gender Gaps and Agricultural Productivity in Mali, Link
[127] BCEAO (2022), Financial Inclusion in Mali, Available here
[128] Fowowe B., Financial Inclusion, Gender Gaps and Agricultural Productivity in Mali, Link
[129] Privacy Shield Framework, Mali – Banking Systems, Link
[130] IBID

bank account), stemming from the prevalence of informality.[131] Despite this potential, banks are mostly concentrated in urban areas and have historically focused on large firms, leaving people in rural areas, low-income earners, and Small and Medium Enterprises (SMEs), especially in the agriculture sector underserved.[132]

Microfinance Institutions were set up to contribute to poverty alleviation and reduction of inequalities by facilitating access to financial services for low-income earners.[133] Microfinance can be defined as a set of financial products and services, including microcredit, micro-savings, microinsurance, fund transfers, etc., designed for individuals excluded from the traditional financial system (such as youth, women, illiterate individuals, rural populations, etc.). [134] Microfinance institutions (MFIs) provide localized services to those who are excluded from the banking system and apply streamlined and flexible procedures, such as reduced collateral requirements, to reach low-income populations.[135] The expansion of microfinance contributes to increasing productive capacities, income generation, and distribution through the financial inclusion of poor and low-income populations.[136] MFIs have a wider customer base than banks in Mali.[137] In 2017, Mali had 127 microfinance institutions, with a loan portfolio of 92.624 billion CFA (equivalent to USD 0.157 billion in 2017) and a client base of over one million people. However, microfinance institutions have faced several challenges since the crisis in 2012, leading to the closure of several organizations. These challenges included a lack of financial resources and enhanced exposure to insecurity, especially in rural areas. The Malian government set up a National Microfinance Development Policy (PNDMF/PA) in 2016 to address the challenges faced by MFIs and ensure the professionalization of the sector for an effective contribution to poverty reduction.[138]

In Mali, the emergence of mobile network operators (MNOs) has brought about convenient access to digital financial services, surpassing the reach of traditional microfinance institutions (MFIs). MNOs play a crucial role in facilitating access to formal financial institutions across the country.[139] The adoption of mobile money has experienced rapid growth, with an average annual increase of 60% between 2013 and 2016.[140] By 2022, 80% of adults in Mali had registered mobile money accounts.[141] MNOs are continuously developing new solutions to enhance access to financial services, such as Singa Ni Mara, the first digital savings and micro-loan product in West Africa. This innovative offering enables quick loan disbursement, reasonable interest rates, and monthly interest payments to account holders based on their savings.[142]

The prioritization of a small customer segment by the banking system, combined with the challenging conditions faced by microfinance institutions, have led to the development of alternative solutions to improve financial inclusion in Mali. The formal financial services available are not well-suited to the needs of the rural population, especially farmers.[143] A smallholder farmer is denied a loan seven times out of ten. [144] Most banks in Mali have limited knowledge of the agricultural sector, which coupled with an unfavorable regulatory framework, results in difficult financing conditions (collateral, repayment duration, etc.). With the support of development partners, the cooperative/associative approach has been set up to thwart the financial exclusion of low-income populations and promote the assimilation of financial planning and management.[145] These institutions incorporate a social approach in their

[131] IBID
[132] Fowowe B., (2022), Financial Inclusion, Gender Gaps and Agricultural Productivity in Mali, Link
[133] Financial Afrik, (2021), Mali: The microfinance sector between growth and challenges, Link
[134] Kone A., (2022), Analysis of the social performance of microfinance institutions in Mali, Available here
[135] IBID
[136] IBID
[137] Fowowe B., (2022), Financial Inclusion, Gender Gaps and Agricultural Productivity in Mali, Link
[138] Moulaye A.S. et al, (2022), Management of outstanding loans in decentralized financial systems in Mali, Available here
[139] BCEAO (2022), Financial Inclusion in Mali, Available here
[140] BCEAO, (2018), Study on Mobile Money and digital financial inclusion in Mali, Link
[141] Fowowe B., (2022), Financial Inclusion, Gender Gaps and Agricultural Productivity in Mali, Link
[142] Ideas 42, (2019), Digital Financial Services in Mali and Madagascar, Link
[143] World Bank, (2015), Improved Access to Credit Helps Boost Agricultural Production in Mali, Link
[144] IBID
[145] Government of Canada, (2018), Inclusive finance reaching financially excluded persons in Mali, Link

operations and provide financial and non-financial products to enable populations to effectively manage their economic and financial assets (savings, insurance, credit, money transfers, training, financial advice, technical capacity building, etc.).[146] The most prominent forms of cooperative/associative financial institutions include:

- **Cooperative networks:** A financial cooperative is a model of financial institution owned and operated by its members, mainly focused on the financial wellness of its members instead of maximizing profit.[147] Financial cooperatives play a crucial role in promoting social development and enhancing the quality of life within communities by emphasizing collective ownership, local management, and rootedness in the community.[148] The Nyèsigiso network, founded in 1993, is an example of financial cooperatives operating in Mali. It brings together mutual institutions and savings and credit unions from various regions, including Kayes, Koulikoro, Segou, Sikasso, Tombouctou, and Bamako, where members contribute fees to ensure mutual assistance.[149] The Credit Union Federation, established and accredited in 1997, offers technical and financial aid to affiliated credit unions, enabling them to provide services to their members.[150]
- **VSLAs:** A Village Savings and Loans Association (VSLA) is a self-managed community-based microfinance model that enables communities to collectively pool their resources to save money, lend each other and start income generation activities.[151] VSLAs aim to improve household cash-flow management, helping low-income earners increase their savings to avoid taking out formal loans that bring the risk of indebtedness.[152] Members of VSLAs meet regularly (weekly, biweekly, or monthly), create a group fund (or cash deposit) by accumulating their savings from which they can receive small loans as needed and repay with interest.[153] Nearly 16,000 VSLAs are currently active in Mali, regrouping more than 430,000 members, among which 83% are women.[154] By promoting savings amongst households, VSLAs contribute to strengthen household food and nutrition security, reduce vulnerability of communities, increase solidarity of communities during crises, and empower women, who represent the main target of VSLAs.[155]

Currently, there is limited national budget directly allocated to climate finance is almost non-existent, although 10.3% and 1.4% of the 2023 budget respectively is dedicated to agriculture (USD 0.5 billion) and environmental protection (USD 67 million). In 2013, the government set up the Mali Climate Fund to support climate change policy implementation and enhance the country's adaptive and resilience capacities, by improving the capacity to mobilize the financial resources necessary for the effective implementation of the national strategy for climate change (SNCC). It continues to be a small fund, with a budget of USD 29 million, of which USD 28.2 million are contributions from Sweden and Norway and USD 0.8 million stem from interests.[156]Currently the Mali Climate Fund has 21 ongoing projects but aims to facilitate the integrated implementation of Mali's climate strategic framework by transitioning from a project-based approach to a multi-sectoral approach. The approach to reach this objective consists in providing essential services, including mobilizing traditional and innovative financing, coordinating with other resources, promoting clean technologies, strengthening public-private partnerships, and financing government entities while enhancing their capacities through partnerships with UN agencies and civil society organizations. The Fund aims to drive transformative

[146] IBID
[147] Investopedia, (2020), Financial Cooperative: Definition, How It Works, and Example, Link
[148] Government of Canada, (2018),Inclusive finance reaching financially excluded persons in Mali, Link
[149] IBID
[150] IBID
[151] Care International, (2015), The resilience champions, Link
[152] VSL Associates, Who we are, Link
[153] Save the Children, (2018), Village Saving and Loans Association: Saving money to save lives, Link
[154] Care International (2022), Village Savings and Loan Associations: Annual Report, Link
[155] Care International, (2015), The resilience champions, Link
[156] Government of Mali, 2022 Annual report on the activities of the Mali Climate Fund, Link

change in climate action by leveraging financial resources, supporting sustainable technologies, and fostering partnerships for effective implementation.[157]

3.5 Mali's Livelihoods

Agriculture, defined as the practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food, and other products, is the dominant livelihood in Mali, with 75% of the population depending on agriculture.[158] The agricultural sector is predominantly based on subsistence farming, with smallholder farmers working on small parcels of land (officially defined as less than 10 ha) representing over 86% of farmers.[159]

Most farmers work on smallholder farms, (this does not include nomadic transhumance farmers), and are organized in unions, cooperatives or other formal or informal groups.[160] These organizations that operate at local level enhance productivity and access to markets and serve to increase livelihood resilience.

The primary livelihoods in Mali relate to rain-fed crop production and livestock keeping, which are often mixed as an income diversification strategy.[161] There is variation in livelihoods across the country, predominantly driven by resource accessibility as well as some cultural practices, including the nomadic tradition in the north of the country and across the Sahel. Detail on livelihoods in Mali can be found in the A: Food Security and Livelihood Sector Analysis chapter.

3.6 Conflict in Mali

Mali has been an epicenter of regional conflict and instability over the past decades and authorities are still struggling to improve security and socio-economic conditions. This situation created a fragile state, weakened local and national governance, economic inequalities, and increased insecurity so that many communities have organized themselves to defend their livelihoods, villages, and families. Conflict is present across all regions of the project and the crisis has had a major impact on the country including causing over 3,500 battle-related deaths across 2012-2020, over 412,000 internally displaced people as of December 2022, and an estimated 3.9 million people in need of protection assistance with many at risk of human rights violations, including sexual violence and gender-based violence.[162,163,164] The conflict is also heavily linked to climate change, with increasing competition for scarce natural resources identified as one of the major long-term causes of conflict. As *Weathering Risk* reports "the combined impacts of conflict and climate change are changing livelihoods, often in ways that weaken social bonds", ultimately feeding the cycle of conflict. In addition, by widening "existing inequalities" a vicious cycle is created particularly impacting disenfranchised groups such as women and youth.[165]

The MINUSMA (Multidimensional Integrated Stabilization Mission in Mali), established in 2013, has played a pivotal role in supporting Mali's stabilization, facilitating the political transition, safeguarding civilians, upholding human rights, providing humanitarian aid, and promoting national and international justice.[166] Its presence has been instrumental in restoring basic government services and rehabilitating critical infrastructure, particularly in the northern region.[167] However, the impending

[157] Mali Climate Fund, (2012) Presentation, Link
[158] CGIAR, (2019), Solar Irrigation to counter climate-vulnerability and improve food security in Mali. Available here
[159] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[160] Springer Link, (2020), Transforming a traditional commons-based seed system through collaborative networks of farmer seed-cooperatives and public breeding programs: the case of sorghum in Mali, Available here
[161] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[162] European Commission, (2023), Mali Fact Sheet, Available here
[163] Care International, (2021), Mali sees highest levels of displacement in its recent history due to a dangerous combination of conflict and climate change, Available here
[164] World Bank, (1990-2020), Battle-related deaths (number of people) – Mali, Available here
[165] Weathering Risk, (2022), Mali: How climate and environmental change compound conflict and inequality, Available here
[166] UK Parliament, (2023), Research Briefing: UN ends peacekeeping force in Mali, Link
[167] UN Foundation, (2021), Back from the brink: How the UN is stabilizing, securing, and strengthening Mali, Link

departure of MINUSMA raises concerns about a potential exacerbation of the security situation, with the likelihood of heightened conflicts and restricted access to certain areas within Mali.

3.7 Mali's Gender, Social Equity, and Inclusion Profile

In terms of the status of women, despite the existence of a legal and regulatory arsenal to strengthen the position of women in Malian society, women's representation remains marginal in political and administrative bodies, as well as in rural institutions and decision-making bodies. In 2013, women accounted for 9.52% of members of parliament; women party leaders accounted for just 2%. Similarly, women farm managers have less access to farmers' organisations: 17% of them belong to a farmers' organisation, compared with 32% of men. The proportion of women among local councilors was 8.3% in the 2009 elections, up 1.9 points in 2004 and 4.3 points in 1999. In 2016, this rate rose sharply to 25.6%. This result was boosted by the provisions of Law No. 2015-052, which requires political parties to include one in three (i.e. one-third) women when registering voters. This provision was complied with, and out of 79,238 candidates, 26,436 were women, i.e. 33.4%[168] . The Conseil National de la Transition (CNT) has twenty-eight (28) women out of one hundred and forty-seven (147) members, i.e. 28.57%. The current transitional government has only 6 women out of 29 members, i.e. 20.68%. Of the ten - nine - governors, only one is a woman, i.e. 5.26%. Women are much more present in childcare and household activities and much less present than men in food production and income generation activities, which are mainly reserved for men. Gender analysis also shows that access to and control over resources, benefits and services, participation in decision-making, and how women and men are treated by customary legal mechanisms all depend on gender.

Women play a vital role in agriculture, environmental management and biodiversity in Mali (particularly agro-biodiversity), as they are primarily responsible for crops that are essential to nutritional security. Socio-cultural factors have generally conditioned the development, use and transfer of the knowledge and skills needed to manage small farms according to gender-related social codes. On these farms, household members have different knowledge and skills. The work and activities carried out by each household member vary according to gender and age. The same applies to roles and responsibilities within each household. These differences between women's and men's spheres of activity and expertise foster the development of distinct but intertwined knowledge, preferences and priorities in the field of agricultural, wildlife and forest biodiversity.

In the agricultural sector, women are the main operators and processors of staple foods (maize, rice, sorghum, sorrel, monkey bread, shea butter, etc.) and are present throughout the agricultural chain. In addition, women are generally involved in small-scale livestock farming and all fish processing and marketing activities; they are the main collectors, processors and sellers of forest food resources. They also have specialised knowledge of forest plants, which are also used for fodder and traditional medicines. However, women generally lack the means to increase their production and productivity. In particular, they are discriminated against in terms of land management (especially access and control), due to socio-cultural factors which mean that in most communities, a woman cannot inherit land. Only 3.1% of farms in Mali are managed by women (compared with 17% for men), and these tend to be small: 54% have less than one hectare. The average sizes of women's plots are also much smaller than that of men (0.5 ha compared with 1.5 ha).

Furthermore, men and women do not have the same opportunities when it comes to supporting production, such as access to finance. Nationally, men have more access to credit than women and generally borrow larger amounts (e.g. men receive almost 100% of loans over 250,000 FCFA (equivalent to US$400 in 2023), as agricultural credit services do not deal directly with women who have no guaranteed source of income. These various discriminatory factors make women and girls particularly vulnerable to the impacts of climate change, especially as economic migration by men is a frequent adaptation strategy that leaves women who remain behind with the responsibility of maintaining agricultural production.

[168] **Source**: Election report/synthesis, 2016

3.8 Existing Agriculture and Agroforestry Projects in Mali

3.8.1 Summary of Complementary Interventions

Several other projects in Mali are currently being implemented (or in the design phase and due to commence in 2023-4) that also seek to address climate change adaptation and mitigation for smallholder farmers and agriculture /agroforestry systems more generally. Given the high risk and vulnerability of Mali to climate change multiple projects are needed to address the adaptation and mitigation gaps. To ensure no duplication will occur, projects with the greatest potential for overlap have been engaged during stakeholder engagement to ensure project activities are not duplicative and instead support collaboration to produce synergies and efficiencies.

This analysis has taken into consideration all GCF-funded projects in Mali and selected the most relevant interventions led by other development actors which cover:

- 10 GCF-funded projects that are currently active in Mali
- 24 projects currently implemented by other development actors and the Malian government that aim to support smallholder farmers or the market systems/infrastructure around agriculture and agroforestry.

These projects have been identified through engagement with project representatives and review of project documents. The analysis revealed various synergies with existing projects, including risks of overlap as well as upscaling opportunities both in terms of activities and locations. The potential areas of overlap and high-level strategies to prevent duplication have been summarized for the most relevant projects. In summary, these overlapping areas and projects are:

- Support for dissemination of CSA techniques amongst smallholder farmers: *(ref: IAAT **Error! Reference source not found.**)*
    - World Bank – West Africa Food System Resilience Program, Phase 2
    - World Bank - Regional Sahel Pastoralism Support Project II (PRAPS II)
    - FP162: GCF & IFAD – Africa Integrated Climate Risk Management Program *(also ref **Error! Reference source not found.**)*
    - FP012: GCF & World Bank – Africa Hydromet Program *(also ref **Error! Reference source not found.**)*
- Financial Inclusion and CSA value chain development, with a focus on smallholder farmers: *(ref: IAAT Component 2:)*
    - IFAD – Inclusive Finance in Agricultural Value Chain Project (INCLUSIF) 2019-2024
    - FP183: GCF & IFAD – Inclusive Green Financing Initiative (IGREENFIN I): Greening Agricultural Banks & the Financial Sector to Foster Climate Resilient, Low Emission Smallholder Agriculture in the Great Green Wall (GGW) countries - Phase I
- Smallholder farmer access to biodigesters and solar irrigation technologies: (*ref: IAAT **Error! Reference source not found.**)*
    - IFAD - Multi-Energy Project for Resilience and Integrated Land Management (MERIT)

In summary, the primary approach to minimize risk of duplication is for GCF IAAT to engage and closely collaborate with the representatives of these projects during implementation. This will ensure that the same beneficiaries are not targeted with the same activities (e.g. in biodigester systems) and that GCF IAAT activities build on and leverage the information systems and training programs developed by existing projects (e.g. information related to CIEWS, or existing training programs for extension agents).

3.8.2 Long-List of Complementary Interventions

Table 2: Summary of GCF projects in Mali/the region[169]

No.	Project	Lessor	Status & End Date	Goals/activities	Intervention zone	Potential Synergies with GCF project
1	Inclusive Green Financing Initiative (IGREENFIN I): Greening Agricultural Banks & the Financial Sector to Foster Climate Resilient, Low Emission Smallholder Agriculture in the Great Green Wall (GGW) countries - Phase I	GCF FP183	GCF (Status: Approved) , End Date: 2028	This cross-cutting programme will enhance access to credit and technical assistance for local farmers, farmers' organizations, cooperatives and micro and small-sized enterprises. This will help them implement climate-resilient and low-emission agriculture and agroforestry	National territory	Support agro micro-enterprise development in GCF project regions by linking rural financial institutions and use of investment models
2	The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW)	GCF FP162	GCF (Status: Approved), End Date: TBD)	The programme will build, strengthen and scale up the resilience and adaptive capacities of smallholder farmers and rural communities. It will provide capacity building and institutional development on integrated climate risks management. This includes reducing obstacles to access agricultural insurance for governments and smallholder farmers to enhance resilience building and strengthening climate weather information services.	National territory	Collaboration and knowledge share for strengthening and scaling up resilience and adaptive capacities of smallholder farmers and in rural communities in GCF project target regions
3	Programme for integrated development and adaptation to climate change in the Niger Basin (PIDACC/NB)	GCF FP092	GCF (Status: Approved), End Date: N/A	This programme will address these drivers by implementing a series of integrated and comprehensive actions that reduce the silting of the Niger River, improve natural resources management and enhance the population's ability to adapt to climate change	Niger Basin (relevant areas within Koulikoro, Mopti, Ségou, Sikasso, Bamaba, Gao, Timbuktu, Ansongo and Bourem	Collaborate to promote improved and climate-smart agroforestry and agriculture interventions
4	Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Mali Country Project	GCF FP012	GCF (Status: Under implementation), End Date: 2025	The project will support training and capacity building, expanding and upgrading existing hydromet observation networks including Automatic Weather Stations and hydrological stations, as well as investments to enhance data collection and communication systems. Improved flood and drought warning systems will also be developed, as well as building systems to ensure that early warnings reach the municipal and community level through better 'last mile' systems, and improved awareness at the local level.	National territory	Collaborate to increase farmers' access to hydromet information and use of improved drought and flood warning systems in GCF project target regions

[169] *Updated as of April 2023*

No.	Project	Lessor	Status & End Date	Goals/activities	Intervention zone	Potential Synergies with GCF project
5	Sustainable Renewables Risk Mitigation Initiative (SRMI) Facility	GCF FP163	GCF (Status: Under implementation), End Date: 2033	This programme is designed to help unlock the large amounts of private finance needed to complement the limited public funding available. It will help the seven target countries shift to low-emission sustainable development pathways and increase access to affordable, reliable, sustainable and modern energy.	National territory	Implementation of solar pump irrigation system in GCF project regions
6	BOAD Climate Finance Facility to Scale Up Solar Energy Investments in Francophone West Africa LDCs	GCF FP105	GCF (Status: Under implementation), End Date: 2027	The programme will help them to achieve their NDCs and address the barriers to solar investments. It will do this by using a blended finance approach to provide affordable long-term funding to solar projects and by providing tenor extension loans that will help de-risk projects, and crowd-in commercial and public banks in scaling up solar investments in the region (20 years project)	National territory	Implementation of solar pump irrigation system in GCF project regions
7	Mali Solar Rural Electrification project	GCF FP102	GCF (Status: Under implementation), End Date: 025	Increase rural population's access to electricity in 50 identified communities by (a) switching energy demand from diesel generators, kerosene lamps, paraffin candles and other emitting sources (25 years project)	National territory	Implementation of solar pump irrigation system in GCF project regions
8	Desert to Power G5 Sahel Facility	GCF FP178	GCF (Status: Approved), End Date: N/A	The Group of Five for the Sahel (G5 Sahel) countries – Burkina Faso, Chad, Mali, Mauritania and Niger –are characterized by high poverty levels, high vulnerability to climate change, and low electrification rates. The project aims to tap into the immense solar energy potential of the Sahel region and bring cheaper, reliable and low-emission electricity to end users. The Facility will address institutional and financial barriers and create an enabling environment to facilitate private sector funding for solar technological innovations and to ensure the sustainability of the clean energy sector.	National territory	Implementation of solar pump irrigation system in GCF project regions
9	Global Subnational Climate Fund (SnCF Global) – Technical Assistance (TA) Facility	GCF FP151	GCF (Status: Under implementation), End Date: 2028	To catalyze long-term climate investment at the sub-national level for mitigation and adaptation solutions through a transformative financing model. The SnCF Global's business model is designed to attract primarily private institutional investment and to deliver certified climate and Sustainable Development impacts and Nature-based Solutions at global scale. The Fund is designed to overcome project-level barriers and limitations in attracting private investment that leads to chronic underfunding of bankable mitigation and adaptation projects at the sub-national level, specifically at the deal size of USD 5 million to 75 million. Four regions: Eastern Europe, LAC, Africa and Asia-Pacific.	Regional level	Support agro micro-enterprise development in GCF project regions by linking rural financial institutions and use of investment models
	Sub-national Climate Fund Global (SnCF Global)	GCF FP152	GCF (Status: Under implementation), End Date: 2040			

No.	Project	Lessor	Status & End Date	Goals/activities	Intervention zone	Potential Synergies with GCF project
10	Infrastructure Climate Resilient Fund (ICRF)	GCF FP205	GCF (Status: approved), End Date: N/A	This program is designed to support investment in climate resilience infrastructure, by providing catalytic first loss equity to catalyze investments from private sector investors and pension funds. The ICRF will be supporting the development of CRI projects in a region struggling to unlock such funding by itself. The project supports 19 countries, with a focus on African states and Least Developed Countries	Regional level	Support the development of climate resilient infrastructure, helping to create a climate resilient enabling environment

Table 3: Summary of other projects/programs in Mali/the region with focus on climate-smart agriculture and agroforestry[170]

No.	Project/ Program	Lessor	Status & Project Dates	Goals/activities	Intervention zone	Potential Synergies with GCF project
1	Regional Support Project for the Sahel Irrigation Initiative (PARIIS) 2018-2024	Government of the Republic of Mali (GRM) and International Development Association (IDA)	status: active, dates: 2018-2024	(i) improve the process of access to land and water on irrigated areas on a transparent and equitable basis to secure producers, (ii) clarify the missions, functions and responsibilities of the various irrigation actors;(iii) implement sustainable management revitalization solutions for existing irrigated systems; (iv) implement development solutions for new small and medium-sized irrigated areas; and (v) share and disseminate information and knowledge on irrigation.	Region of **Koulikoro** (Circles Dioïla, Koulikoro); Region of **Ségou** (Circles of Ségou, Barouéli and Office du Niger area)	Implementation of solar pump irrigation system in Koulikoro and Seqou regions
2	Agro-industrial Competitiveness Support Project (PACAM) 2017-2022	World Bank; International Development Association (IDA)	status: active, dates: 2017-2022	The project development objective (PDO) is to increase the processing of agricultural products for the mango and animal feed sectors in the production basins of Sikasso, Bamako and Koulikoro through (i) the diversification of agriculture by increasing the production, processing and export of mangoes and improving animal feed; (ii) improving access to mango production areas by developing 310 km of rural tracks; (iii) modernization of mango collection and packaging facilities; (iv) promotion of animal feed production; and (v) the implementation of the business plans of the Productive Alliances selected within the framework of sub-projects.	**Sikasso** region (Circles of Sikasso and Yanfolila), **Koulikoro** and **Bamako** region	Support agro micro-enterprise development in Koulikoro regions
3	Inclusive Finance in Agricultural Value Chain Project (INCLUSIF) 2019-2024	Government of the Republic of Mali (GRM), International Fund for Agricultural Development (IFAD), Danish	status: active, dates: 2019-2024	The development objective of the project is to increase the financial inclusion of small producers and small and medium-sized agri-food enterprises (SMEs) in Mali. The project aims to enable smallholder farmers to invest in the necessary infrastructure and equipment by providing a range of financial products, including	Regions of **Kayes, Koulikoro,** Sikasso, **Ségou** and **Mopti**	Support agro micro-enterprise development in Koulikoro, Segou, and Mopti regions by linking rural financial institutions and investment models

[170] *Updated as of April 2023*

No.	Project/ Program	Lessor	Status & Project Dates	Goals/activities	Intervention zone	Potential Synergies with GCF project
		Cooperation (DANIDA), CANADA, the ABC Microfinance (Babyloan), Rural Finance Institutions, Private Sector and Beneficiaries		savings, credits and micro-insurance, to help them production and marketing of agriculture products		
4	National Program for Small Dams and Lowlands (PNPBBF) 2004-2023	Government of the Republic of Mali (GRM) and Don Japon (KRII)	status: active, dates: 2004-2023	The program is part of the dynamics of water control to secure agricultural production and diversify the incomes of rural populations. More specifically, it aims to develop water resources, whether permanent or not, through the construction of small dams, flooding works, plains of market gardening areas for the development of agriculture, livestock, fishing, arboriculture and drinking water supply.	National territory	Collaborate to integrate climate-smart water management technologies in the target regions
5	Project for The Development of Productivity and Agricultural Diversification in the Arid Zones of Mali Pdazam 2018- 2023	World Bank	status: active, dates: 2018-2023	The objectives of the project are as follows: Gradually develop land in areas with significant hydro-agricultural potential; Modernize and increase the level of equipment for producers; Improve productivity and build resilience of vulnerable rural households in targeted drylands.	Regions of **Kayes**, **Koulikoro**, **Ségou** and **Mopti**	Collaboration to integrate climate-smart interventions to enhance resilience building in Koulikoro, Segou and Mopti regions
6	Irrigation Development Program in the Bani Basin and At Selingue (PDI-BS) 2010-2020 extended to 2023	African Development Bank (AfDB), Arab Bank for Economic Development in Africa (BADEA), Islamic Development Bank (IDB), ECOWAS Bank for Investment and Development (EBID), Eximbank South Korea, Saudi Fund for (FSD), Kuwait Fund for Arab	status: TBC, dates: 2010-2020 extended to 2023	The Project's sector goal is to contribute to increased food security and poverty reduction. Its specific objective is to contribute sustainably to increasing rice production and agro-sylvo-pastoral and fish production. The PDI-BS covers three 33 zones: the Sankarani basin in Sélingué (supervised by the ODRS), the Bani basin in Bla and the Djenné zone (supervised by the ORM)	Regions of **Koulikoro** (Kangaba, Kati), **Ségou** (Ségou, Bla, San) and **Mopti**	Implementation of solar pump irrigation system in Koulikoro, Mopti and Seqou regions and integrate climate-smart water management technologies

No.	Project/ Program	Lessor	Status & Project Dates	Goals/activities	Intervention zone	Potential Synergies with GCF project
		Economic Development (FKDEA), Fund of the Organization of Petroleum Exporting Countries (OPEC) and Government of the Republic of Mali (GRM)				
7	Support Project for the Cashew Industry in Mali 2016-2020 extended to March 2022	European Union (EU); Spanish Agency for International Development Cooperation (AECID)	status: TBC, dates:	Main objectives of this project are: i) Increase economic and rural employment opportunities in the cashew sector and the incomes of the populations in the regions concerned; ii) Improve the food and nutritional security of beneficiary populations; and iii) Strengthen the governance of the cashew sector.	Regions of **Kayes** (Circles of Keniéba, Bafoulabé, Kita and Kayes); **Koulikoro** (Circles of Kati, Kangaba and Dioïla); **Sikasso** (All circles)	Integrate improved agroforestry system with cashew production in Koulikoro region
8	Support Program for the Development of the Office du Niger Zone Phase 2 (PADON2) 2011-2018 extended to June 30, 2022	French Development Agency (AFD)	status: TBC, dates: 2011-2018 extended to June 30, 2022	Increasing agricultural production in the area, starting with the construction of public hydraulic infrastructures and their availability to economically viable farms (3 to 5 ha). This involves consolidating 1,900 hectares of hydro-agricultural facilities and improving water management in the ON zone	Region of **Ségou** (Circle of Niono)	Implementation of solar pump irrigation system in Seqou region and integration of climate-smart water management technologies
9	Multi-Energy Project for Resilience and Integrated Land Management (MERIT) 2019-2026	International Fund for Agricultural Development (IFAD)	status: active, dates: 2019-2026	Contribute to improved food and nutrition security, poverty reduction and strengthen resilience, including climate resilience, for poor rural people in southern Mali. Key activities include sustainable improvement in access to renewable energy and soil productivity	Kayes, Koulikoro, Segou, Bamako, and Sikasso	Implementation of solar pump irrigation system in Koulikoro region and integration of climate-smart water management technologies
10	Livestock Development Support Project in Mali (PADEL-M) 2018-2022	Government of the Republic of Mali (GRM)/ International Development Association (IDA)	status: TBC, dates: 2018-2022	Improve the productivity and marketing of non-pastoral animal production in the targeted value chains (livestock/meat, milk, poultry farming and aquaculture) and strengthen Mali's capacity to respond to eligible crises.	National territory	Integrate agroforestry with fodder production to enhance livestock productivity in the GCF project locations
11	Project for the Development and Enhancement of Milk Production in Mali (PRODEVALAIT) 2019-2023	Government of the Republic of Mali (GRM)	status: active, dates: 2019-2023	Its overall objective is Mali's self-sufficiency in locally produced fresh milk and more specifically: (i) Significantly increase local milk production;(ii) Ensure the accessibility of local milk collection for processing industries; and(iii) Set up local milk processing industries.	National territory	Integrate agroforestry with fodder production to enhance livestock productivity in the GCF project locations

No.	Project/ Program	Lessor	Status & Project Dates	Goals/activities	Intervention zone	Potential Synergies with GCF project
12	West Africa Food System Resilience Program (FSRP) (Pipeline)	World Bank and Ministry of Rural Development	status: Pipeline, dates:	Increase preparedness against food insecurity and improve the resilience of food systems in participating countries Major components include: i) Digital advisory services for agriculture and food crisis prevention and management; ii) Sustainability and adaptive capacity of the food systems; iii) Regional food market integration and trade; and iv) Contingent emergency response	Ségou Region (Ségou and Niono) and Sikasso Region (Koutiala, Yorosso, Kadiolo, and Sikasso).	Collaborate to increase farmers access to digital information platform in Segou region and replicate this model to other target regions
13	Regional Sahel Pastoralism Support Project II (PRAPS-2)	World Bank	status: Active, dates:	To improve the resilience of pastoralists and agro-pastoralists in selected areas in the Sahel region: PRAPS2 will improve livestock productivity by improving access to health services and supply of inputs i.e. access to feed and forage, improve value chain extension.	Western and Central Africa: Mauritania, Niger, Senegal, Burkina Faso, Chad and Mali.	Collaborate on Ségou presence and transfer learnings to other target regions. Share promotion of resilient fodder tree activities with PRAPS.
14	Strengthening resilience in Mali	GIZ	status: Active, dates: December 2014 to March 2026	The objective of the project is to strengthen the resilience of food-insecure populations against food and nutrition crises, especially returned and repatriated refugees and internally displaced persons, and the diversity of food consumption among women of reproductive age in the Inner Niger Delta, specifically in south Tombouctou. Project activities include: support for small scale farmers and herders by providing them with production resources and training, schemes to repair wells to increase water access, and capacity building of national authorities and local administrations help to improve the resilience against food and nutrition insecurity through national and regional programmes, policies and strategies.	Timbuktu	Collaborate on capacity building of national authorities and local administrations help to improve the resilience against food and nutrition insecurity through national and regional programmes, policies and strategies Collaborate on Tombouctou i) well-based access to water farmers to increase climate shock resilience and ii) access to production resources to diversify crops grown (adding vegetables as well as rice) and iii) herd management techniques (e.g. manure management)
15	Sahel Resilience Project: *Strengthening Capacities for Disaster Risk Reduction and Adaptation for Resilience in the Sahel Region:*	Swedish Government, UNDP	status: Active, dates: 2019-2024	The project's objective is to foster risk-informed solutions for sustainable development in Western Sahel and Lake Chad Basin countries: Burkina Faso, Chad, Mali, Mauritania, Niger, Nigeria, and Senegal. Key activities include: i) enhanced data collection, analysis and reporting systems for disaster risk tracking and enhanced regional recovery and resilience-building processes that address underlying disaster and climate change risks.	Burkina Faso, Chad, Mali, Mauritania, Niger, Nigeria, and Senegal	Collaborate on increased access to climate risk data to enhance ability to respond to climate shocks

No.	Project/ Program	Lessor	Status & Project Dates	Goals/activities	Intervention zone	Potential Synergies with GCF project
	fostering risk-informed solutions for sustainable development					
16	Joint Programme for the Sahel in Response to the Challenges of COVID-19, Conflict and Climate Change (SD3C-MLI)	IFAD, Netherlands	status: Active, dates: 2020-2027	The Joint Programme for the Sahel in Response to the Challenges of COVID-19, Conflict and Climate Change (SD3C) in the Sahel and Senegal aims to consolidate the livelihoods of small producers, in particular women and youth living in cross-border areas of the six targeted countries(Burkina Faso, Chad, Mali, Mauritania, Niger, and Senegal). It seeks to address the trilogy of challenges posed by COVID-19, conflict and climate change in the Sahel. The project conduct activities across 3 macro topics: i) Increase in agrosilvopastoral and fishery productivity and production through climate-resilient agricultural practices and technologies., ii) Economic integration through interventions aimed at strengthening cross-border, markets and securing border transactions, iii) Political dialogue, coordination and management integrated into the coordination mechanism of the G5 Sahel.	6 Sahel countries, including Mali. In Mali, includes **Koulikoro, Tombouctou, Gao, Menaka,** Kidal and **Mopti** (using the new boundaries)	Collaborate on the dissemination and growth of CSA techniques for agro-silvo-pastoral farming and funding of women & youth entrepreneurs in overlapping areas
17	Feed the Future	USAID	status: Active, dates: 2021-2026	The project aims to catalyze integrated, inclusive, and diverse on-farm production systems leading to increased sales, availability, and access to nutritious foods for farming households. working with farmers to increase and diversify production of crops and livestock, and sustainably improve on-farm resilience to climate, economic, and conflict-related shocks and stresses. The project operates through 3 sub-components: sene yiriwa, sugu yiriwa and keddo diren. Activities include: support for increased use of climate-smart agriculture, increased access to climate meteorological data, support for improved land and water resource management; increased availability of nutrient-dense food. Keddo Diren specifically works to promote stability through participatory and inclusive management of key land and water resources including dry season wetlands and rainy season upland pastures and addresses conflict over competition for dwindling natural resources and establishes diversified small ruminant and animal feed	80 communes from 12 circles in the Delta zone: Bandiagara, Bankass, Dire, Djénné, Douentza, Goundam, Koro, **Mopti**, Niafunké, Ténénkou, **Tombouctou**, and Youwarou.	Collaborate on support for the adoption of CSA techniques, funding of women and youth run businesses and access to climate data. Potential to incorporate practices to limit conflict over natural resources. Note that this project is in parallel to the Albarka project that is parallel financed with GCF IAAT

No.	Project/ Program	Lessor	Status & Project Dates	Goals/activities	Intervention zone	Potential Synergies with GCF project
				businesses operated by women and youth as a strategy to improve community resilience.		
18	Agriculture Women and Sustainable Development Program (AGRIFeD - Agriculture Femmes et Développement Durable)	MPFEF MDR MEADD CT MEF MMEE MCENM FAO, le PAM Directions régionales du Développement Rural	status: Active, dates: 2022-2026	The programme works with female farmers to modernize their techniques, enables their access to information on the latest advances in agriculture and increases the value of their products by improving their conservation methods. Overall it targets combat gender inequalities in agriculture and the negative impact of climate change on women's livelihoods.	The towns of Kayes, **Koulikoro,** Sikasso**, Segou, Mopti, Gao, Timbuktu**	Collaborate on Koulikoro, Segou, Mopti, Gao, Timbuktu training and support for women farmers
19	Strengthening the resilience of women producer groups and vulnerable communities in Mali	Agency for Environment and Sustainable Development (AEDD), Ministry of Environment and Sanitation, Government of Mali, United Nations Development Programme (UNDP), Global Environment Facility (GEF) Government of Canada	status: TBC, dates: 2020-2023	The project targets 2 outcomes: i) sustainable climate-resilient water management systems provided to vulnerable communities, including women farmers, which in turn ought to support the development of subsistence activities and ii) innovative approach and sustainable climate resilient technologies provided to women farmers and producers in vulnerable communes to enhance and secure the production of local livelihood systems from climate impacts	Kayes, **Koulikoro** and Sikasso	Collaborate on Koulikoro work on deployment of CSA technoloqies and support for women farmers
20	Promote integrated agro-pastoralism, strengthen social cohesion (Integrated agro-pastoral project in the regions of Gao, Ménaka and Mopti in Mali (PAI-GM)	GIZ	status: Active, dates: 2019-2024	The project aims to increase resilience of pastoral and agro-pastoral households to socio-economic crises. Activities focus on: proving the water supply and the provision of relevant services for animal health, such as vaccinations. It also trains livestock herders in climate- and soil-friendly pastoral and livestock farming practices; efforts to make existing water sources usable for agriculture and livestock farming as well as accessible to the local population; promotes local stakeholders and existing mechanisms that strengthen social cohesion and contribute to preventing and managing land use conflicts between population groups.	**Gao, Ménaka and Mopti**	Collaborate on Gao, Menaka and Mopti training for CSA practices
21	Pro-Arides	Netherlands Ministry of Foreign Affairs	Status: Active 10 year duration	pro-ARIDES aims to contribute to increased resilience, food security and incomes of farmer and agro-pastoralist households in the Sudano-Sahel zone of	**the Ségou Region (**Tominian and San cercles) **and the**	Collaboration on Segou and Mopti implementation of supporting local agricultural

No.	Project/ Program	Lessor	Status & Project Dates	Goals/activities	Intervention zone	Potential Synergies with GCF project
				Burkina Faso, Mali and Niger, through effective, decentralised institutions and organisations for improved service provision, natural resource and land management and local economic development.	**Mopti Region (**Koro and Bankass cercles)	businesses and value chains with CSA practices and access to finance Leverage lessons learnt on integrated multi-stakeholder governance of land
22	Program for the Promotion of Agroecological Cropping Systems and Soil Protection in Mali (PAESOL)	Government of Mali, Direction nationale de l'Agriculture	Status: Active, dates: 2022-2026	Key focus includes: Agriculture & Agroecology *Further details to be added after government consultations to be conducted in w/c 8th May*	Sikasso ; Koutiala; Bougouni, Kayes; Niro of the Sahel; Kita; **Koulikoro**; Dioïla ; Kayes	*Synergy analysis be added after government consultations to be conducted in w/c 8th May*
23	Landscape Restoration and Resilience Project (AEDD/ABFN)	Government of Mali,,Agence de l'Environnement et du Développement Durable (AEDD)	status: Active, dates: 2022-2028	Key focus includes: Environment *Further details to be added after government consultations to be conducted in w/c 8th May*	Kayes, **Koulikoro, Mopti,** Bamako	*Synergy analysis be added after government consultations to be conducted in w/c 8th May*
24	Project climate security and sustainable management of natural resources in the regions of central Mali for the consolidation of peace	1. Agence de l'Environnement et du Développement Durable (AEDD)	status: Active, dates: 2022-2028	Key focus includes: Environment Security, Peace, Natural Resources *Further details to be added after government consultations to be conducted in w/c 8th May*	**Mopti**	*Synergy analysis be added after government consultations to be conducted in w/c 8th May*

3.8.3 Further information regarding the most relevant Complementary Projects

Table 4: IFAD – Inclusive Finance in Agricultural Value Chain Project (INCLUSIF) 2019-2024[171]

Status	Shared locations	Relevant activities in Complementary Project
Status: Under implementation; 2018 - 2024	Koulikoro, Segou, Mopti	• Component 1 - Development of rural financial services, including a focus on increasing financial inclusion to smallholders which includes socio-economic training for disadvantaged groups, (primarily women) to allow beneficiaries to be brought into the banking system. • Component 2 – support for business plan development to increase access to finance for producer's organisations and SMEs • Build partnerships of smallholders with the private sector and support rural microenterprises

Overall Project Complementarity	GCF IAAT activities that will deliver gap-filing / upscaling to complementary project	Risk of Duplication & mitigation across projects	Relevant Lessons Learnt to Leverage
- Includes main target of increasing financial inclusion through financial education and overall microfinance market re-structuring aligns with GCF IAAT's sub-goal increasing financial inclusions for investment in commercial agroforestry and high-value plantation crops of increasing financial inclusion - As part of the training and incubation services provided to small holder farmers [SHF], GCF IAAT will include reference to the Inclusif supported financial services and instruments. GCF IAAT will also leverage the lessons' learnt from Inclusif's existing work in increasing access to finance work in component 2	- GCF IAAT can enhance knowledge sharing and training provided to SHF by Inclusif, by expanding Inclusif's financial literacy training to other relevant topics, such as CSA techniques in component 1 - Training as part of the incubation activities in component 2 will also include connection between SHF and new financial sources targeted at similar organisations but will avoid duplicating the curriculum of Inclusif by liaising with the Inclusif implementers - Component 2 will also leverage the learnings from Inclusif's existing work supporting microfinance institutions, and expand these to new areas and organisations	- Training offered to same beneficiaries through different institutions (farm schools for GCF IAAT vs FIER for INCLUSIF) - Mitigation: engagement with local INCLUSIF implementation and clarify on curriculum to ensure no cross-over in overlapping geographical areas	- **Crucial to work with multiple actors:** IFAD entry point was smallholder farmers for INCLUSIF. This was not sufficient as it is difficult to enact change from the smallholder farmer perspective without having change driven from the private sector, and without changing enabling environment (e.g. land legal system based on laws from 2003). - **Need to factor in data collection in project design:** when piloting something, need to ensure data collection is included to ensure we can demonstrate results. - **Time to change ingrained practices:** Flagged the sociological relationship between the way of farming and the farmers identities as practices have often been practiced for decades or generations. This made shift to contract farming challenging. - **Income generation decreases social and conflict risks:** Need to focus on opportunities for generating income; low income a key driver for people leaving but also for joining terrorist groups - **Microfinance instruments, even when organisations are supported, can still present non-attractive terms to farmers:** Flagged risk of Micro-finance institutions' products not always being appropriate for smallholder farmers (e.g. rates too high). Flagged some financial instruments e.g. value chain finance (new finance provided by private sector) has actually led to dependence on private sector for seeds, money e.g. in cotton industry and is not sustainable.

[171] IFAD, (2018), President's report: Proposed loan and grant to the Republic of Mali for the Inclusive Finance in Agricultural Value Chain Project, Available here ; and interview with Norman Messer, Regional Director, IFAD in 04/23

Table 5: FP183: GCF & IFAD – Inclusive Green Financing Initiative (IGREENFIN I): Greening Agricultural Banks & the Financial Sector to Foster Climate Resilient, Low Emission Smallholder Agriculture in the Great Green Wall (GGW) countries - Phase I[172]

Status	Shared locations	Relevant activities in Complementary Project
Approved April 2022 Implementation until 2028	Koulikoro, Segou (TBC)	• Concessional loans to farmer's organizations (FOs), women and youth-led organizations, cooperatives and MSMEs (including agribusiness dealers and solar operators) to finance adoption of best adaptation and mitigation practices • Capacity building for MSMEs, cooperatives, FOs, women and youth organizations, governments, LNABs, MFIs, commercial banks to enhance uptake of green business projects • Improve policy dialogue, government technical and institutional capacity, advocacy, training, knowledge management, information dissemination and stakeholder management • Enhanced knowledge management and exchanges accelerating the uptake of best practices and learning and informing policy and investments across projects of the GCF and others • Create a digital marketplace with all services provided by platforms and other providers • Conduct awareness-raising and training on climate resilient, low emission agriculture for FOs, Cooperative, MSME, MFIs and Banks

Overall Project Complementarity	GCF IAAT activities that will deliver gap-filing / upscaling to complementary project	Risk of Duplication & mitigation across projects	Relevant Lessons Learnt to Leverage
• Both targeting increased climate resilience for vulnerable smallholder farmers, GC IAAT and GREENFIN 1 share objectives, target beneficiaries and locations (2 of GCF IAAT's 5 regions are also engaged by IGREENFIN 1) • GCF IAAT will ensure that information pertaining to the relevant activities from GREENFIN 1 is disseminated as part of its incubation program for small holder-farmers • It will also broaden the geographic range of the project whilst simultaneously supporting the same regions more deeply, covering 3 additional regions whilst focusing exclusively on Mali. In addition, it will focus more explicitly on training small holder farmers (in addition to MSMEs)	• The component 2 training program for women and youth entrepreneurs will explicitly link the entrepreneurs to i) the concessional funding provided by IGREENFIN 1 in Mali, ii) the digital marketplace. It will also expand coverage of the existing work by IGREENFIN for Capacity building for MSMEs, cooperatives, FOs, women and youth organizations, governments, LNABs, MFIs, commercial banks to enhance uptake of green business projects by expanding the geographic coverage within Mali • The knowledge sharing that is included as part of component 3 will leverage the existing platforms for CSA technology knowledge sharing started by IGREENFIN1 •	• Due to a high degree of overlap in activities and beneficiaries it will be important to mitigate duplication by ensuring that i) exact targeted locations are varied and/or ii) close collaboration is ensured throughout the implementation of projects	N/A ***To leverage during project implementation as FP183 is only in the early stage of implementation***

[172] Green Climate Fund, (2022), Inclusive Green Financing Initiative (IGREENFIN I): Greening Agricultural Banks & the Financial Sector to Foster Climate Resilient, Low Emission Smallholder Agriculture in the Great Green Wall (GGW) countries - Phase I, Available here

Table 6: World Bank - West Africa Food System Resilience Program, Phase 2[173]

Status	Shared locations	Relevant activities in Complementary Project
Active 2023-2028	Ségou Region (Ségou and Niono)	In Mali FSRP includes the following complementary project activities: - Modernizing national extension services through updating the curriculum and digitizing extension services - Supporting the development of strategic value chains including rice, onions and maize through policy, capacity extension, and hard investments in infrastructure (e.g. processing facilities and markets) - Restoration of 1,200 HA of degraded land through zai pits, agroforestry and farmer-managed natural regeneration

Overall Project Complementarity	GCF IAAT activities that will deliver gap-filing / upscaling to complementary project	Risk of duplication	Lessons Learnt [Source: interview w/ World Bank project member, April 23]
FSRP is working towards increasing food system resilience in Segou, Mali as part of a broader regional project in West Africa. GCF IAAT will extend the work of FSRP that relates to CSA practices to beyond Segou (which is only one of 5 regions targeted), and leverage the lessons FSRP have learnt on digitizing extension services, supporting strategic value chains and degraded land restoration.	- Component 1 in GCF IAAT will extend FSRP's work by expanding their digital extension services and support for land restoration practices outside of Segou and to other areas, particularly Tombouctou and Mopti which are more impacted by conflict and harder to reach for in-person extension services - Component 2 of GCF IAAT will support parallel strategic value chains, leveraging the lessons learnt from FSPR in VC development and bringing those to CSA relevant VCs	- GCF IAAT's work in Segou is at risk of duplicating FRSP's activities - Mitigation: engagement w/ FSRP's local implementation team to ensure no overlapping activities for the same communities	Conflict risk is the major risk; highlighted a number of potential lessons learnt to minimize risk to the project: • Before implementation, useful to undertake local political economic analysis to limit risk of inflaming local tensions • Utilize digital support e.g. educational CSA materials delivered online (as part of extension service expansion) as these activities can continue if travel restrictions are in place • Allow longer than expected for activities to occur as conflict can cause pauses in implementation

[173] World Bank, (2023), West Africa Food System Resilience Program (FSRP) Phase 2, Available here ; and interview with Sebastian Heinz, WB nominated contact for FSPR, 04/23

Table 7: World Bank - Regional Sahel Pastoralism Support Project II (PRAPS II)[174]

Status	Shared locations	Relevant activities in Complementary Project
Approved 2021 Status: Active Dates: 2022-2028	Segou, Mali	- Improve Productive Capacity and Market Integration of Farmers and Pastoralists - Exploit satellite imagery data and other digital monitoring tools, as well as applications to inform pastoralists on the state of natural resources and infrastructure (such as the GARBAL15 satellite information service for pastoralists in Mali), that will contribute to provide pastoral indicators informing the national Early Warning Systems. - Adaptation: The Project will also work to improve access to and use of feed and forage (through specific value-chains development along the main regional agropastoral livestock corridors – i.e. production, storage, processing and commercialization), and to complement scarce natural resources during the lean season to improve pastoralists' and agropastoralists' resilience - Training and vocational education and training (TVET) programs for youth and women on topics such as feed and forage production, processing, conservation and strategic use; business plan preparation; climate-smart livestock and digital agriculture, as well as on TVET directly related to the establishment of micro-projects; (ii) microproject financing to increase sources of revenues, using competitive funding (grants) to finance investments generating local value addition and employment opportunities - Reduction rate of conflicts linked to mobile livestock systems in three transhumance and trade axes

Overall Project Complementarity	GCF IAAT activities that will deliver gap-filing / upscaling to complementary project	Risk of duplication	Lessons Learnt
- Collaborate on Ségou presence and transfer learnings to other target regions. - Share promotion of resilient fodder tree activities with PRAPS	Within component 2, there is an opportunity for GCF IAAT to provide training to PRAPS II investees to strengthen their business management capacities. PRAPS II aims to provide financial support to projects led by farmers, especially women and youth, but the program does not include a post-investment support to ensure viability of projects	*N/A*	• **Clustering:** Improving spatial coherence, promoting clustering and avoiding the geographic dispersions of investments • **Institutional strengthening:** Strengthening institutions and actors in charge of pastoral development and governance support should also focus on improving and implementing policies on securing agro-pastoral land, by boosting the enforcement of agropastoral and citizen rights, and going beyond the "business as usual" approach i.e. regulations awareness raising.

[174] World Bank, (2021), Regional Sahel Pastoralism Support Project II (P173197), Available here ; and interview with Rhoda Rubaiza, national coordinator of PRAPS II in Mali

Table 8: IFAD - Multi-Energy Project for Resilience and Integrated Land Management (MERIT) [175]

Status	Shared locations	Relevant activities in Complementary Project
Ongoing – 2019- 2026	Koulikoro, Segou	• Supporting the creation of a multi-stakeholder platform to promote an inclusive policy dialogue on renewable energies and biogas • Dissemination of 5,000 biodigesters as well as supporting local artisans to support their deployment • Creation of 150 Adaptation Community Plans to support a local context driven climate adaptation approach • Awareness raising and capacity building on renewable energies and training through mixed farmer field schools on agroecology and fodder productions. • Professionalization of fodder seed producers

Overall Project Complementarity	GCF IAAT activities that will deliver gap-filing / upscaling to complementary project	Risk of duplication	Lessons Learnt [Source: interview w/ MERIT program coordinator, May 12]
• MERIT shares a focus with GCF IAAT by supporting small-scale farmers who are the most vulnerable to climate change through shared approaches: by supporting the dissemination and development of biodigesters and their market and building capacity through farm-school centered training. • GCF IAAT will build on and upscale MERIT's work by broadening the biodigester dissemination and scope of the field-school curriculum	• Component 2 in GCF IAAT will extend the dissemination of biodigesters from 5000 by MERIT to a further 5000; and by adding further to this effort by disseminating solar pump irrigation broadening the clean energy access to crop farmers as well as those with livestock. • GCF IAAT will expand the efforts of MERIT by integrating CSA techniques and agroforestry into awareness raising and capacity building efforts for smallholder farmers (component 1) When designing local curricula, adaptation community plans will be leveraged as per their availability.	• Dissemination of biodigesters to the same beneficiaries in Koulikoro and Segou • Mitigation: engagement with MERIT implementation partners to identify overlapping candidates for biodigesters and ensure no duplication • Training in farm schools on renewable energies • Mitigation: engagement with MERIT implementation partners to ensure no duplication of beneficiary selection	• **Need to build supply chain for biodigesters:** There is low capacity in-country to build biodigesters. MERIT provides technical and financial management training to masons and regroups them into Economic Interest Groups to support supply chain development and build a sustainable market for biodigesters

[175] IFAD, Multi-Energy for Resilience and Integrated Territorial Management: Project Design Report, Available here ; and interview with Daouda Diallo, MERIT program coordinator

Table 9: FP012: GCF & World Bank – Africa Hydromet Program[176]

Status	Shared locations	Relevant activities in Complementary Project
Approved June 2016 Ends Jan 2025	All regions (TBC)	• Capacity building for hydro-meteorological agencies' staff and management • Strengthening institutions of hydrometeorology, food security and civil protection • Improving hydromet and early warning infrastructure • Strengthening stakeholder engagement and providing a platform for the exchange of knowledge and climate information needs • Developing specialized weather, climate and hydrological products and services tailored to sector specific needs • Strengthening last mile connectivity, including mobilization and sensitization of the community

Overall Project Complementarity	GCF IAAT activities that will deliver gap-filing / upscaling to complementary project	Risk of Duplication & mitigation across projects
GCF IAAT will leverage the infrastructure and information systems developed by the Hydromet project to i) inform farmers and extension agents in selecting the most pertinent CSA techniques for each community, and ii) support investors to be informed about the climate risk profile of investments	• Leverage local Hydromet data to support farmers at farm schools to i) identify the relevant CSA practices and ii) increase knowledge and use of CIEWS (component 1) • Component 4 will also support national climate adaptation and mitigation capacity building at the institutional, including government, level	• Risk of duplicating institutional capacity building efforts • Mitigated by engaging w/ Hydromet team as part of the broader consultation process undertaken during the activities that form part of component 3

[176] Green Climate Fund, (2016), Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Mali Country Project, Available here

Table 10: FP162: GCF & IFAD – Africa Integrated Climate Risk Management Program[177]

Status	Shared locations	Relevant activities in Complementary Project
Ongoing - Until 2027	Segou, Koulikoro (TBD)	• Strengthen climate weather information to support decision-making and planning in agro-forestry, livestock, agricultural insurance products and services • Training of meteorological experts in country on impact-based forecasting methodologies, data collection and interpretation • Training smallholder farmers on the timely use of early warning products (including agro-climatic information) to improve their understanding of climate variability • Training extension agents on early warning systems for droughts, floods or extreme precipitation • Promoting the use of adaptation and mitigation techniques and technologies on agro-pastoralism to address the water deficit • Training modules on financial literacy, marketing and business management • Developing micro-insurance schemes tailored to each country context

Overall Project Complementarity	GCF IAAT activities that will deliver gap-filing / upscaling to complementary project	Risk of duplication
• In their joint objective to increase the resilience of smallholder farmers, and specifically in Mali in 2 overlapping locations (Segou and Koulikoro), GCF IAAT will build on the existing work of Africa ICRMP by including education regarding crop insurance as one of its topics in farm schools and extensions agents as well as expand FP162's existing work by supporting existing agricultural information channels to include topics beyond weather advisory and insurance	• In component 1 GCF IAAT will diversify the climate-smart solutions promoted by the Africa ICRMP (i.e., expand solutions beyond weather advisory and weather insurance) to extension agents through the introduction of broader CSA topics to the curriculum • In component 1 GCF IAAT will also expand the coverage of the smallholder farmer training to include other CSA-relevant topics beyond early warning products and insurance • Component 4 will also support national climate adaptation and mitigation capacity building at the institutional, including government, level	• Providing capacity-building modules to the same farmers, extension agents and private sector technicians targeted in Segou and Koulikoro • Mitigation: GCF IAAT will liaise with the Africa ICRMP project in advance of starting extension agent and field school engagement to ensure capacity-building modules are not duplicated in the same area, and that the focus of GCF IAAT will be on complementary training modules

[177] Green Climate Fund, (2021), The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW), Available here

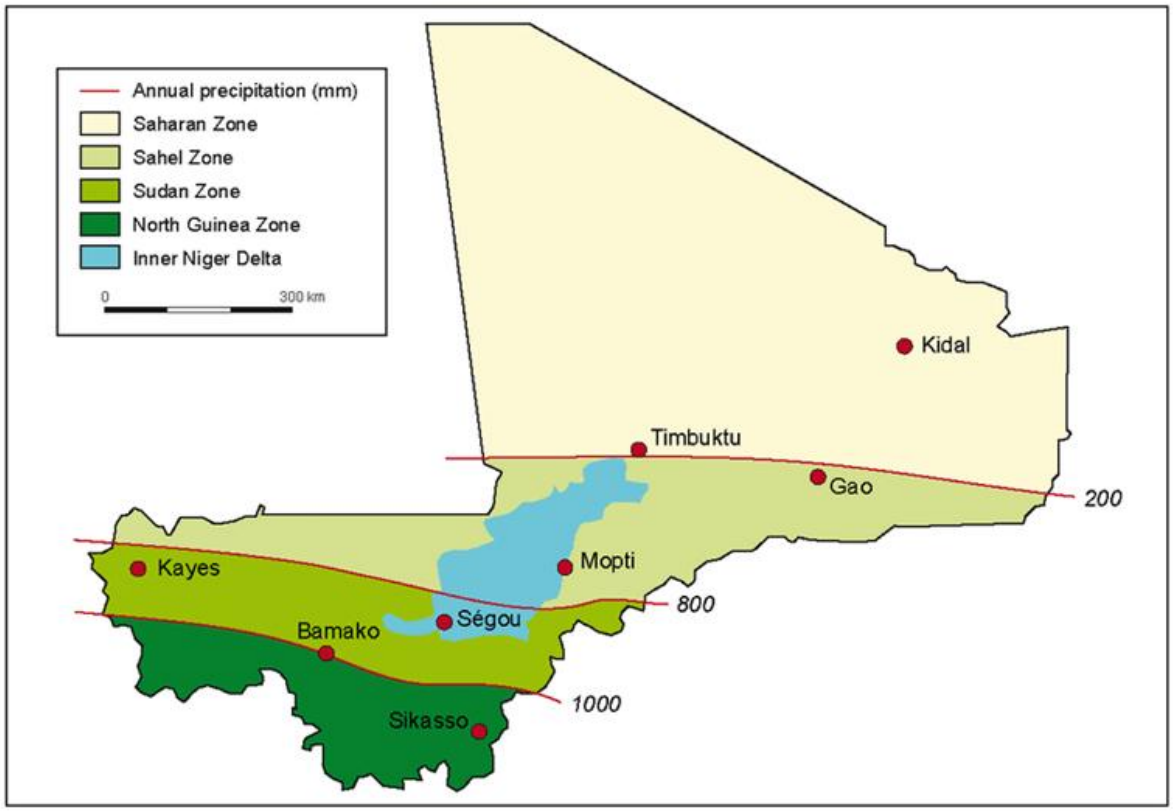
IV. MALI'S CLIMATE AND RECENT TRENDS

4.1 Introduction

Mali is ranked the 11th most vulnerable country and the 23rd least ready country for the impacts of climate change, out of 192 countries according to the ND-GAIN ranking.[178] Mali's vulnerability stems from its erratic rainfall throughout the country, and the hot climate, with an average mean temperature of ~28°C[179]. These climatic conditions impact Mali's agricultural productivity and food insecurity especially during extreme events such as floods, droughts, and heatwaves.

Malian climate is characterized by three seasons: a dry season in March to June, a rainy season from June to September, and an off-season or cold season from October to February with a drying Saharan wind. Mali is most commonly divided into 5 distinct agro-climatic zones (see **Error! Reference source not found.**), that are in large part defined by their variation in rainfall, with variation of up to ~800mm on an annual basis. Mali is dominated by the Saharan desert to the north and the tropical savanna to the south, which results in a semi-arid climate with distinct seasons that differ in duration throughout the country. The Sahara Desert covers nearly half of Mali's northern territory, where the dry season can last more than nine months. Moving southward, the climate transitions to the semi-arid Sahel region (interrupted by the seasonally flooded alluvial plain of the Inner Niger Delta), then to the Sudanian savanna, which has a tropical wet and dry climate, in the south and west.

Figure 10: Main agro-climate zones of Mali and annually flooded area of the Inner Niger Delta[180]



[178] NDC Gain index, (2002-2021). Mali, Available here
[179] World Bank, (2023), Climate Knowledge Portal Mali profile, Available here
[180] Hummel, D., Doevenspeck, M. and Samimi, C. (2012), Climate Change, Environment and Migration in the Sahel, Selected Issues with a Focus on Senegal and Mali (pp.44-49), Available here

During the wet season, Mali experiences high temperatures and frequent rainfall. The dry season, on the other hand, is characterized by hot days and cool nights, with virtually no rainfall. Across the country, there is 'high' vulnerability to extreme heat, drought, flooding and wildfires.[181] The problems of extreme heat are particularly pronounced in the Northern Saharan and Sahelian desert and semi-desert areas. The average temperature in Mali varies between 22°C in January and 34°C in May.[182]

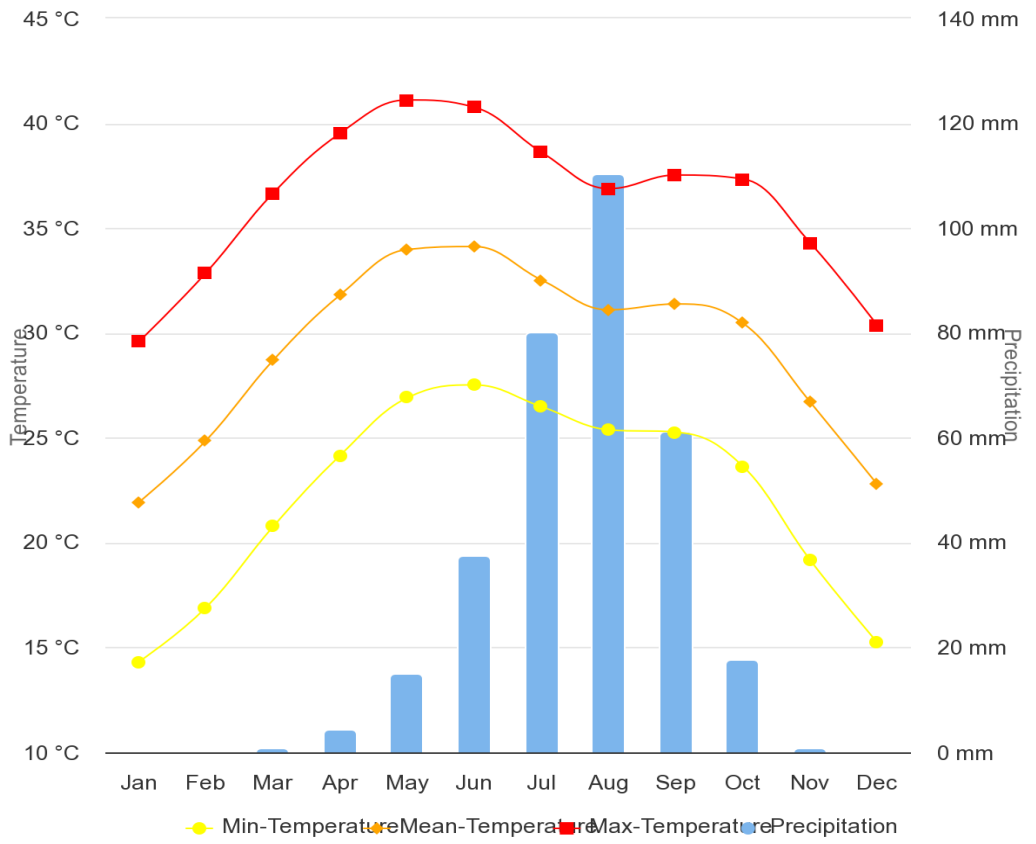
Mali is predominantly dependent on the Niger River for its water supply which in turn is fed by precipitation from the West African monsoon[183], as well as the Senegal river basin. These two basins provide wetlands, flood plains and lakes that provide opportunities for agriculture, as well as fishing. In addition, these rivers provide the majority of groundwater which is the primary source of drinking water, and the water used in food production[184].

4.2 Temperatures and extreme heat

Mali is one of the hottest countries in the world with an average mean temperature of ~28°C which varies throughout the year, and between regions.[185] Mali experiences its coldest average temperatures of around 22°C in December / January (part of the dry season). The temperature then increases until its peak in May / June at an average of 34°C, as precipitation increases. There is generally a steady decrease until August, then a slight increase in September and October when temperatures and precipitation drop until the cycle repeats. This cycle, as well as the mean, minimum, and maximum temperatures by month can be seen in the line chart component of Figure 11.

Figure 11: Monthly mean, minimum, and maximum temperatures (and precipitation) in Mali 1991-2020. (World Bank Climate Knowledge Portal)[186]

[181] World Bank, Think Hazard Mali profile, Available here
[182] World Bank, (2023), Climate Knowledge Portal Mali profile. Available here
[183] Krampe, F., Hegazi, F. and Smith, E. (2021) 'Climate-related Security Risks and Peacebuilding in Mali', SIPRI. Available here
[184] Winrock International, (2021), Mali Water Resources Profile Overview, Available here
[185] World Bank, (2023), Climate Knowledge Portal Mali profile. Available here
[186] World Bank, (2023), Climate Knowledge Portal Mali profile. Available here

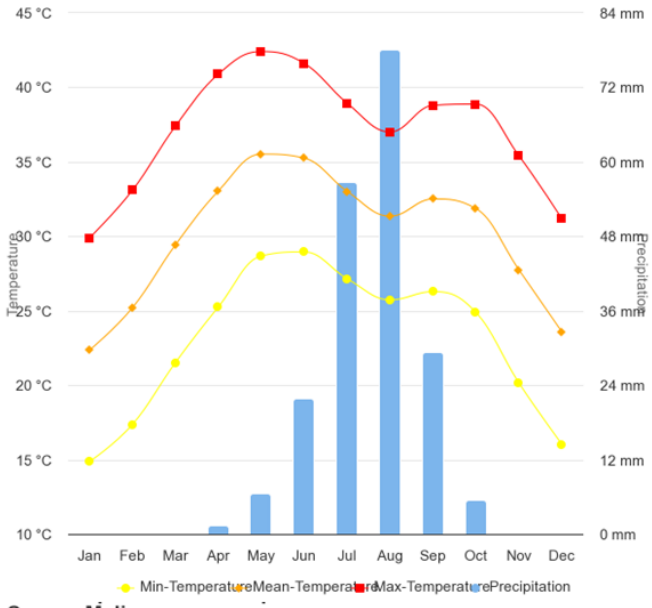


These temperatures vary across the country, with the North of the country (including IAAT project regions Gao and Tombouctou) experiencing higher temperatures than those in the south (including IAAT project regions Koulikoro and Segou). Furthermore, in the south of the country, there is more pronounced temperature variation with a more notable drop in temperature going into the peak of the rainy season around August. These trends are visible in Figure 11.

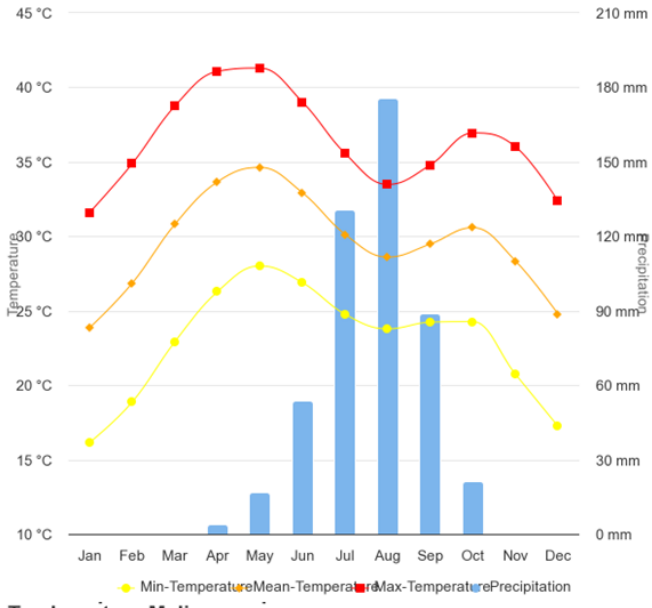
Figure 12: Monthly mean, minimum, and maximum temperatures (and precipitation) by project region 1991-2020 (World Bank Climate Knowledge Portal)[187]

[187] World Bank, (2023), Climate Knowledge Portal Mali profile. Available here

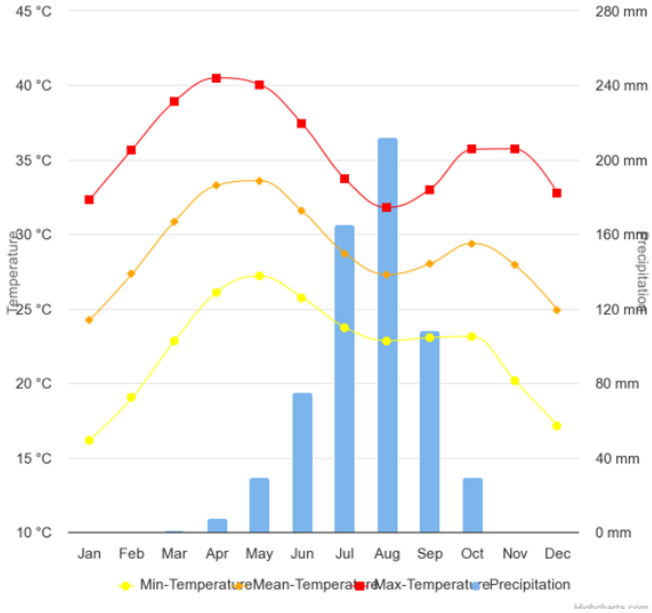
Gao, Mali



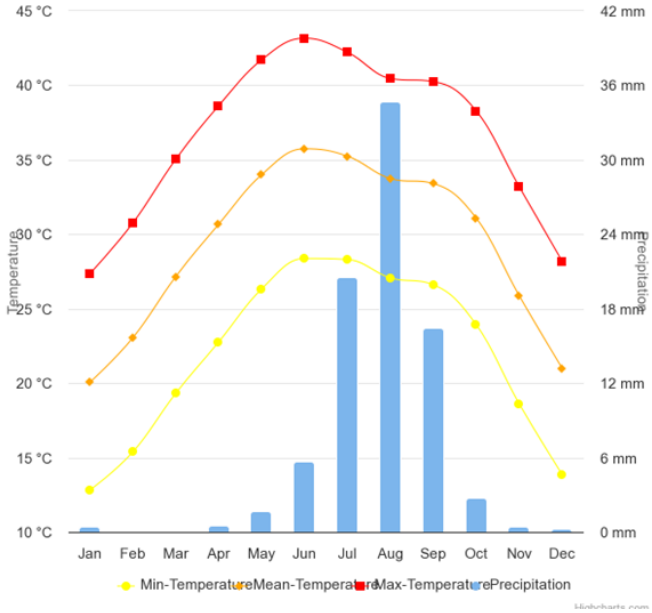
Mopti, Mali

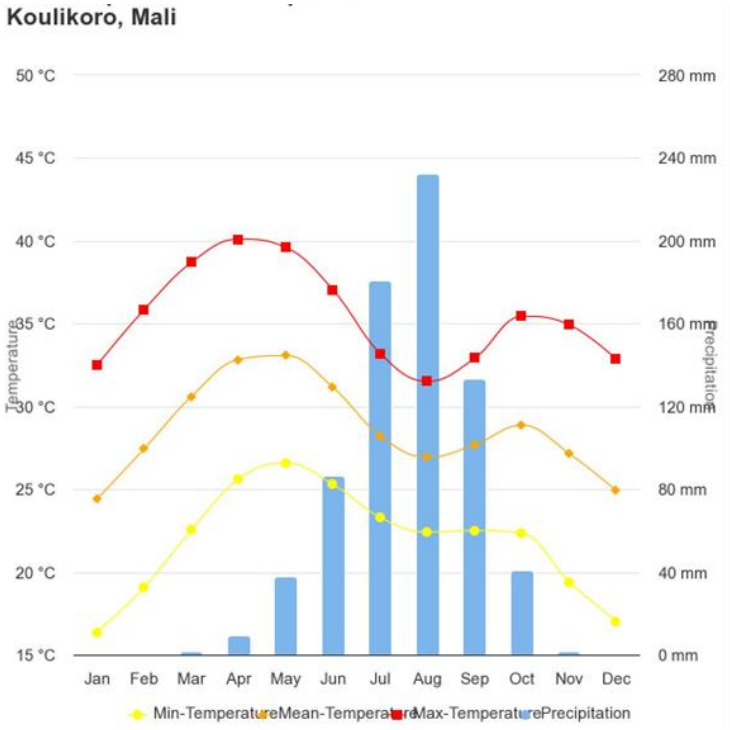


Segou, Mali



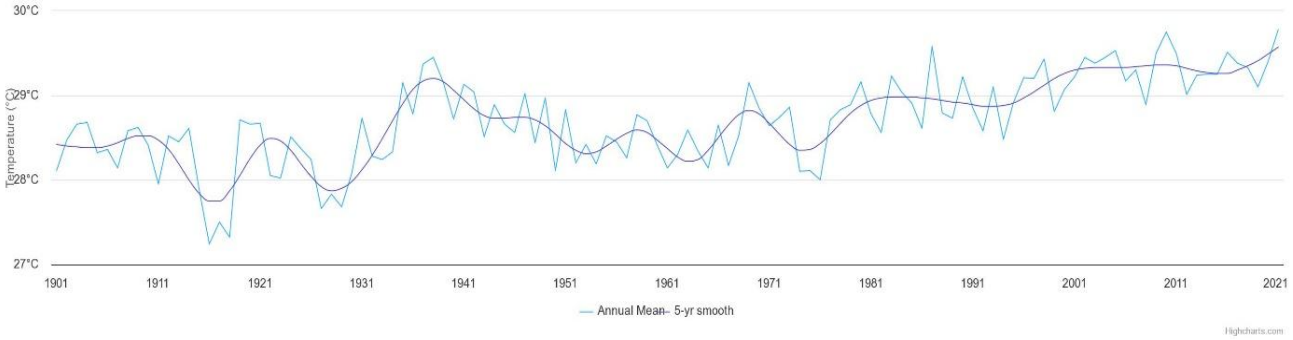
Tombouctou, Mali





Since the 1960s, the mean annual temperature in Mali has increased by 0.7°C, an average rate of 0.15°C per decade,[188] this general upward trend can be seen in Figure 13**Error! Reference source not found.**. This rate of increase is more rapid in the hot, dry season, with average temperatures in April-June increasing from 39.55°C (1961-90) to 40.23°C (1995-2020) in Gao.[189] It must be noted that there is multi-decadal variability in temperature in Mali, as seen in Figure 11. Despite the mean annual temperature increase of 0.7°C since 1960, there is significant variability within that period. The 1960s, 1980s, 2000s and the 2020s represent hotter periods, and the 1970s, 1990s and 2010s represent cooler periods. Furthermore, by examining the data from the late 1930s, it is evident that mean annual temperature reached a decadal peak of ~29.5°C at the end of the 1930s, a mean temperature not reached again until 1987. This demonstrates that there are two historic trends in temperature change in Mali: firstly, that of temperature increases, and secondly that of temperature variability.

Figure 13: Observed average annual mean temperature of Mali (1901-2021) [190] (World Bank Climate Knowledge Portal)



Mali experiences extreme heat events across the country,[191] with extreme heat defined relative to the local context. In the context of Mali, the Potsdam Institute for Climate Impact research defines ‘very

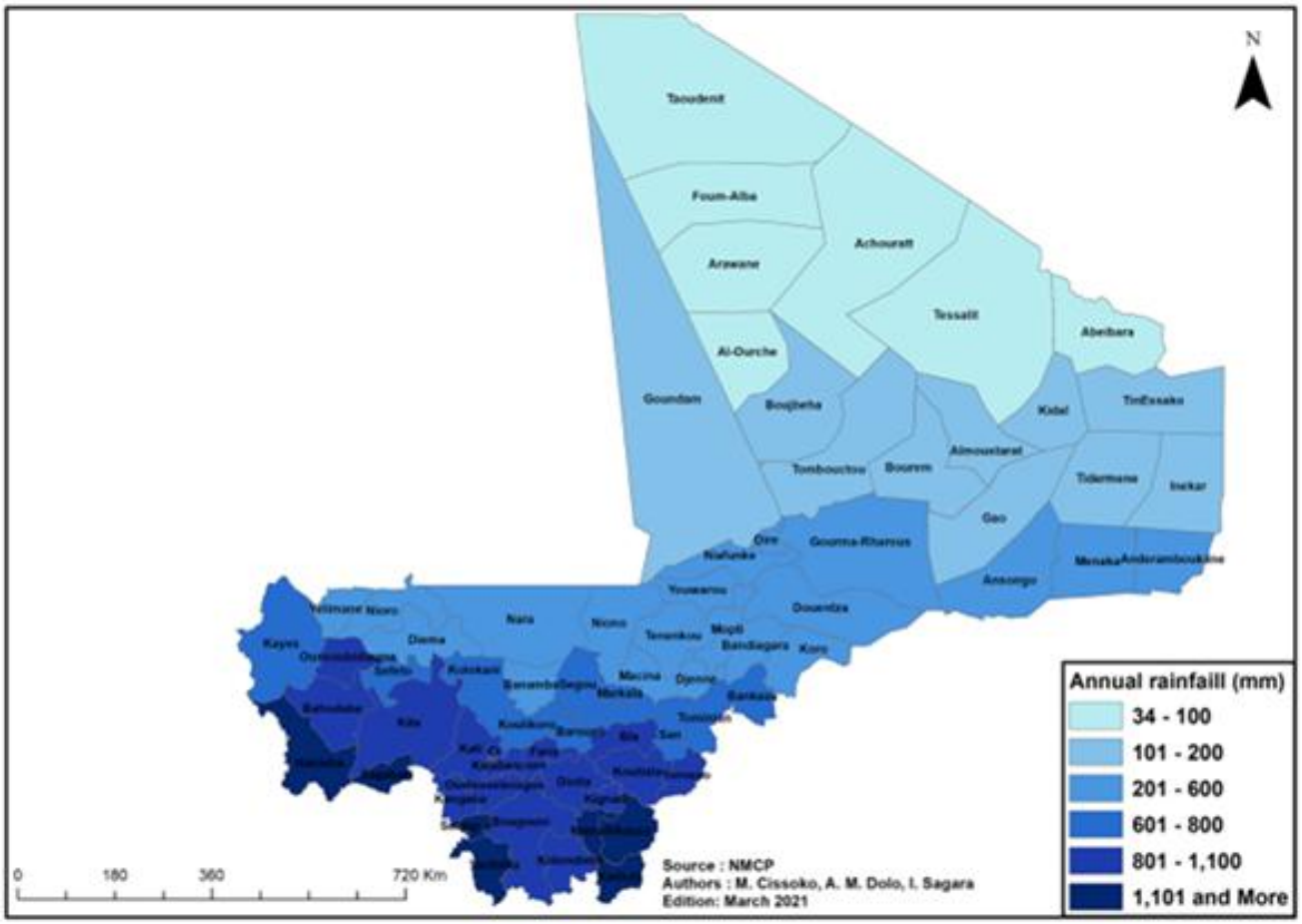
[188] UNEP, Interactive Country Fiches: Mali Domestic material consumption of fossil fuels (1970-2018), Available here
[189] World Bank, (2023), Climate Knowledge Portal Mali profile. Available here
[190] IBID
[191] Fitzpatrick, R.G. et al., (2020), How a typical West African day in the future-climate compares with current-climate conditions in a convection-permitting and parameterised convection climate model, Available here

hot days' as days with a daily maximum temperature of >35°C. Currently, the majority of Mali (in terms of geography) currently experiences >200 'very hot days' per year.[192]

4.3 Rainfall, including coefficient of variation in rainfall (annual and seasonal), and change in dry and wet days

In Mali, there is significant variability in the levels of precipitation both between regions, and between seasons. As is evident in Figure 14, precipitation varies significantly across Mali, with the north of the country experiencing low rainfall of <100mm annually, compared to the southern-most parts of the country which experience over ten times that amount. Figure 12 shows the annual precipitation in the IAAT project regions throughout the year. Across the different regions there is a common rainfall cycle throughout the year with little or no rainfall in November-March, which then increases until the peak of rainy season in August and then decreases sharply. However, looking at the level of precipitation in mm, it is evident that there is significant variation in the levels of precipitation across the country.

Figure 14: Precipitation across Mali[193]



The Red Cross Red Crescent Climate Centre,[194] highlights that precipitation trends in Mali since 1960 are difficult to categorize because rainfall in the Sahel is characterized by high variability on both annual and inter-decadal time scales. Consequently, trends in precipitation are not linear with periods of severe drought between 1970 and 2000, and a wetter period in the 2010s.[195]

[192] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali – Agrica, Available here
[193] Cissoko, M., Magassa, M., Sanogo, V. et al. (2022). Stratification at the health district level for targeting malaria control interventions in Mali, Available here
[194] International Committee of the Red Cross (2021) Country overview Mali - Red Cross Red Crescent Climate Centre. Available here
[195] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here

Non-linear trends, but notable trends in precipitation are evident in Figure 15 and Figure 16[196] which depict monthly precipitation levels from 1951 to 2020 using the average monthly precipitation for the decade. The first trend is that the seasonal distribution of precipitation has changed over time with the wet months (June, July, August, September) getting drier since the 1950s making the seasons less pronounced. Secondly, in spite of interdecadal variation, there has been a general trend of decreased precipitation in all regions in Mali.

Figure 15: Monthly precipitation trends over longer-term horizons (1951-2020) for Mal

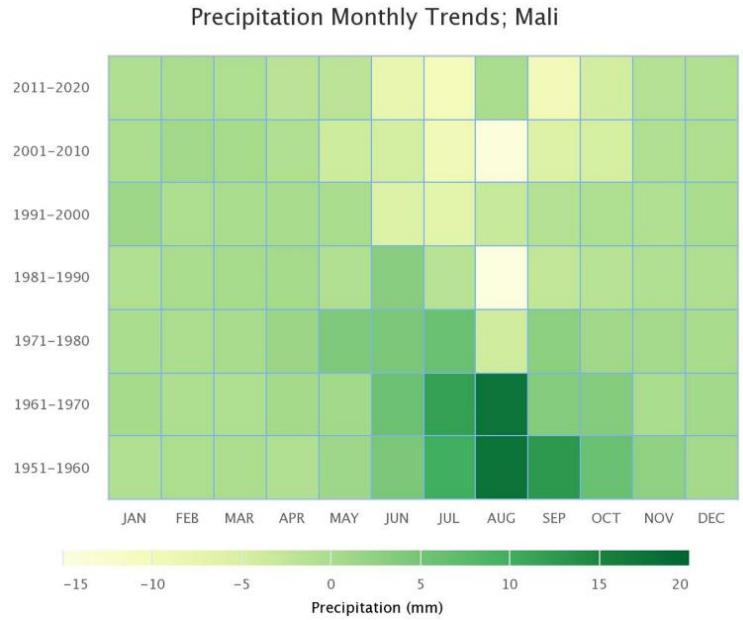
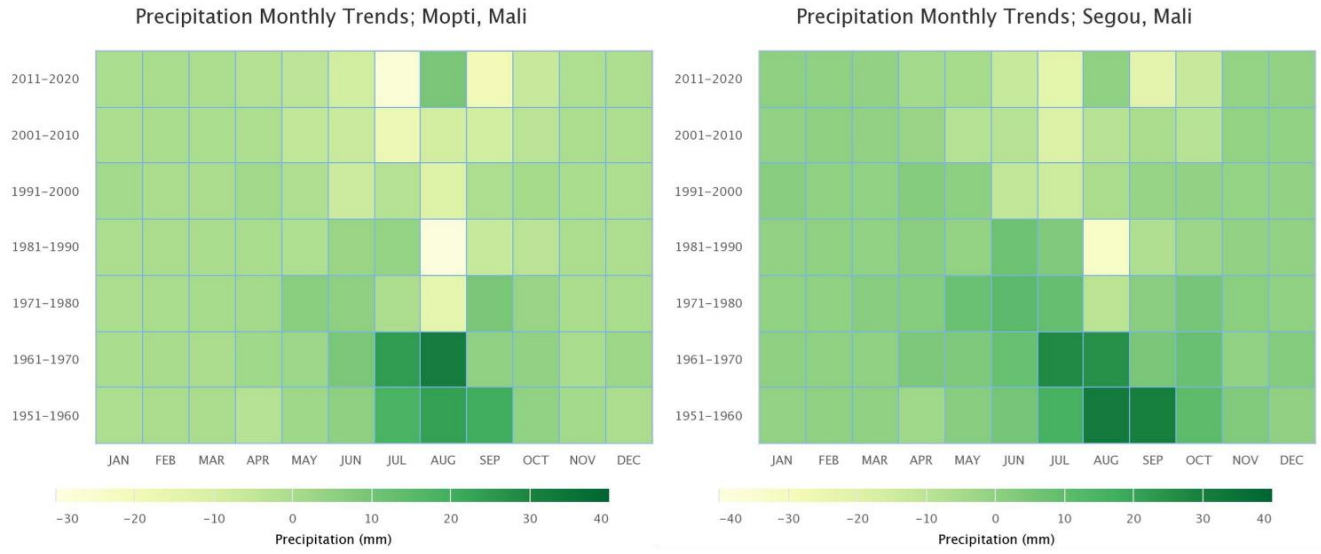
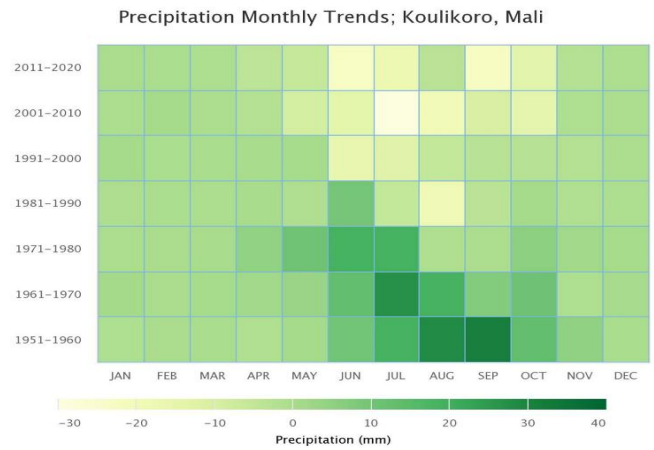
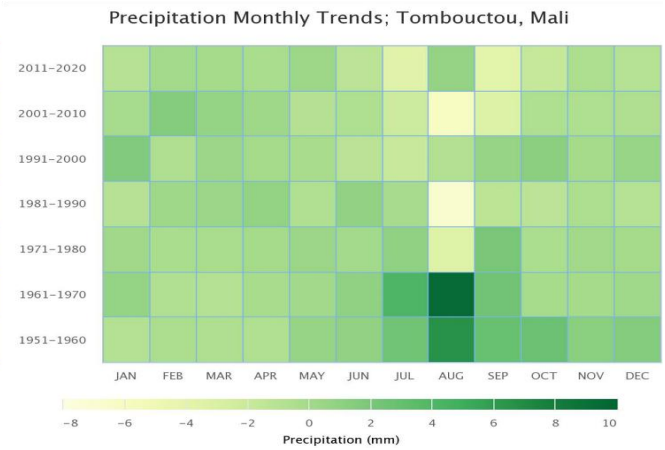


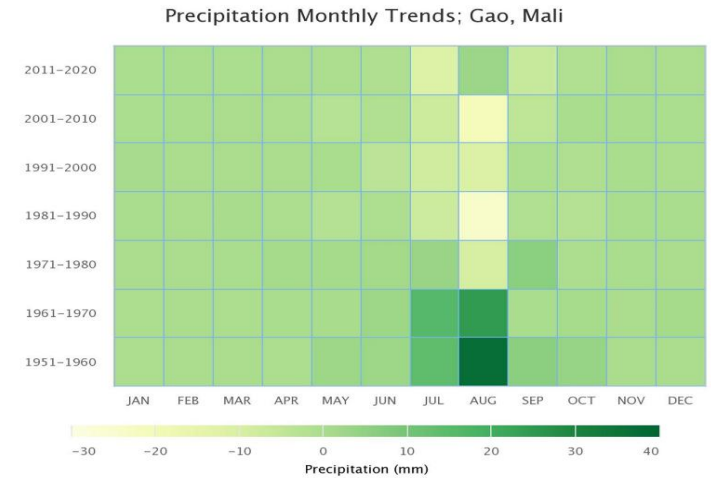
Figure 16: Monthly precipitation trends over longer-term horizons (1951-2020) for Gao, Koulikoro, Mopti, Segou, and Tombouctou regions of Mali



[196] World Bank, (2023), Climate Knowledge Portal Mali profile, Available here







The field data collected from farmers confirms erratic rainfall as one of the main climate hazard hindering productivity of farmers with 80% of farmers surveyed in the five regions highlighting it as a major climate hazard they confront.[197]

4.5 Incidence of floods and droughts

The high risk of both floods and droughts are linked to the historic temperature and precipitation trends. With higher temperatures and decreased precipitation, the higher risk of droughts follows logically. In terms of flood risk, with higher temperatures the ground becomes dryer and harder, this means that lighter precipitation can lead to floods as there is decreased absorptive capacity in the soil.[198]

4.5.1 Droughts

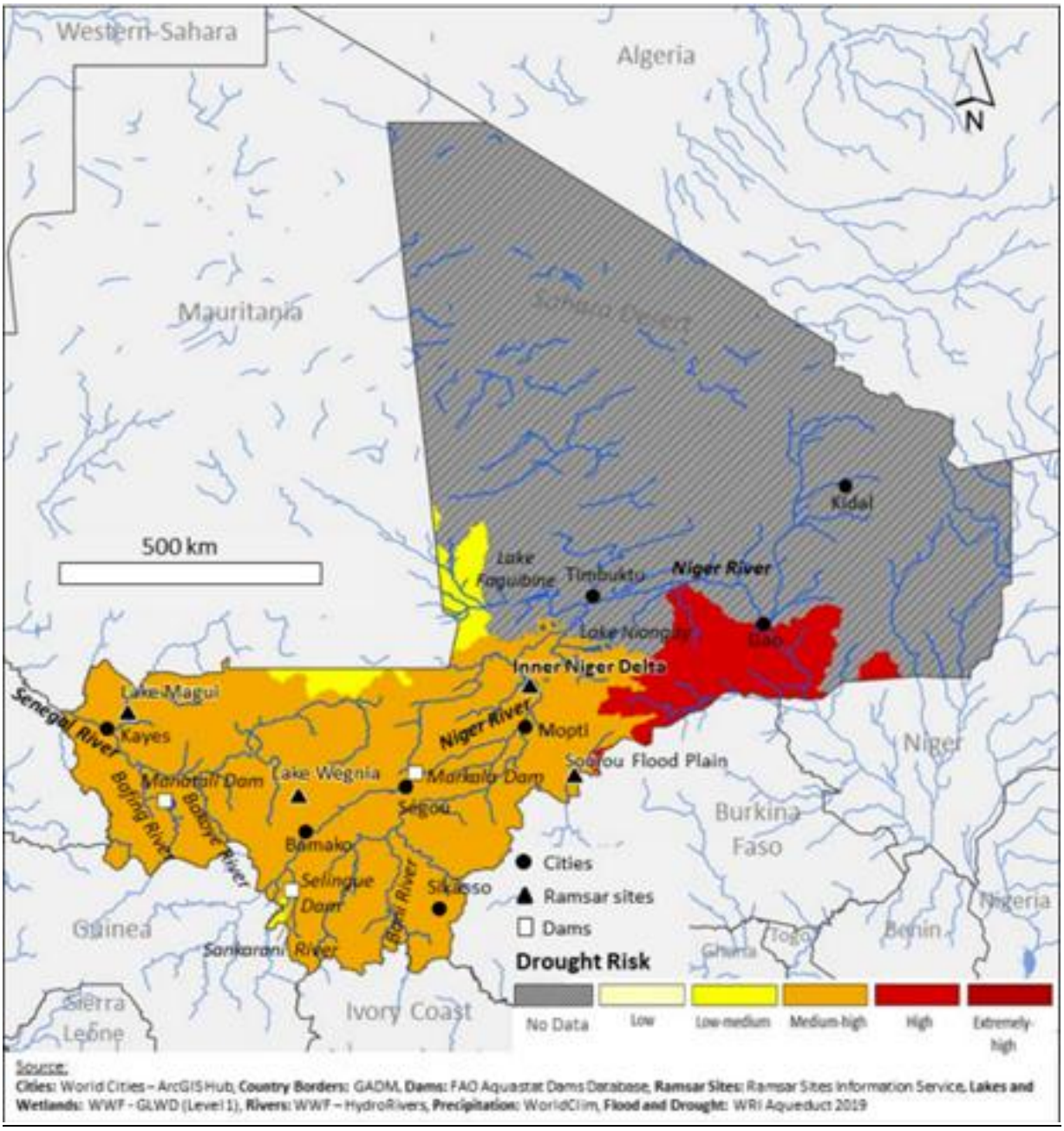
Droughts, defined as periods with abnormal precipitation deficit, have plagued Mali in the recent decades and are growing in occurrence and intensity. Mali is ranked among the countries that are most vulnerable to drought according to the Intergovernmental Panel on Climate Change.[199] The country records a drought severity index of -5, which is the highest level of drought, based on the Palmer severity index.[200] At present, it is estimated that four hundred thousand people are currently affected by droughts

197 IAAT Field Data Collection – Farmer respondents

198 International Committee of the Red Cross (2021) Country overview Mali - Red Cross Red Crescent Climate Centre. Available here
199 Makougoum C. T. P., (2020), Changement climatique au Mali : Impact de la sécheresse sur l'agriculture et stratégies d'adaptation, Available here
200 IBID

each year[201] in Mali with drought risk impacting those in the Mopti and Gao regions in particular, as seen in Figure 17. Field data collection also revealed drought as one of the main climate hazards in Mali. 70% of farmers in the five regions consider drought as one of the primary climate hazards.[202]

Figure 17: Drought risk in Mali. US AID 2021, original drought risk data WRI Aqueduct 2019[203]



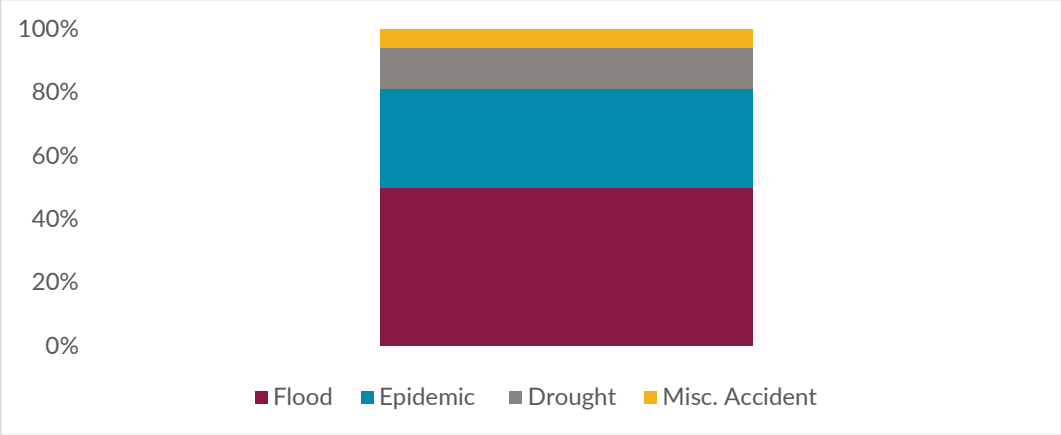
4.5.2 Floods

Floods are the most frequent natural hazards in Mali making up 50% of all natural hazard occurrences from 1980 to 2020 (Figure 18). Mali is principally affected by floods during the rainy season each year, most significantly in several localities in the inner delta of the Niger River, generally from August to October or early November. It is estimated that 500,000 people are currently affected by floods each

[201] International Committee of the Red Cross (2021) Country overview Mali - Red Cross Red Crescent Climate Centre. Available here
202 IAAT Field Data Collection – Farmer respondents
[203] Winrock International, (2021), Mali Water Resources Profile Overview, Available here

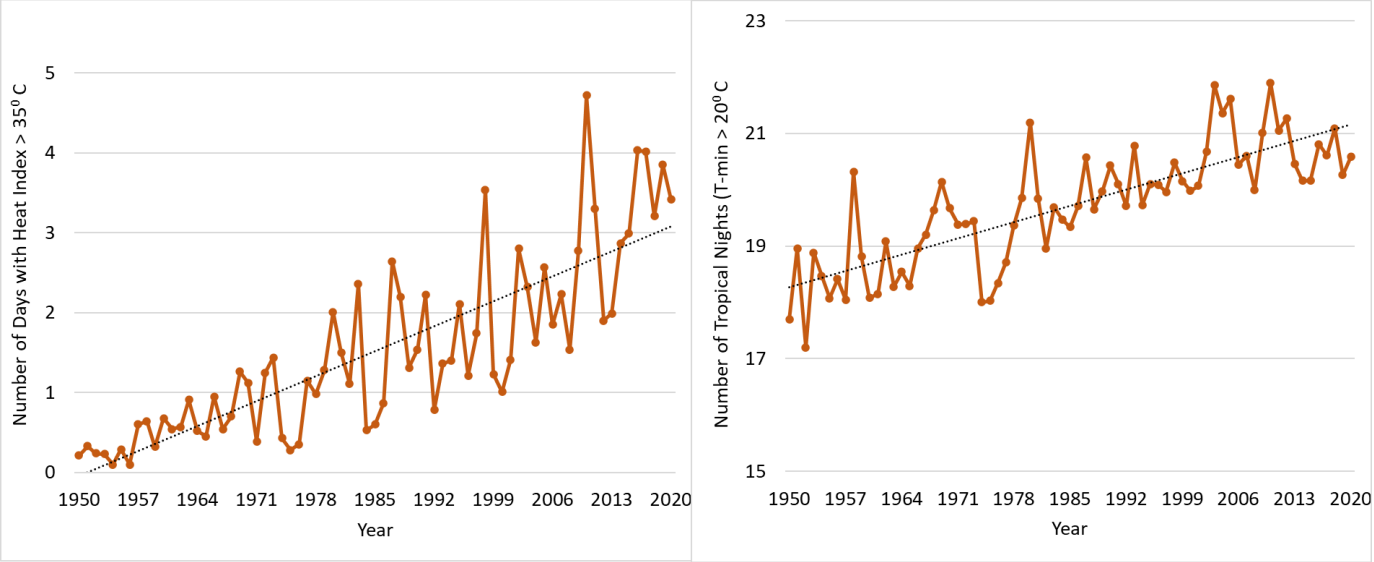
year in Mali. Results from the field data collection highlight floods as one of the primary climate hazards in Mali. 73% of farmers in the five regions mentioned floods as a major risk stemming from climate change.[204]

Figure 18: Average Annual Natural Hazard Occurrence for 1980-2020[205]



4.5.3 Heat stress: Average annual number of days with heat index > 35^{0}C between 1950 and 2020 has significantly increased in Mali (Figure 19 left). Similarly, the average annual number of tropical nights (T- min > 20^0 C) has also increased (Figure 19 right). These historical trends show that both maximum and minimum temperatures are gradually increasing in Mali. This is gradually changing the suitability of crop and livestock production across Mali with increasing heat stresses.

Figure 19: Annual number of days with Heat Index > 35^0 C (Left) and number of tropical nights, T-min > 20^0 C (Right)[89]



[204] IAAT Field Data Collection – Farmer respondents
[205] World Bank, (2023), Climate Knowledge Portal Mali profile. Available here

V. CLIMATE CHANGE PROJECTIONS AND HAZARDS IN MALI

5.1 Climate change projections

The principal climate hazards that Mali is exposed to are driven by temperature and precipitation changes, resulting in events of droughts, heatwaves and floods.

5.1.1 Approach to overcoming climate projection limitations

According to the IPCC, climate change projections are particularly difficult to generate for Mali, and wider Sub-Saharan Africa and/ or Sahelian countries[206]. This is due to a combination of data availability factors including a lack of accurate domestic data sources, gaps in the historical record, and funding constraints to improve data collection. These challenges are exacerbated due to the multi-decadal variability in temperature and precipitation, as well as limited understanding of the impact of aerosols on projected temperatures and precipitation levels[207], which means that trends are challenging to both hindcast and forecast.

The Climate Information Platform[208] has been used as the primary source for temperature and precipitation climate projection data with additional sources used for reference or comment when required. The Climate Information Platform assesses a variety of indicators across different time frames (the projection for 2030 (2011-2040), the projection for 2050 (2041-2070), and the projection for 2100 (2071-2100)), applied to multiple Representative Concentration Pathways (RCPs) - RCP 4.5 and RCP 8.5 using a reference period of 1981-2010. RCP 4.5 is the 'low emissions scenario' and it represents a future where greenhouse gas emissions are moderated and significant efforts are made to reduce emissions. It assumes a lower trajectory of greenhouse gas concentrations and assumes a stabilization of radiative forcing. RCP 8.5 is the 'very high emissions scenario' and represents a future where greenhouse gas emissions continue to increase rapidly throughout the 21st century, resulting in higher concentrations of greenhouse gases and higher radiation forcing. RCP 4.5 is widely recognized as the best possible scenario if all current climate pledges are met, and additional emissions reduction occurs. RCP 8.5 is dubbed the 'worst case scenario', however commentators deem it increasingly likely. Where possible, projections following the medium emissions scenario (RCP 6.5) will also be included. Due to the challenges in defining accurate projections in Mali, this analysis will center around the projections for 2030 and 2050.

5.1.2 Temperature and extreme heat projections

Methodological challenges persist for temperature change projections, however there is consensus between different models that temperatures are due to rise across the country.

Table 11 shows average temperature projections under different time series and emissions scenarios for each of the regions within scope of the project. Under both emissions scenarios RCP 4.5 and RCP 8.5 in the 2030 projection time frame, Mali is likely to witness temperature increases of ~1°C across the country. For the 2050 projection time frame, these temperature projections increase to ~2°C under emissions scenarios RCP 4.5, and nearly 3°C under emissions scenario RCP 8.5. This trend is corroborated by the Potsdam Institute for Climate Impact Research's modelling,[209] and that of the World Bank.[210]

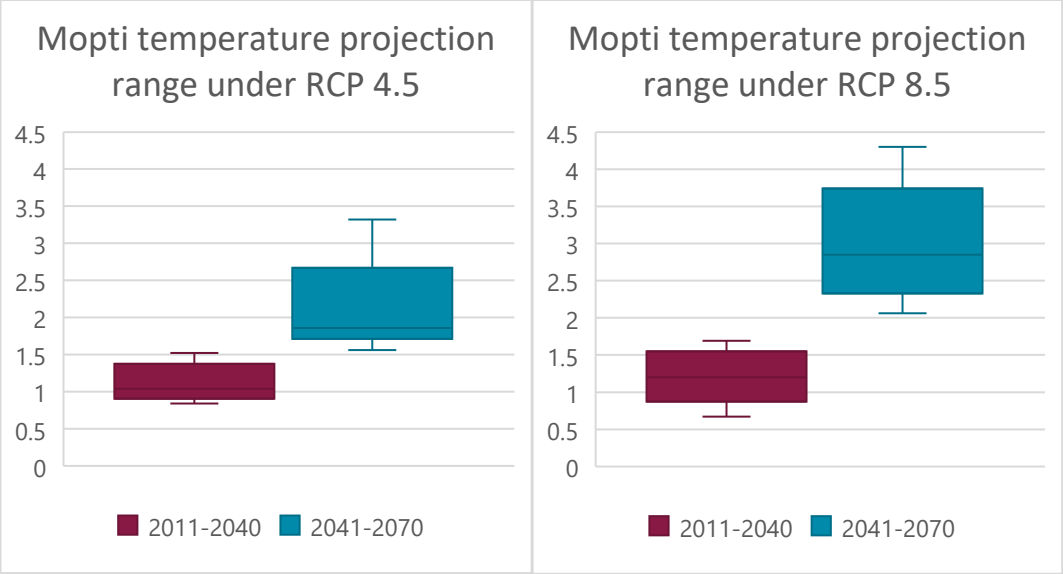
[206] International Committee of the Red Cross (2021) Country overview Mali - Red Cross Red Crescent Climate Centre, Available here
[207] Schewe J., Levermann A., (2022), Sahel Rainfall Projections Constrained by Past Sensitivity to Global Warming, Available here
[208] Climate Information platform, Available here
[209] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here
[210] World Bank, (2023), Climate Knowledge Portal Mali profile. Available here

Table 11: Temperature projections: increase average medium temperature (°C) under different time series and emissions scenarios by region (Climate Information Platform)[211]

Region	Projection for 2030		Projection for 2050	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Gao	1.04	1.11	1.90	2.78
Koulikoro	0.95	1.11	1.83	2.64
Mopti	1.04	1.20	2.02	2.85
Segou	1.01	1.25	2.05	2.91
Tombouctou	1.02	1.21	1.88	2.70

Whilst the projected median temperature rise is consistent across the country for the different time frames and emissions scenarios, there is significant underlying variation beneath these medium values, as evident in Figure . The region of Mopti has been selected here as an illustrative example of the wider trend of diminishing accuracy (as a factor of time and emissions scenarios) of temperature projection modelling in Mali, and globally. In the 2050 time horizon, and under emissions scenario 8.5, the minimum and maximum modelled temperature increases have a wider range than under RCP 4.5. For example, the range of projected temperature increase is just over 0.5°C under emissions scenario 4.5 in the near time frame, versus over 2°C for emissions scenario 8.5 in the far time frame. This is due to diminishing uncertainty for all climate projections for all countries under higher emissions pathways and longer time horizons.

Figure 20: Temperature projection range under different emissions scenarios and time horizons (Climate Information Platform)

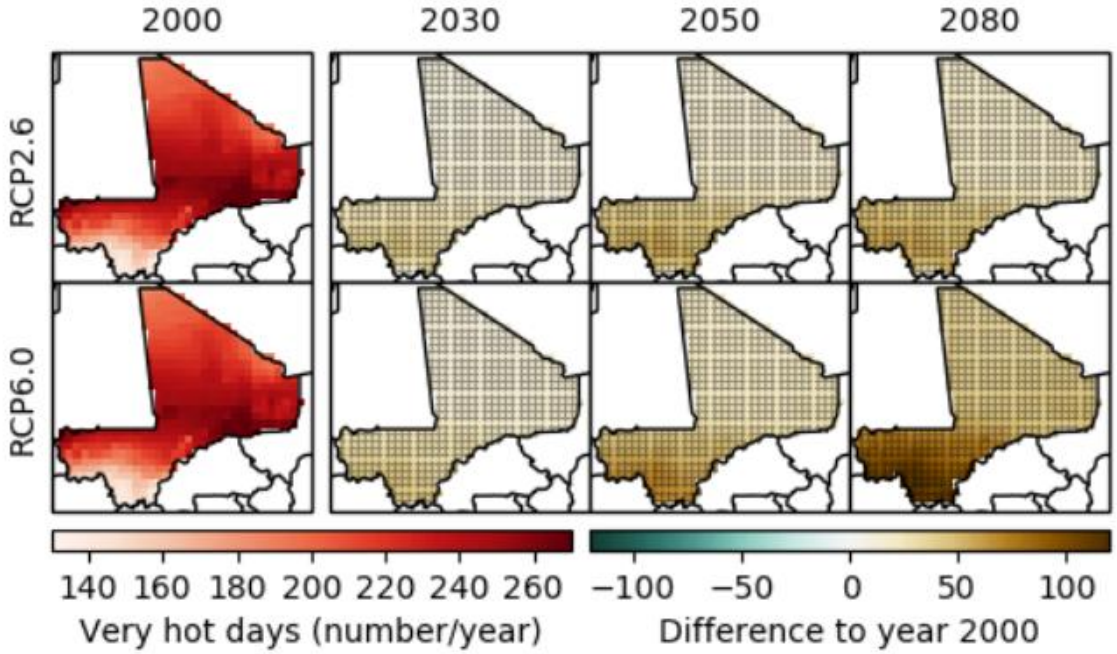


Alongside temperatures, extreme heat is also projected to rise with the number of 'very hot days' (days with a daily maximum temperature of >35°C) expected to increase across Mali, and in the south of the country. Figure 21 shows the projected change in 'very hot days' per year against a 2020 baseline according to climate scenarios, in different time periods. According to this modelling, by 2080

[211] Using the Climate Information Platform, this analysis has taken the projections for the capital cities for each of the regions (cities of the same name), acknowledging that there will be variation within the region itself.

under the RCP 6.0 scenario, significant parts in the south of the country (namely Sikasso, Bamako, and parts of Kayes and Koulikoro) will experience around 100 additional very hot days per year.

Figure 21: Projections of very hot days against 2020 baseline ((The Potsdam Institute for Climate Impact Research, 2022)[212]



5.1.3 Precipitation projections

As discussed, projections of precipitation changes remain uncertain with variation across different projection sources, as well as variation across different regions in Mali under different RCP scenarios. Examining the projected precipitation from the Climate Information Platform displayed in Table 12, two trends are evident i) variability across different regions and ii) inconsistency in directional trends between under RCP 4.5 vs RCP 8.5 scenarios in the Projection for 2050 time frame.

In the 2030 time frame, precipitation is expected to increase in all regions of the IAAT project with the percentage increase ranging from 1% to 10%. In the Gao, Mopti and Tombouctou regions, precipitation is projected to increase by a greater percentage under scenario 8.5 than 4.5, whereas in the Koulikoro and Segou regions precipitation is projected to increase by a lesser percentage under scenario 8.5 than 4.5.

In the 2050 time frame the projections display both heightened variability between regions and between the emissions scenarios. This is primarily due to the high uncertainty and natural year-to-year variability, which is demonstrated by the range of projections under different climate models. In the Koulikoro and Segou regions, precipitation is expected to decrease under the 4.5 scenario but increase or stay the same under the 8.5 scenario. The opposite trend is projected in the Mopti region with precipitation expected to stay the same under the 4.5 scenario but increase under the 8.5 scenario. The Tombouctou and Gao regions display the same trend as in the projection for 2030 with precipitation expected to increase under both emissions' pathway scenarios and to a greater degree under scenario RCP 8.5.

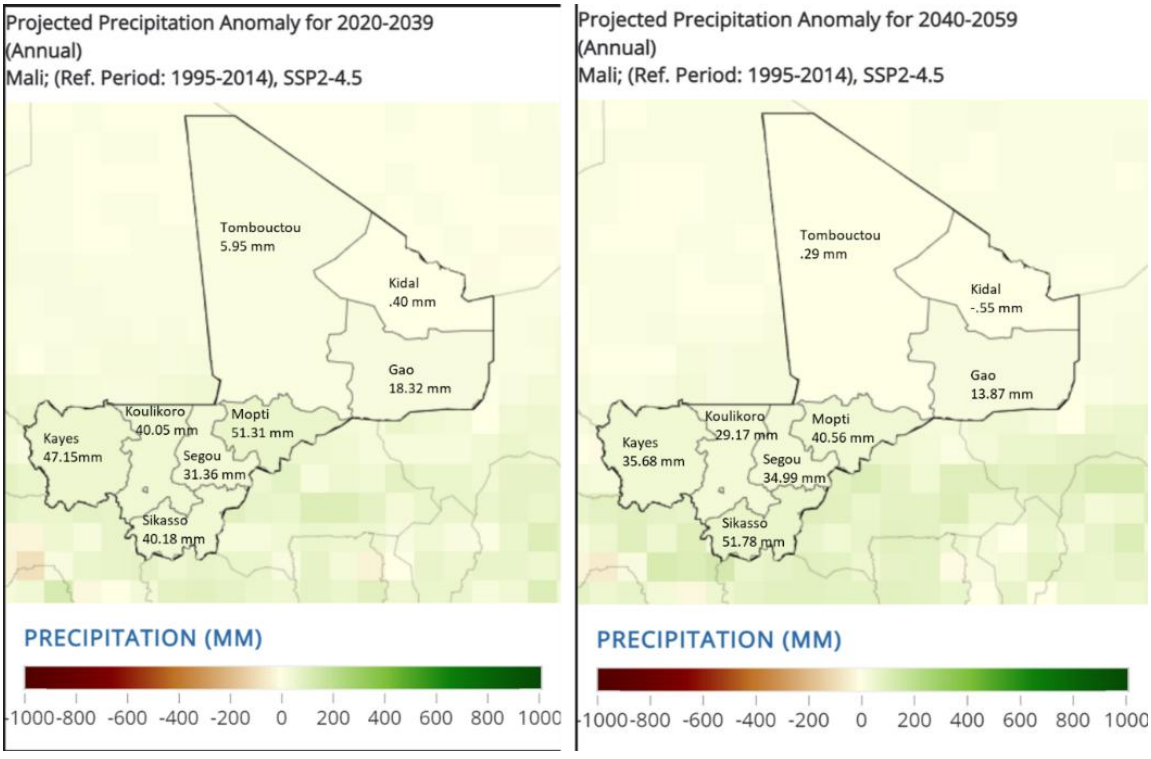
[212] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here

Table 12: Precipitation projections: change in average precipitation under different time series and emissions scenarios by region (Climate Information Platform) [213]

Region	Projection for 2030		Projection for 2050	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Gao	6%	10%	4%	17%
Koulikoro	3%	2%	-1%	3%
Mopti	2%	3%	0%	-1%
Segou	4%	3%	-2%	0%
Tombouctou	1%	10%	4%	8%

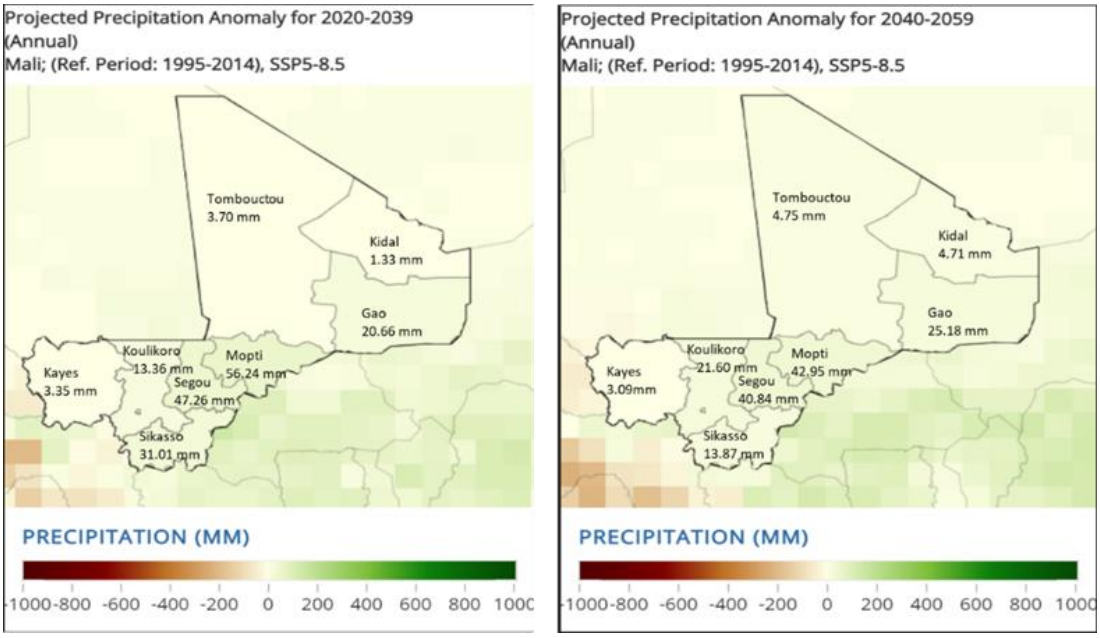
Projected regional variability is corroborated when examining the Climate Change Knowledge Portal's[214] analysis for 2020-2039 and 2040-2059 under RCP 4.5 (Figure) and RCP 8.5 (Figure 19) which show the projected change in precipitation under different emissions scenarios, for different time periods by region. However, this analysis does not result in the same percentage change in precipitation levels as those from the Climate Information Platform, with no precipitation decreases projected. This might be partially due to the different time horizons employed by the World Bank, but more likely is that it demonstrates the challenges of projections in this region.

Figure 22: Projected precipitation change (mm) in Mali 2020-2059 - RCP 4.5 (World Bank Climate Knowledge Portal)[215]



[213] Using the Climate Information Platform, this analysis has taken the projections for the capital cities for each of the regions (cities of the same name), acknowledging that there will be variation within the region itself.
[214] Please note that this data is used here in spite of the different time horizons used by the World Bank.
[215] Source: approved IAAT Concept Note. Original source World Bank, (2023), Climate Knowledge Portal Mali profile. Available here

Figure 19: Projected precipitation change (mm) in Mali 2020-2059 - RCP 8.5 (World Bank Climate Knowledge Portal) [216]



Despite limited consensus on projected levels of precipitation across Mali, there is however broad consensus that the rainfall events will be more erratic and more intense.[217] This is likely to have significant impacts across Mali and will be discussed below.

Drought

The high uncertainty of projections regarding water availability impedes the capacity to accurately forecast future drought events.[218] The Potsdam Institute for Climate Impact Research developed various models to assess the potential impact of climate change on the progression of droughts in Mali.[219] While some of these models predict almost no change in the national crop land area exposed to at least one drought per year in response to global warming, others project up to a threefold increase in drought exposure.[220]

Precipitation, temperature, evapotranspiration, as well as soil moisture are key indicators on drought conditions. The Potsdam Institute for Climate Impact Research projects potential evapotranspiration to increase by 2.4% in 2030, 3.7% in 2050 and 7% in 2080 under RCP6.0 compared to year 2000 levels. Table 13 displays groundwater projections under different scenarios and timeframes. As with precipitation projections, there is significant variation between regions and different scenarios. In the Gao region under the 4.5 scenario, groundwater is projected to stay the same for both time horizons, but under the emissions scenario 8.5, it is predicted to increase by a greater degree soon than in the more distant future. This is in stark contrast to the projections for Mopti where groundwater levels are projected to decrease under both scenarios and both time horizons. This provides an indication that droughts will remain in frequent occurrence across Mali, which matches the Think Hazard 'High' rating for all regions in Mali (except Kayes which is out of scope of this project) which indicated that droughts are expected to occur on average every 5 years.[221] The high variability and contrasting trends also

[216] Source: approved IAAT Concept Note. Original source World Bank, (2023), Climate Knowledge Portal Mali profile. Available here
[217] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here
[218] Global Facility for Disaster Reduction and Recovery (2019), Disaster Risk Profile, Mali, Available here
[219] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here
[220] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here
[221] World Bank, Think Hazard Mali profile, Available here

provides further evidence to suggest that precipitation, and other climate indicator projections are particularly challenging in Mali.

Table 13: Groundwater projections: change in average precipitation under different time series and emissions scenarios by region (Climate Information Platform) [222]

Region	Projection for 2030		Projection for 2050	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Gao	0%	18%	0%	9%
Koulikoro	2%	-1%	-5%	-2%
Mopti	-5%	-15%	-17%	-23%
Segou	2%	1%	-8%	-3%
Tombouctou	6%	11%	3%	26%

Floods

Similarly, in accordance with the challenges of precipitation projections, flood projections present challenges. High temperatures make soil dry and reduce soil's absorption rate, which increases the likelihood of floods especially in the face of extreme rainfall events as in Mali's wet season. With temperatures projected to rise, and the trends in precipitation showing significant increases in some regions of Mali, the conditions suggest that floods will either stay the same or get more frequent. This is corroborated by the Think Hazard 'High' rating for both the River Flood and the Urban Flood hazards[223]. In the case of the risk of river flooding, all regions in Mali (except Kidal which is out of scope of this project) are rated as high which means that potentially damaging and life-threatening river floods are expected to occur at least once in the next 10 years. For urban flooding all regions except Kidal, Sikasso (out of scope) and Koulikoro are rated as high which means that that potentially damaging and life-threatening urban floods are expected to occur at least once in the next 10 years.

5.2 Impacts of changing climate trends on agriculture and agroforestry systems

5.2.1 Introduction

Climate change both directly and indirectly affects agricultural production in Mali, threatening food security and livelihoods. The effects of climate change including erratic rainfall and increased temperatures hamper food production both directly (e.g., the increased occurrence of droughts and heatwaves) and indirectly (e.g., proliferation of pests and soil erosion) and hinder the development of different sectors of the economy.[224] IFAD forecasts that agricultural production is expected to decline by about 17% by 2050, [225] with reductions in both i) the available area for cultivation and animal grazing, and ii) yield of various crops.[226] This presents a major threat to food security in the country given the high reliance on agriculture with 80% of the workforce employed in agriculture.[227]

[222] Using the Climate Information Platform, this analysis has taken the projections for the capital cities for each of the regions (cities of the same name), acknowledging that there will be variation within the region itself.
[223] Global Facility for Disaster Reduction and Recovery, Think Hazard Mali profile, Available here
[224] Raza, Ali et al., (2019), Impact of Climate Change on Crops Adaptation and Strategies to Tackle Its Outcome: A Review, Available here
[225] IFAD,(2023), Mali, Available here
[226] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[227] N'Diaye, I. et al., (2020), Adaptation de l'Agriculture et de l'Élevage au Changement Climatique au Mali: Résultats et leçons apprises au Sahel. Available here

5.2.2 Climate change constrains agricultural production.

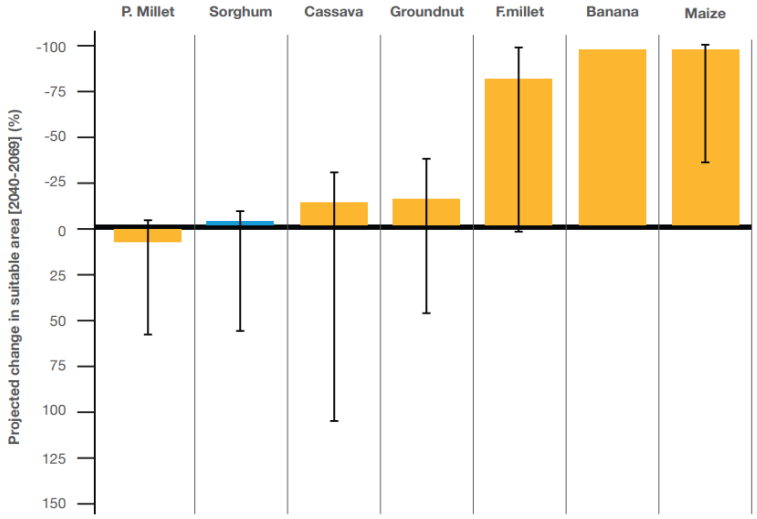
Agricultural land loss

The impacts of climate change are expected to lead to a major reduction of suitable land for agriculture. The increasing droughts, and erratic rainfall, coupled with warmer temperatures have already contributed to the accelerated degradation of agricultural land and soil erosion. [228] For example, erratic rainfall affects the flood patterns of 4.2 million hectares of wetlands in the country and generates a negative impact on soil-stabilizing vegetation growth.[229] This contributes to soil erosion which hurts the quality of agricultural land and is estimated to generate a 6% annual loss of GDP in Mali.[230] To date, the primary effects of soil erosion are felt in the northern semi-arid belt between Gao and Mopti, with the Southern regions only moderately or mildly degraded at present.[231]

The field data collected from farmers confirms agricultural land loss as a major challenge to agricultural and agroforestry productivity. Overall, 56% of farmers in the five regions highlight soil depletion and lack of arable land as a major threat to agriculture and agroforestry development.[232]

Looking forward, the impact on land degradation and the impact on agricultural production is likely to get worse. Figure **Error! Reference source not found.** models the impact of changing climatic conditions and land degradation on available agriculture for different crop types. In this model, the World Bank predicts a decline of suitable land for all key crops in Mali except pearl millet. The extent of land degradation could lead to the incapacity to grow maize, banana, and finger millet by 2040-2069.[233]

Figure 24: Projected percentage change in a suitable area in Mali, 2040-2069 (World Bank)[234]



Desertification is a further cause of land loss and a major impediment for the development of agriculture and agroforestry in Mali. According to the U.N., climate change and human activity have exposed 98% of Mali to the threat of creeping desertification.[235] This is further emphasized by the low water table and high rate of evaporation of surface water. ReliefWeb estimates that the Sahara Desert is expanding rapidly, growing by 48km a year and strongly contributing to land degradation.[236]

[228] ECDPM, (2019), The when and how of climate conflict: The case of Mali, (2019). Available here
[229] USAID, (2023), Climate links: Mali, Available here
[230] The Economics of Land Degradation, (2023), Mali, Available here
[231] The Economics of Land Degradation, (2023), Mali, Available here
232 IAAT Field Data Collection – Farmer respondents
[233] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[234] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[235] International Committee of the Red Cross, (2022) Climate change in Mali: "We drilled deep but found nothing", Link
[236] IPS, (2019), Displaced by the Desert: An expanding Sahara leaves Broken Families and Violence in its Wake, 2019, Link

Desertification impacts both sedentary farmers as well as pastoralists due to the reduced land available for both cultivation and for animal grazing.

Crop strain and yield reduction

Dependence on rainfall has been a major constraint on crop and livestock production, generating stress and failure.[237] The under-exploitation of Mali's irrigation potential, with only 5% of land currently irrigated in Mali,[238] increases the country's vulnerability to unpredictable rainfall, increasing droughts, and rising temperatures.[239]

Despite climate change affecting most of the crops in Mali, the magnitude of impact varies across commodity groups. Maize is vulnerable to hot temperatures above 35°C, compared to millet, sorghum and groundnuts, which are more resilient to hot temperatures and dry periods. [240] These impacts are already being felt with the yields of coarse grains having decreased by 28% in the 2016-2017 planting season due to droughts.[241] The losses incurred with most commodities nearly double every decade due to increasing effects of climate change over time.[242]

Looking forward, models predict different outcomes for crop production loss. Maize is generally expected to experience the most severe impact, with rainfed and irrigated yields respectively falling by as much as 22 and 27 percentage points below their No-CC baselines in 2050.[243] Other models predict maize grain yield losses to decline by 51% to 57% by 2050 in comparison to millet which will decline by only 7% to 12%.[244] According to the World Bank, vegetables, oilseeds, cereals, sugar crops and cotton will be the five most impacted commodity groups by 2050[245]. Decreasing yields are also likely to decrease fodder availability and quality which is predicted to decline by 5%-36% from 1940-69.[246] Changes to fodder availability is likely to put additional pressure on livestock farmers and pastoralists.

Water availability

Across Mali, 400,000 people live in areas exposed to the occurrence of water scarcity each year.[247] Droughts are recurrent in Mali and have contributed to severe food crises since 1972, due to declining levels of precipitation since the mid-1950s.[248] In 2021, drought induced a 10.5% decrease in cereal production, threatening the livelihoods of over three million people.[249] The field data collected from farmers confirms water scarcity as a major challenge to agricultural and agroforestry productivity. SEMS reported that water scarcity was a key concern, whilst lack of water management was reported by 60% of farmers in the five regions highlight access to water / lack of irrigation as one of the main challenges hampering productivity.[250]

The impacts of water scarcity on livelihoods have been felt acutely in the North of Mali. For example, the prevalence of droughts in Mali led to the drying up of the Lake Faguibine in the north of Mali (80 km from Tombouctou), which was the main source of livelihood for the communities.[251] The depletion of Lake Faguibine bears several consequences including the disappearance of the irrigated farming

[237] USAID, (2020), Climate risks in food for peace geographies: Mali, Available here
[238] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[239] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here
[240] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here
[241] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[242] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[243] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[244] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[245] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[246] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[247] Global Facility for Disaster Reduction and Recovery, (2019), Disaster Risk Profile, Mali, Available here
[248] Global Facility for Disaster Reduction and Recovery, (2019), Disaster Risk Profile, Mali, Available here
[249] International Committee of the Red Cross, (2022) Climate change in Mali: "We drilled deep but found nothing", Link
[250] IAAT Field Data Collection – Farmer respondents
[251] International Committee of the Red Cross, (2021) Climate change turns Mali's Lake Faguibine into desert and forces people to move, Link

lands and the lack of water for breeding, leading to disputes between farmers and livestock herders.[252]

Floods further contribute to production decreases through the contamination of water sources which enable the development of pests.[253] In addition to agricultural damage, the various impacts of floods include the destruction of dwellings, loss of assets, disappearances and even deaths.[254] The economic damages provoked by flooding can reach USD 600 million per year. In 2020, 6,000 houses and over 7,000 tons of food were damaged by seasonal flooding, affecting 80,000 individuals, mostly women and children.[255]

Factors increase food insecurity

These impacts (land degradation, yield reduction and water scarcity) can negatively impact agricultural output and therefore food security. To date, the cycle of droughts, floods, and hotter temperatures, as well as the proliferation of pests, have generated severe impacts on crop production, decreasing yields and agricultural land, and reducing the nutritional value of some crops.[256] This has contributed to Mali's food insecurity which is evidenced by the high levels of acutely malnourished children aged 6-59 months which increased by ~53% from 2020-2021 and reached 1.2 million children between September 2021 and August 2022[257].

Looking forward, potential decreases of cereal yield will likely generate major food tensions in Mali, due to their predominance in farms and nutrition representing 68% of all daily caloric intake and 70% of cultivated area.[258] According to the Center of Africa-Europe Relations, the predicted losses in livelihoods due to declining resource availability could generate an overall loss of welfare ranging from USD 70 to 142 million and increase the share of the population at risk of hunger from 44% to over 70%.[259]

Non-climatic factors also challenge food security

Coupled with and related to the impacts of changing climate trends, other socioeconomic events or trends have a significant impact on agriculture and agroforestry systems. The socio-economic and political context in Mali also presents concerns regarding food security, and these concerns are further exacerbated by climate change. The growing population, coupled with conflict and insecurity in northern Mali, creates significant threats to food security and hinders the country's capacity to ensure sustainable management of resources and efficient use of local products in national and global markets.[260]

There has been a large increase in inter- and intra-communal competition for public resource use particularly between livestock herders and sedentary farmers.[261] The scarcity of resources is heavily linked to climate change, with a decreasing supply of water, fodder, grass, and firewood. Internal and cross-border migration is also impacting agriculture and agroforestry systems, and being impacted by climate-related agricultural trends. In 2022, 5% of Sahelian transhumance herders that were trapped were stranded in Gao due to security concerns. These stranded herders contributed to a strain on water supplies in the region[262].

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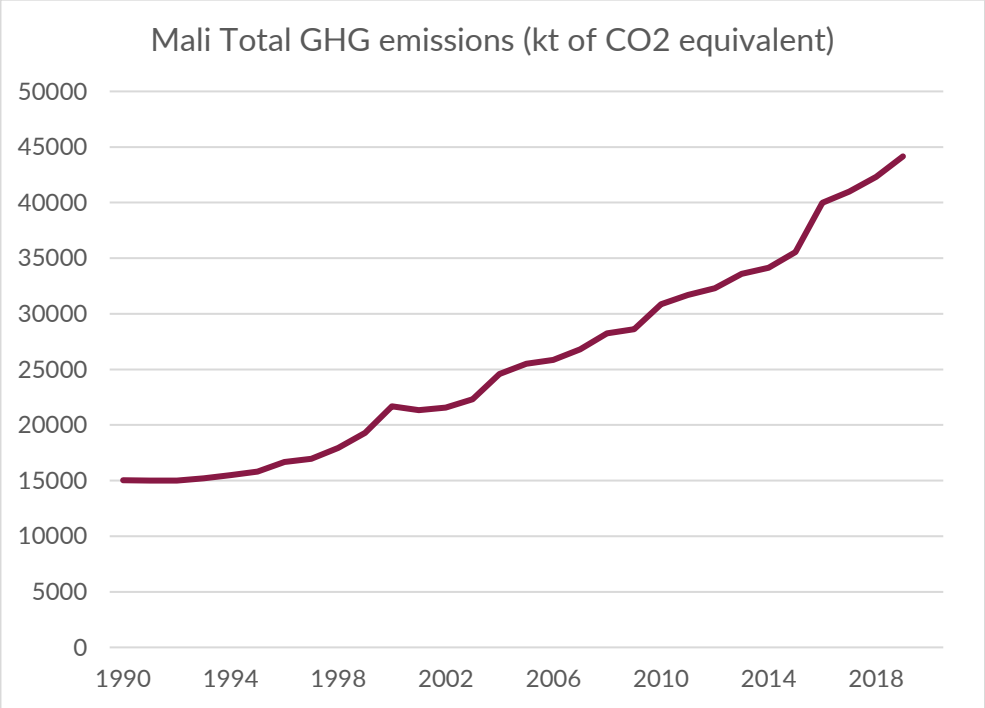
[252] International Committee of the Red Cross, (2021) Climate change turns Mali's Lake Faguibine into desert and forces people to move, Link
[253] International Committee of the Red Cross, (2021) Climate fact sheets: Mali, Link
[254] International Committee of the Red Cross, (2021) Climate fact sheets: Mali, Link
[255] SIPRI, (2021) climate-related security risks and peacebuilding in Mali, Link
[256] IBID
[257] ACM/ALIMA/CARE, (2022), Breaking the spiral of the Food and Nutrition Crisis in Mali, Available here
[258] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[259] ECDPM, (2019), The when and how of climate conflict: The case of Mali, (2019), Available here
[260] United Nations, (2018) Devastating Impacts of Climate Change Threatening Farm Outputs, Increasing Global Hunger, Delegates Say as Second Committee Takes Up Agriculture, Food Security, Link
[261] Brottem, L., (2023), *The growing complexity of farmer-herder conflict in West and Central Africa,* Available here
[262] International Organisation for Migration (2022), Transhumance Tracking Tool (TTT – DTM) Mapping of Stranded Herders, Available here

5.3 The Causes of GHG emissions in Mali and Mitigation Options

5.3.1 Current emissions levels in Mali and the breakdown by sector

Mali's total greenhouse gas (GHG) emissions are rising but remain low relative to global averages. Since records began, emissions have been rising steadily with total emissions estimated at 44 million tons CO2eq per annum according to the World Bank's most recent estimates, as shown in Figure .[263] However, Mali's emissions represent only 0.01% of total CO2 emissions worldwide and Mali's per capita emissions (0.19 t per capita) are approximately only 4% of the global average (4.69 t per capita).[264]

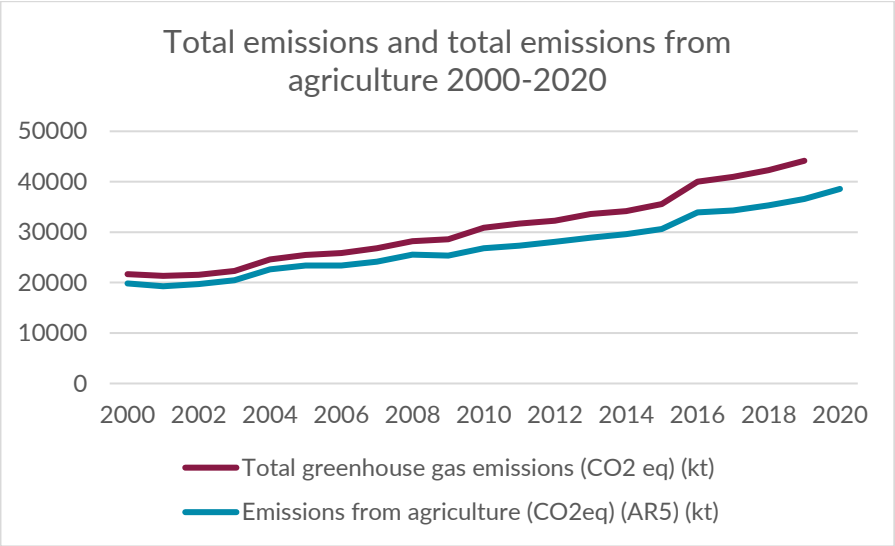
Figure 25: Greenhouse gas emissions Mali [265]



Agriculture is the dominant source of GHG emission in Mali, with CGIAR and FAO estimating it accounts for 70%[266] to 80%[267] of total GHG emissions. Agriculture is the key driver of emissions for two main reasons: i) it is one of Mali's largest economic sectors and the largest employer[268] and ii) emissions from energy production (often the largest source of emissions in other countries) are relatively low due to the use of hydropower.[269]As a result, emissions from agriculture have largely driven the trend in total emissions as evident in Figure .

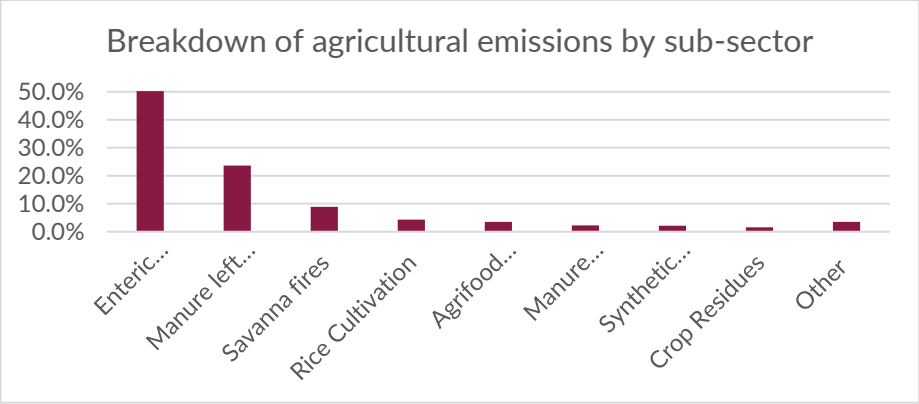
[263] World Bank (2023), Total greenhouse gas emissions, Available here.
[264] Our World in Data, (2021), Mali: CO2 profile, using Global Carbon Project 2023 data. Land use is not included in the estimation. Available here
[265] World Bank (2023) Total greenhouse gas emissions, Available here.
[266] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[267] Estimated FAO total emissions from agriculture (Available here) as a percentage of the World Bank (2023) Total greenhouse gas emissions. (Available here). NB that there will be some discrepancy due to differing methodologies employed.
268 N'Diaye, I. et al., (2020), Adaptation de l'Agriculture et de l'Élevage au Changement Climatique au Mali: Résultats et leçons apprises au Sahel. Available here
[269] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here

Figure 26: Total emissions and total emissions from agriculture 2000-2020[270,271]



Within agriculture, the two largest contributors of GHG emissions are from the rearing of livestock: enteric fermentation (CO2 and methane) and manure left on pastures (methane and nitrous oxide) which represent 50% and 24% total emissions from agriculture respectively.[272] Other important sources of agricultural emission are savanna fires (which are in part employed to prevent the risk of further fires), and rice cultivation representing 9% and 4% of agricultural emissions.[273,274] All other sources of agricultural emissions contributing greater than 1% of the total are outlined in Figure .

Figure 27: Percentage of agricultural emissions by sub-sector[275]



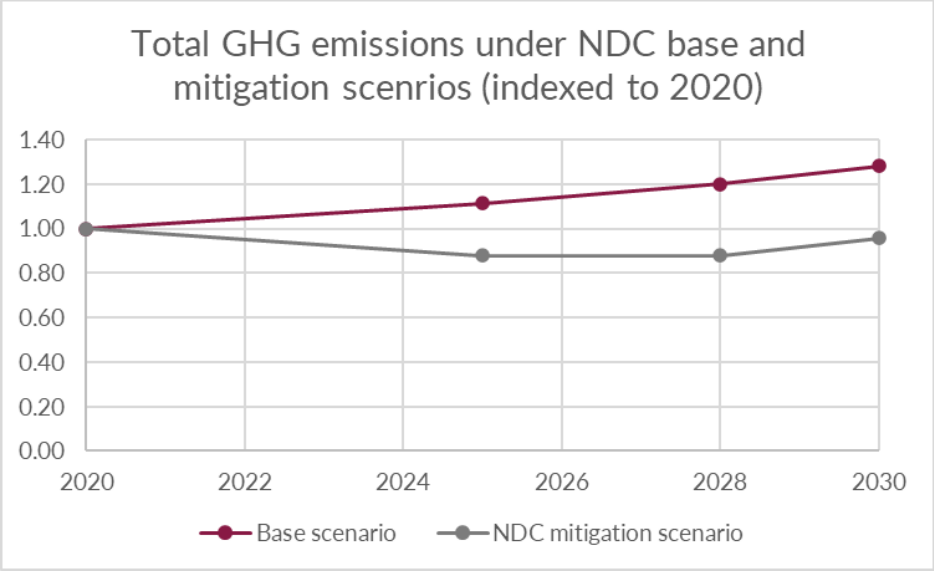
5.3.2 Emissions projections and mitigation potential

Due to high population growth (3.2% from 2020 to 2021[276]), and factors associated with Mali's socioeconomic development (such as increasing access to electricity[277]), Mali's GHG emissions are forecast to increase. Considering this, the government of Mali has committed to reducing its GHG

[270] FAO, (2023), Total emissions from agriculture, Available here
[271] World Bank, (2023), Total greenhouse gas emissions, Available here
[272] FAO, (2023), Total emissions from agriculture, Available here
[273] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[274] Human Ecology, (2002), Preventative Burning Strategies in the Wooded Savanna of Southern Mali, Available here
[275] FAO, (2023), Total emissions from agriculture, Available here
[276] World Bank, (2022), Population growth (Annual percentage – Mali), Link
[277] Instat Mali, (2023) Enquete modulaire et permanente auprès des ménages EMOP, Available here

emissions under its Nationally Determined Contribution (NDC) submitted to UNFCCC in 2021[278] for which it developed a 'baseline' and 'mitigation' scenario. The relative emissions levels under these two scenarios set against a baseline of 2020 emissions can be seen in Figure . The level of ambition for GHG emissions reductions in the 'mitigation' scenario compared to the 'baseline' scenario for 2030 represents a 31% decrease in the energy sector, a 25% decrease for the agriculture sector, a 39% decrease for the forestry sector and a 31% decrease for the waste sector.

Figure 28: Total GHG emissions under NDC base and mitigation scenarios (indexed to 2020)[279]



5.4 Mitigation techniques in Mali and barriers for adoption

Under both the baseline and the mitigation scenarios laid out in the NDCs, Mali will continue to play a minor role in global emissions. However, mitigation techniques are significant as they have the potential to not only reduce GHG emissions in line with the NDC, but also to promote sustainable, green growth. Considering this, techniques that target the key emissions areas within agriculture (such as livestock - enteric fermentation, manure left on pastures), and increase the climate resilience of the agricultural sector should be prioritized. These fall into three themes that have been identified through desk research and expert interviews: animal production practices, crop production practices, and land use change and intensification[280]. These are in line with the government's NDC submission which committed to promoting CSA[281] including improving irrigation, managing fertilizer use, improving animal husbandry, and promoting reforestation. Below the three key areas have been outlined, alongside a summary of current adoption rates and the barriers to further adoption.

Most of the emissions result from livestock production, which represents a dominant livelihood in Mali. Therefore, emissions reduction through animal production practices must be considered alongside sustainable livelihood development. Without curbing livestock rearing, measures that target the livestock food consumption and grazing, as well as measures that reduce GHG emissions from manure can produce positive results in Mali.

For example, biodigesters enable households or communities (depending on size) to transform organic waste, principally livestock manure into productive outputs including biogas, as well as

[278] Ministry of The Environment, Sanitation and Sustainable Development, (2021), Revised Nationally Determined Contributions, Available here
[279] Ministry of The Environment, Sanitation and Sustainable Development, (2021), Revised Nationally Determined Contributions, Available here
[280] McKinsey & Company, (2023), What climate-smart agriculture means for smallholder farmers, Available here
[281] Ministry of The Environment, Sanitation and Sustainable Development, (2021), Revised Nationally Determined Contributions, Available here

digestates including organic fertilizer. The primary mitigation opportunity results from the energy produced by biogas which can displace energy from firewood, charcoal, and other non-renewable sources. In Mali, burning firewood and charcoal account for about 78% of energy use in Mali's households[282]. The second mitigation opportunity results from the emissions avoided through the management of organic waste, which could reduce the emissions from 'manure left on pastures' which represents 24% of agricultural emissions. The third mitigation opportunity also results from the increased supply of organic fertilizer, which could, in some circumstances, reduce GHG emissions from synthetic fertilizer use.

At present, the biogas system market is Mali is very early stage, with a complementary project (ABC, Sahel) stating that the "foundations of the market" still need to be developed.[283] The primary barriers that constrain the biodigester market result principally from the high cost of the high capital costs and low levels of both local and international investments, the lack of access to waste, and the high labour demand required.[284] In addition, lack of technical information on use as well as access to the technologies and poor implementation of biodigesters that focus exclusively on the energy production and not on the other outputs e.g. fertilizer have skewed public perception on the return on investment of the technique.[285]

5.4.1 Land use change and intensification: agroforestry

To manage land use change and intensification, and increase carbon sequestration, reforestation is a key policy objective in Mali, highlighted by its prominence in the NDCs and the Climate-Smart Agriculture Investment Plan (CSAIP).[286] Agroforestry has been included as a component to deliver the reforestation policy aims and is defined as carbon sequestration from adding above ground woody carbon storage (tree cover) in crops and grasslands. This practice increases carbon in agricultural landscapes by supporting the planting and natural regeneration of trees on crops and grasslands.[287]

Agroforestry performs three functional roles: *productive*, *protective*, and *socioeconomic.*[288] Firstly, as a practice it can support crop production, provide a source of fodder, provide fuel, provide shade for animals etc., this makes agricultural activities more *productive*. Secondly, there are potential environmental benefits e.g. reduced soil erosion, restoring soil health, carbon sequestration etc., which serves to *protect* land. Thirdly, agroforestry can be used as a means of income diversification and to increase farm yields, this emphasizes the *socioeconomic* benefits.

The *productive*, *socioeconomic*, and to some extent *protective* benefits of agroforestry serve as drivers to adopt agroforestry at a household level, with tangible benefits for farmers evident. A notable feature of agroforestry is that, because of the time required to cultivate mature trees, there is a delay between adopting agroforestry and the time to obtain the benefits. This delay, especially associated with the longer-term environmental benefits, means that clarity on land ownership, and coordination is often required from local authorities to implement the practice.[289] As explored below, this can provide a barrier to agroforestry adoption.

5.4.2 Land use change and intensification: Irrigation to improve crop production practices

To both improve crop production and target land use change and intensification, irrigation has been identified as a key policy objective by the government of Mali. Irrigation could play a key role in reducing GHG emissions from rice cultivation which is the agricultural sub-sector that has the fourth highest emissions. [290] In the CSAIP for Mali[291] rice intensification is one of eight CSA investment

[282] African Development Bank, (2015). Renewable energies in Africa: country profile of Mali, Available here
[283] Interview with the SNV representative for the ABC and MERIT biodigester projects
[284] R. van Veenhuizen et al., (2017), Policy brief: Integrated development of biogas in West Africa, Available here
[285] Interview with the SNV representative for the ABC and MERIT biodigester projects
[286] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[287] Roe et al., (2021), Land-based measures to mitigate climate change: potential and feasibility by country, Available here
[288] Kennedy Muthee et al., (2022), A quantitative appraisal of selected agroforestry studies in the Sub-Saharan Africa, Available here
[289] Kennedy Muthee et al., (2022), A quantitative appraisal of selected agroforestry studies in the Sub-Saharan Africa, Available here
[290] FAO, (2023), Total emissions from agriculture, Available here
[291] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here

areas, and the only one that highlights emissions reduction potential. This intensification will partially be delivered in the form of improved and increased irrigation systems.

Irrigation was identified as a primary constraint that inhibits farmers agricultural production in IAAT field data, cited as the second most important barrier to productivity (33% of all respondents) and making efficient and productive irrigation key for Mali's sustainable development.[292]

There are two main options to reduce emissions associated with irrigation: crop intensification and replacing diesel pumps with solar pumps. Irrigation pumps in Mali typically run on diesel and electricity as sources of energy meaning that whilst increasing adoption of diesel and electricity fueled irrigation pumps can increase crop resilience and farmer adaptation to climate change, it also contributes to increased emissions.[293] As well as potential increased costs for the farmer. Solar irrigation pumps have therefore been identified by IWMI as a technology that can create both mitigation and adaptation benefits for smallholder farmers, by increasing access to irrigated land and providing a renewable source of energy for farmers.[294] However, similarly to biogas systems, barriers remain to solar irrigation pump adoption including: high upfront cost (an initial investment of anywhere between USD 840 and 4,700 is often needed), limited access to information for farmers, limited marketing attempts targeted at resource-poor and resource-limited farmers and underdeveloped markets for other items in irrigation value chain (e.g. for inputs (such as seeds and fertilizer) and outputs (irrigated agricultural products).[295,296]

In addition, improved irrigation practices can play a particularly key role in rice cultivation, which is the fourth highest emitting agricultural sub-sector.[297] In the CSAIP for Mali the system for rice intensification (SRI) is one of eight CSA investment areas, and the only one that highlights emissions reduction potential.[298] SRI fields adapt better to climate change, give off fewer greenhouse gas emissions, and allow farmers to increase productivity while using less seed, water and purchased agrochemical inputs.[299] One practice within SRI is alternate wetting and drying (AWD), also known as "intermittent irrigation" which involves providing water intermittently to rice paddies and results in reduced methane emissions.[300] Further, SRI trials in the Tombouctou region in 2008 showed average yield increases of 66% (ranging from 34-87%), with water savings of at least 32%. However, there is still low uptake for SRI across Mali as a whole which is reported at only 29,180 farmers across Mali in 2022.[301, 302]

5.4.3 Summary

As Mali's contribution to global emissions is minor, adaptation is the primary focus in Mali. However, to align with the NDCs and to promote the development of a long-term resilient agricultural sector, mitigation techniques are an important additional consideration. The barriers to low-carbon and mitigation technologies and practices have been summarised into a barrier that will be targeted to be overcome by the project: "Immature markets (for relevant inputs and outputs) for low-carbon agriculture technologies/ practices such as agroforestry, solar irrigation, and biodigesters, alongside cultural barriers."

[292] IAAT Field Data collection 2023 – Farmer respondents
[293] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[294] CGIAR, (2018), Solar Irrigation to counter climate-vulnerability and improve food security in Mali, Available here
[295] AICCRA, (2023), Pay-as-you-go model makes solar-powered irrigation affordable for farmers in Mali, Available here
[296] Agrilinks, (2022), Closing the Demand-Supply Gap in Mali's Solar-Powered Irrigation Value Chains, Available here
[297] FAO, (2023), Total emissions from agriculture, Available here
[298] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[299] Oxfam, Policy Landscape for the Scaling-Up of Agroforestry in Mali, Available here
[300] SRI 2030, What, Available here
[301] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[302] Ministère du Développement Rural, (2023), Plan Triennal de Campagne Agricole Consolidé et Harmonisé

VI. CLIMATE CHANGE ADAPTATION GAPS IN AGRICULTURE AND AGROFORESTRY

6.1 Introduction

Mali's current and projected vulnerability to climate trends and events has driven a steady need to adapt to climate hazards in order to maintain agricultural production. This includes adjustments in both behavior and in resources and technologies[303] so that potential damages from changing climatic conditions are moderated, and consequences managed.[304] Increasing this 'adaptive capacity' contributes to the broader goal of climate resilience as it reduces vulnerability to climate hazards, by focusing on the skills and mechanisms that can be deployed to respond to these challenges, and is increasingly important in Mali due to the projected changes in temperature, and the uncertainty over precipitation. In parallel, as outlined in *chapter 0*, it is key that new options to adapt to climate change in Mali have limited GHG emissions to align with the government's plans for climate resilient, low-carbon development.

Gaps identified refer to shortcomings in adaptive capacity that can increase both household and national climate vulnerability. The adaptation gaps outlined in the following section have been identified through a literature review, and stakeholder interviews and data collection. The gaps have been grouped into five key themes. The first relates to the suitability and availability of techniques that increase low-carbon and climate resilient agriculture and agroforestry. The second relates to information availability, both in terms of information on how, when, and what adaptive strategies are best employed. The third relates to the availability and accessibility of finance to enable investments in adaptive measures. The fourth relates to institutional capacity. In addition, the presence of intersectional challenges, particularly regarding gender and age are also considered in a fifth theme. To address climate change adaptation gaps, this analysis will comment on the existing capacity to adapt to climate change and limit emissions within agriculture and will explain where the key adoption gaps remain in relation to the key current and future climate risks identified in Chapter IV and Chapter V.

6.2 Suitability and availability of adaptive techniques

Technologies and practices are key to increasing adaptive capacity, and there is a tradition of low-cost yet effective technologies and practices being employed at both the household and national levels in Mali.[305] The technologies and practices typically do not just target "adaptation" on their own, with "climate smart agriculture" techniques targeting 3 parallel outcomes: adaptation to climate change, increased agricultural productivity and a co-benefit of reduced carbon emissions. Different practices are favored in response to distinct climate hazards but they broadly fall into six categories as defined by GIZ: 1) Use of improved seeds, 2) Soil and water management, 3) Timing of farming practice, 4) Changing crop/livestock distribution and densities, 5) Tillage and associated practices; and 6) Farm crop and livestock diversification.[306] Each of these categories was assessed in terms of the current uptake and the challenges relating to the technology/practice in the context of Mali. All categories' bars 3 and 5 are currently employed in Mali to some extent.

6.2.1 Use of improved seeds - current state and resulting adoption gaps

Improved seeds are a priority adaptive technique as certain seed varieties are better able to withstand drought, heat, pest/disease, and other hazards, and/or can deliver increased yields.[307] These seed varieties need to be carefully selected to meet the climatic conditions, as well as the broader agro-cultural context within the specific implementation area.

[303] IPCC, (2007), IPCC Fourth Assessment Report: Climate Change. Available here
[304] Climate Adapt, (2022), Assessing climate change risks and vulnerabilities, Available here
[305] USAID, (2017), Decentralized Governance and Climate Change Adaptation: A Case Study on Mali, Available here
[306] GIZ, (2017), Agricultural adaptation: Six categories of good practices and technologies in Africa, Available here
[307] The range of practices were initially identified through the GIZ (2017), Agricultural adaptation: Six categories of good practices and technologies in Africa, Available here and have been supplemented through additional sources.

Certain hazard tolerant and / or higher yield crop varieties are suitable for Mali with successful adoption. Heat-resistant varieties of sorghum, pearl millet, groundnut and cowpea crops have been introduced and have demonstrated superior features including higher yields and increased profitability in some areas.[308] Adoption of improved seeds varies by value chain: it is estimated at ~23% for rice according to the 2017 Agricultural census, but only ~5% for maize.[309] With support, adoption can be increased: for example, the CCAFS programme successfully introduced drought-tolerant varieties of key crops with adoption rates rising to above 65% amongst participants in 2016.[310] Notably, as the climatic conditions differ across Mali, resulting in the differing livelihoods zones and crop production, seed varieties need to be specifically tailored to the conditions in each climatic zone. For example, seeds that offer more stable yields when exposed to floods are employed in the Niger delta which experiences an annual flooding cycle.[311]

Despite significant research being conducted and new varieties being produced by the Institute of Rural Economy (IER), only a limited portion of farmers use improved seeds in Mali. Field data collection among farmers in the five regions of the IAAT project, suggests that access to inputs is one of the most frequent constraints to implementing adaptive techniques with 52% of all farmers surveyed citing it as an issue.[312] Limited availability, high prices, and the prevalence of traditional seed propagation methods are the main barriers hindering access to certified and hybrid seeds in Mali. The Access to Seeds Index finds that of the 16 seed companies operating in Mali that were assessed, only four companies accompany their sales activities with extension services reducing their reach to smallholder farmers.[313]

Indeed, the limited adoption of improved seeds is mainly due to the limited production. While the quantity of seed required for rice is estimated at 78,000 metric tons (MT), only 5,238 MT are reported by the government to be produced in 2022.[314] The limited production of improved seed is exacerbated by the reliance of farmers, especially shallot and sweet potatoes producers, on bulb propagation, and the use of their own cuttings. The high price of hybrid seeds also contributes to the reduction of farmers' abilities to invest in improved seeds, with prices and availability fluctuating due to national level market challenges, as well as local supply chain challenges.[315]

The second challenge relates to future suitability. What constitutes improved or appropriate seeds is not universal across Mali[316] with different requirements needing to be tailored to the climatic conditions, as well as the farming practices in the specific region. It is anticipated that this challenge will increase as current seed selection might not be suitable to future climatic conditions, therefore the practice, as well as the market and information supporting the technique will need to evolve.[317]

6.2.2 Soil and water management - current state and resulting adoption gaps

Soil and water managements includes a variety of techniques including composting, biofertilizers, Zai pits, irrigation, crop rotation and other erosion control measures.[318] Due to smallholder's dependence on rain-fed agriculture, and the decreasing trends in precipitation, a range of options are currently employed to manage water. For example, field contouring technology, introduced in rural Koutiala reduced water run-off from 20% to 50%, depending on soil type, and increased crop yields by

[308] Global Centre of Adaptation (2020), Available here
[309] INSTAT, (2019), Enquête Agricole de Conjoncture Intégrée aux Conditions de Vie des Ménages 2019-2020, Available here
[310] Ouédraogo et al., (2019), Uptake of Climate-Smart Agricultural Technologies and Practices: Actual and Potential Adoption Rates in the Climate-Smart Village Site of Mali, Available here
[311] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[312] IAAT Field Data collection 2023 – Farmer respondents
[313] Access to Seeds Index, (2019), Mali Profile, Available here
[314] Ministère de Développement Rural, Plan Triennal de Campagne Agricole Consolidé et Harmonisé (2023)
[315] Sanga, U, Sidibé, A., Schmitt Olabisi, L., (2021) Dynamic pathways of barriers and opportunities for food security and climate adaptation in Southern Mali, Available here
[316] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[317] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[318] The range of practices were initially identified through the GIZ (2017), Agricultural adaptation: Six categories of good practices and technologies in Africa, Available here and have been supplemented through additional sources.

approximately 30%.[319] Furthermore, zaï pits, one of the traditional adaptation strategies in Mali, have proven very effective in soil and water conservation.[320] 96% of women and 95% and youth consulted among farmers highlighted the importance of resource conservation, including waste and water management.[321] However, most farmers face challenges to successfully manage water. 62% of farmers highlighted the lack of waste and water management as one the main constraints for the implementation of agricultural best practices.[322] The number of farmers facing this constraint is exacerbated in some regions, especially Gao and Tombouctou, where all farmers highlighted being affected by the limited capacity to efficiently manage water.[323]

In addition, soil management using organic fertilizers was cited as the adaptation practice with the highest awareness rate in Mali in a 2019 study. [324] The IAAT field data collection corroborates this finding as the use of organic fertilizer to support soil health was the third most frequently occurring adaptive strategy employed by farmers.[325] Despite broad access to organic fertilizers, the quantities used are low due to limited availability and high prices. The subsidies provided during the Malian government's 2022 campaign provided access to fertilizers for 333,000 farmers, for a total of 93,000 MT of both mineral and organic fertilizers.[326] This is significantly lower than the amounts required to significantly improve production, which is 218,000 MT for rice alone and 264,000 MT for maize.[327] Use of organic fertilizers also varies between regions and by gender. As an illustration, 91% of men but only 31% of women use organic fertilizers in Mopti, compared to only 35% of men and 16% of women in Kayes.[328] These variations across regions, and low quantities used overall, are driven by the low availability of fertilizers, high market prices as well as gender norms. The fluctuations in the global market have led the price to triple in Mali (from FCFA 11,000 per bag to FCFA 35,000 – 40,000 per bag), encouraging the government to increase subsidies on fertilizers by FCFA 2 billion in 2023.[329] These subsidies mostly aim to increase the use of local fertilizers, which should be available at FCFA 2,500 per bag.[330]

Higher technology options to promote soil and water management are also underexploited in Mali. For example, only 5% of land is currently irrigated in Mali.[331] This low adoption is in part attributed to the lack of high-quality, low-cost equipment, with the cheaper pumps used for solar irrigation breaking quicker.[332] Without irrigation, the historic dependence on precipitation for farming persists; a challenge that is expected to increase with forecasts projecting heightened variability in precipitation (see *5.1.3 Precipitation* projections for more information). Solar pump driven irrigation is one potential option to increase irrigation adoption in Mali, whilst limiting carbon emissions of the agricultural system. This technique and the barrier to its adoption have been examined in the above section: *5.4 Mitigation techniques in Mali and barriers for* adoption.

[319] TNA, Mali: Africa, Available here
[320] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[321] IAAT Field Data collection 2023 – Farmer respondents
[322] IBID
[323] IBID
[324] Ouédraogo et al., (2019), Uptake of Climate-Smart Agricultural Technologies and Practices: Actual and Potential Adoption Rates in the Climate-Smart Village Site of Mali, Available here
[325] IAAT Field Data collection 2023 – Farmer respondents
[326] INSTAT, (2019), Enquête Agricole de Conjoncture Intégrée aux Conditions de Vie des Ménages 2019-2020, Available here
[327] INSTAT, (2019), Enquête Agricole de Conjoncture Intégrée aux Conditions de Vie des Ménages 2019-2020, Available here
[328] Ministère du Développement Rural, (2023), Plan Triennal de Campagne Agricole Consolidé et Harmonisé
[329] Ministère du Développement Rural, (2023), Plan Triennal de Campagne Agricole Consolidé et Harmonisé
[330] Commodafrica, (2022), Au Mali le Président de la transition fixe les priorités agricoles, Link
[331] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[332] IWMI, (2022), Closing the Demand-Supply Gap in Mali's Solar-Powered Irrigation Value Chains, Available here

6.2.3 Changing crop/livestock distribution and densities - current state and resulting adoption gaps

Changing crop/livestock distribution and densities typically involves intercropping and reducing stock density. [333] Intercropping at the household level has seen some successful application in Mali, with the CCAFS programme citing an adoption rate of over 50% amongst randomly selected participants since 2000.[334] In addition, crop and livestock systems have long-been supported by the improvement of fodder cropping and with the implementation of fodder banks.[335]

Due to cases of resource competition and depletion, shifting from larger animals (e.g., cows) to smaller animals (e.g., goats) that require less food and water to sustain milk production has also been cited as a potential technique.[336] Whilst this does serve as an adaptive technique, there are significant socio-cultural challenges that prevent adoption in Mali with smaller animals typically tended to by women and not tended to by men.[337]

In addition, on an individual level, nomadic pastoralist farmers have changed migration patterns to ensure access to inputs e.g. water. This individual-level adaptation strategy has further exacerbated livestock distribution and density as nomadic pastoralist farmers have been forced to remain near permanent water sources leading to considerable overgrazing.[338] This in turn increases the need for techniques to promote soil and water management displaying the interconnectedness of adaptive strategies and the need for coherence.

6.2.4 Farm crop and livestock diversification- current state and resulting adoption gaps

Diversification as an adaptation technique in this context is comprised of two components. Firstly, diversification in the form of a household broadening the income streams within agriculture e.g. introducing new crops or introducing livestock production; secondly, by diversifying livelihoods to include income from other sectors.[339] In addition to increase adaptative capacity, some methods for the diversification of crops, for example inter- and alternate cropping, can increase biomass, biodiversity and carbon sequestration potential.[340]

Across Mali both forms of diversification are an established and long-standing practice[341] with Household Economic Analysis demonstrating that a range of income and food sources in many cases are needed for survival.[342] Examples of diversification includes agroforestry through the introduction of trees including acacia senegal which is commonly planted due to the extraction of gum arabic which can be sold to expand income streams.[343]

However, diversification remains uneven across Mali. Crop diversification as a practice is more common among higher educated farmers in Mali, this means that other socio-economic factors compound adaptation gaps.[344] Furthermore, with projections that crops such as maize, bananas and certain millet varieties being wholly unsuitable for growing in Mali by 2040–2069[345] the practice of

[333] The range of practices were initially identified through the GIZ (2017), Agricultural adaptation: Six categories of good practices and technologies in Africa, Available here and have been supplemented through additional sources.
[334] Ouédraogo et al., (2019), Uptake of Climate-Smart Agricultural Technologies and Practices: Actual and Potential Adoption Rates in the Climate-Smart Village Site of Mali, Available here
[335] ICRISAT, Developing a climate resilient agricultural sector in Mali, Available here
[336] Rahimi, J., Fillol, E., Mutua, J.Y. et al., (2022), A shift from cattle to camel and goat farming can sustain milk production with lower inputs and emissions in north sub-Saharan Africa's drylands, Available here
[337] DT Global, (2019), Malian Female Farmers Increase Income Using Livestock Fattening Techniques, Available here
[338] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[339] The range of practices were initially identified through the GIZ (2017), Agricultural adaptation: Six categories of good practices and technologies in Africa, Available here and have been supplemented through additional sources.
[340] GIZ (2017), Agricultural adaptation: Six categories of good practices and technologies in Africa, Available here
[341] ICRISAT, Developing a climate resilient agricultural sector in Mali, Available here
[342] RCPA (2020) Mali: seasonal food security and livelihoods assessment – household economy analysis (HEA). Available here
[343] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[344] Douyon A. et al., (2022), Impact of Crop Diversification on Household Food and Nutrition Security in Southern and Central Mali, Available here
[345] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here

livelihood diversification will need to expand significantly and ensure it is future-proofed for evolving climatic conditions.

6.2.5 Agroforestry

Agroforestry performs three functional roles: *productive*, *protective*, and *socioeconomic.*[346] Firstly, as a practice it can support crop production, provide a source of fodder, provide fuel, provide shade for animals etc., this makes agricultural activities more *productive*. Secondly, there are environmental benefits e.g. reduced soil erosion, restoring soil health, carbon sequestration etc., which serves to *protect* land. Thirdly, agroforestry can be used as a means of income diversification and to increase farm yields, this emphasizes the *socioeconomic* benefits.

The barriers to agroforestry adoption have been outlined in detail in the section "**Error! Reference source not found.Error! Reference source not found.**as part of the key mitigation options outlined in section *"*

[346] Kennedy Muthee et al., (2022), A quantitative appraisal of selected agroforestry studies in the Sub-Saharan Africa, Available here

5.3 The Causes of GHG emissions in Mali and **Mitigation Options***".*

6.2.6 Opportunities to close adoption gaps across the adaptive techniques

A blend of techniques that are both high-tech and low-tech are needed to close adaptation gaps. These techniques must consider current adaptation requirements, be 'future fit' to respond to changing hazards and consider practical implementation requirements and the strength of existing barriers to adoption (see the following sections for more information). The full assessment of the most appropriate CSA techniques for the 5 regions of Mali targeted by IAAT can be found in Chapter 0 7.3 Technologies and Techniques Options Assessment.

6.3 Availability of information and appropriate skills/capabilities

Availability of information and skills underpins adaptation. Firstly, information is required to know *"when"* climate trends and hazards will present a risk to individuals or systems, thus knowing that adaptation is required. Secondly, information is required on *"what"* adaptive measures are best implemented to confront different hazards, which is coupled with the practical skills and capabilities to know *"how"* to implement the practices or technologies effectively.

6.3.1 Information availability on hazards and early warnings

Current state and resulting adoption gaps

According to the UNFCC[347], information on the nature and evolution of climate hazards faced by a society, and timely information warning of specific hazards is an essential component to achieving adaptive capacity. This is a key issue in Mali due as it limits ability to respond to ongoing climate hazards, as well as helps to create limited consensus on climate projections which reduces the national government's ability to establish strategies to mitigate the future changes.

To date, Climate Information and Early Warning Systems (CIEWS) have been operational and state-funded in Mali since the 1980s. The National Meteorological Agency (Mali Météo) provides "accurate and locally adapted seasonal weather forecasts on various aspects, including beginning of the rainy season, length of the growing season, daily weather information, 10-day forecast, among other parameters".[348] In addition, food security and nutrition monitoring are carried out by the Early Warning System (SAP) of the Food Security Commissariat (CSA). [349]

However, challenges exist with the CIWES system as critical weather and climate information is not consistently communicated to the rural farmers in good time[350]. This undermines individuals' ability to deploy resources to act quickly to mitigate climate hazards. Furthermore, there is low confidence in the Mali Météo information which exacerbates this issue.[351] The issue of early warnings was, however, not highlighted in IAAT field data collection which did not call out early warnings or hazard information as a key solution to remove adaptation barriers.[352]

Opportunities to close adoption gaps

There are several GCF projects ongoing in Mali aiming to increase early warnings information including the Hydromet Project (FP012) and Africa Integrated Climate Risk Management Program (FP162). More specifically, the Hydromet Project FP012 is providing flood warnings, convening advice from agro-meteorological information systems about the optimal date for cropping, the most profitable crops, and how to avoid crop losses from drought, pests and diseases. In addition, the Africa

[347] UNFCCC, Assessing and Enhancing Adaptive Capacity, Available here
[348] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[349] Green Climate Fund, (2016), Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Mali Country Project, Available here
[350] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[351] Green Climate Fund, (2016), Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Mali Country Project, Available here
[352] IAAT Field Data collection 2023 – Farmer, household and organization respondents

Integrated Climate Risk Management Program FP162 is strengthening climate weather information to support decision making and planning in agro-forestry, livestock, agricultural insurance products and services, and providing training e.g. to meteorological experts in the country to improve early warnings services. Supporting the outcomes of these projects and their reach is a compelling opportunity to increase use of and the efficacy of CIEWS.

6.3.2 Knowledge of CSA techniques and capabilities

Current state and resulting adoption gaps

Across Mali, policies and programs have aimed to boost human capital through information dissemination and training. Information dissemination has positively impacted knowledge of CSA practices with the majority of the 300 randomly selected household heads from 48 villages in the Segou region surveyed by the CGIAR Program on Climate Change, Agriculture and Food Security (CCAFS) being aware of practices including agroforestry, intercropping, crop diversification, and irrigation (non-exhaustive).[353] Additionally, the Ministry of Environment in Mali is actively promoting several CSA practices through knowledge sharing and subsidies, with a focus on several pertinent climate adaption options, including agroforestry, stone lines/bunds, contour trenching, and zaï pits. [354]

However, significant knowledge gaps remain regarding locally appropriate adaptation options. For example, there is limited information available on the costs and benefits of different high-tech and low-tech options and how to best combine them in the context of Mali's climate.[355] IAAT field data collection identified that over 60% of farmers cited insufficient knowledge as a barrier to implementing climate-resilient agricultural practices.[356]

Even in circumstances where awareness of appropriate CSA technologies and practices exists, issues relating to capabilities or desire to adopt new practices persist. In the case of agroforestry, there is high awareness of the practice and its benefits (including that it has low upfront investment costs and decreased dependence on costly agricultural inputs, thus low reliance on financial credit).[357] However, despite this high awareness (87% of farmers in the CCAFS program), adoption is limited, with only 21% of farmers adopting the practice in the programme.[358] The limited adoption of practices including agroforestry was found to result in part from the illiteracy of farmers, a lack of technical capacity to adopt new practices, and limited understanding on the potential productive, protective and socioeconomic benefits of the practice.[359]

Extension services perform a critical role in building essential agricultural knowledge and skills, and disseminating information, and their reach is approximately 40% across Mali.[360] They perform activities including trainings and information-sharing including crop-recommendation bulletins which are shared over local radio and have been successful in improving knowledge and implementation of new heat-resistant crop.

However, due to their key role, the shortcomings of extension services result in adaptation gaps in Mali. At present farmers are underserved by extension services as they are under resourced and ill equipped to assist farmers with adopting innovative CSA practices.[361] This is partially because extension agents lack up-to-date knowledge, meaning that farmers are trained on technologies and

[353] Ouédraogo et al., (2019), Uptake of Climate-Smart Agricultural Technologies and Practices: Actual and Potential Adoption Rates in the Climate-Smart Village Site of Mali, Available here
[354] Duan, Faye, (2020), Policy Landscape for the Scaling-up of Agroforestry in Mali, Available here
[355] Adaptation Fund, (2011), Proposal for Mali, Available here
[356] IAAT Field Data collection 2023 – Farmer respondents
[357] Duan, Faye, (2020), Policy Landscape for the Scaling-up of Agroforestry in Mali, Available here
[358] Ouédraogo et al., (2019), Uptake of Climate-Smart Agricultural Technologies and Practices: Actual and Potential Adoption Rates in the Climate-Smart Village Site of Mali, Available here
[359] Ouédraogo et al., (2019), Uptake of Climate-Smart Agricultural Technologies and Practices: Actual and Potential Adoption Rates in the Climate-Smart Village Site of Mali, Available here
[360] Alliance for a green revolution in Africa, (2021), Agra Mali Report Final. Available here
[361] World Bank & FAO, (2021), A Blueprint for Strengthening Food System Resilience in West Africa: Regional Priority Intervention Areas Public, Available here

practices that are not 'future fit'. For example, there is little to no information available through extension services relating to solar irrigation.[362] In addition, extension services lack inclusivity with women and youth systematically excluded. This is driven by a multitude of factors including a lack of representation with women making up only 10-25% of extension agents,[363] and the average age of extension agents being 50 years old.[364]

The importance of closing information and capacity-related adaptation gaps is increasing with the evolution of climate threats as current knowledge of adaptation measures will be insufficient in response to the threats of the future. As an example, the World Bank suggests that going forward, the standard practice of drought/ flood/ heat / pest resistant seed variety selection will have to evolve in line with harsher climatic conditions.[365] They predict crops such as maize, bananas and certain millet varieties being wholly unsuitable for growing by 2040–2069, therefore the practice of seed selection (different variety of the same crop) might need to change to crop selection to ensure adaptation.

Opportunities to close adoption gaps

IAAT field data collection found that the primary recommendation to increase climate resilience is to focus on capacity building and technical assistance with over 50% of respondents citing it as a recommendation.[366] This was echoed through interviews with complementary projects. The Malian organization Sahel Eco also highlighted the need for capacity building for farmers, particularly in water management techniques. They noted the need to increase knowledge of existing technologies and to train individuals on how they can be implemented, ensuring training is both theoretical and technical.[367]

6.4 Availability and accessibility of finance

Adaptation gaps are also driven by the lack of availability and accessibility to finance. Furthermore, there are challenges relating to the financial incentives behind adopting adaptive technologies and practices which exacerbate adaptation gaps.

Current state and resulting adoption gaps.

Mali has experienced moderate GDP per capita growth, with average annual growth around 2.5% from 2015 to 2019 and negative growth during Covid[368], and remains one of the poorest countries in the world. In addition, the market infrastructure is immature meaning the deployment of financial capital is limited. Some progress has been made in the availability of capital for smallholder farmers through microfinance organisations such as Kafo Jiginew and international funders. For example, the European Investment Bank announced new support to Kafo Jiginew in 2020 which is expected to enable around 60,000 microfinance loans to be provided to smallholder farmers and provide financing for almost 15,000 people.[369] In 2022, 21 active projects were funded by the Mali Climate Fund, for a total amount of USD 20 million. 18 out of these 21 projects focused on agriculture.[370] However, the World Bank and FAO report that access to credit for smallholder farmers continues to be low in Mali and across West Africa. In addition, the use of agricultural credit to purchase inputs also remains low,[371] with over 70% of farmers in Mali refused agricultural loans, predominantly due to the perception of high risk.[372]

[362] IWMI, (2022), Closing the Demand-Supply Gap in Mali's Solar-Powered Irrigation Value Chains, Available here
[363] USAID, (2018), Mali: In-depth Assessment of Extension and Advisory Services, 2018, Available here
[364] World Bank & FAO, (2021), A Blueprint for Strengthening Food System Resilience in West Africa: Regional Priority Intervention Areas Public, Available here
[365] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[366] IAAT Field Data collection 2023 – Farmer respondents
[367] Interview with Sahel Eco project - 2023
[368] World Bank, GDP per capita growth (annual %) – Mali (1968, 2022), Available here
[369] Government of Mali, 2022 Annual report on the activities of the Mali Climate Fund, Link
[370] Government of Mali, 2022 Annual report on the activities of the Mali Climate Fund, Link
[371] World Bank & FAO, (2021), A Blueprint for Strengthening Food System Resilience in West Africa: Regional Priority Intervention Areas Public, Available here
[372] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here

This hinders adaptive capacity as it inhibits both the ability of individual households to respond to immediate shocks by increasing food stocks[373] for example, and the ability of individual households to invest in adaptive practices or technologies to protect themselves against future shocks.

Opportunities to close adoption gaps

Work is required to close the financing gap and increase credit to smallholder farmers, in fact 'financial support' was the second most frequently occurring suggestion to increase resilience and adaptation by farmers in the IAAT field work.[374] As well as increasing the flow of finance through banks and micro-finance institutions, this could include the introduction of more innovative financial products and services. For example, for higher-cost technologies e.g., biodigesters, projects operating in Mali including the ABC project have used innovative financing structures including pay as you go and carbon offset credits to overcome financing challenges for smallholders, whilst supporting sustainable market development.[375] Other options for smallholder farmers include crop insurance which provides a means to reduce climate exposure by insuring their harvest against climate events (e.g., drought, flood) as well as indirectly reducing their risk profile to lenders and therefore accessing other sources of finance.[376] However, so far this product gained limited traction in Mali and across Sub-Saharan Africa where uptake is only 3% with barriers including a lack of awareness of the product, a lack of understanding of the product, and low profitability.[377,378,379]

6.5 Wider market considerations

Current state and resulting adoption gaps

In addition to barriers accessing finance to improve adaptive capacity at the household level, wider challenges relating to the return on investment exist for specific CSA practices. The World Bank and FAO highlight that adoption of adaptive technologies and practices (e.g., changing to different crop types) is not possible until the market infrastructure supports the sale of these products.[380] With the majority of smallholder farmers practicing subsistence farming, practices that rely on producing crops not suitable for household consumption remain inappropriate without the development of markets to sell them.

Opportunities to close adoption gaps

The World Bank and FAO state that increasing farmers' access to markets and providing commercial opportunities are the most promising ways to boost adoption of CSA practices.[381] Within this, one pathway towards better market access is to enable producer associations to deliver aggregation, value addition (for example, cleaning, grading, and quality control), and commercialization services to their members. [382] IAAT field data collection which included interviews with cooperatives highlighted the appetite for cooperatives to play a role in wider market development through coordination.[383]

[373] ACM/ALIMA/CARE, (2022), Breaking the spiral of the Food and Nutrition Crisis in Mali, Available here
[374] IAAT Field Data collection 2023 – Farmer respondents
[375] Interview with the SNV representative for the ABC and MERIT biodigester projects.
[376] Ada Microfinance, (2022), Index-based agricultural insurance, Available here
[377] Ada Microfinance, (2022), Index-based agricultural insurance, Available here
[378] GSMA, (2020), Agricultural insurance for smallholder farmers: Digital innovations for scale, Available here
[379] GSMA, (2020), Agricultural insurance for smallholder farmers: Digital innovations for scale, Available here
[380] World Bank & FAO, (2021), A Blueprint for Strengthening Food System Resilience in West Africa: Regional Priority Intervention Areas Public, Available here
[381] World Bank & FAO, (2021), A Blueprint for Strengthening Food System Resilience in West Africa: Regional Priority Intervention Areas Public, Available here
[382] World Bank & FAO, (2021), A Blueprint for Strengthening Food System Resilience in West Africa: Regional Priority Intervention Areas Public, Available here
[383] IAAT Field Data collection 2023 – Organization (Cooperative) respondents

6.6 Institutional capacity and connectivity

Current state and resulting gaps

With adaptation gaps present at individual household, community, regional and national levels, institutions (both formal and informal) are important to manage adaptation gaps and improve climate resilience. Commune-level management and administration influences climate change adaptation through community-level planning, including in the five-year development planning process (PDESC). The presence of the institutions of governance at the commune and village levels boosts adaptive capacity as it functions as an intermediary or gatekeeper through which information (on technology, government regulations and policies, etc.) and external resources can flow.[384] This supports implementation of adaptive measures and community-wide collaboration. However, commune-level management and administration has limited capacity to influence adaptation. As suggested by USAID's research, several challenges (e.g., lack of adequate funding and a reliance on external contractors) prevent local authorities from effectively leveraging the PDESC to foster adaptation.[385] Furthermore, commune-level management and administration, and the services that are offered have been cited to exclude women and youth due to decision-making structures that rely on the male heads of households. [386,387]

Challenges regarding coordination between the national and local level also present a barrier to implementing CSA and agroforestry supportive policies that are approved at the national level. Policies relating to agroforestry provide a good example of this, where there is both a disconnect between national policies and local conventions further compounded by an 'incomplete' transfer of authority from national to local government, with much decision making, budgetary control, and policy execution remaining central, in spite of the 'decentralized' model.[388,389,390] This makes it difficult for local governments and authorities to implement practices like agroforestry on state-owned lands as there is a conception that they do not have the authority to do so.

Opportunities to close capacity gaps

IAAT field data collection highlighted the need to strengthen institutions to support the implementation of adaptive techniques with 22% of farmers suggesting it as an area of focus to increase climate resilience, representing the third most frequently occurring answer.[391]

Opportunities to close adaptation gaps include: i) building capacity at the commune-governance level to increase knowledge of adaptation and mitigation needs, and the best practices for incorporating these into the PDESC planning cycle, ii) improved coordination between national and local governance on the mechanisms to implement agroforestry and iii) elevate and build the capacity of local informal governance mechanisms that are trusted by local communities to make decisions on shared resource management. Importantly, opportunities involve working with multiple levels of institutions rather than solely focusing on local or national institutions

6.7 Intersectionality in climate change adaptation gaps

Adaptation gaps are further exacerbated for marginalised groups in Mali, as are compounded by other socio-economic threats.

[384] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link
[385] USAID, (2017), Decentralized Governance And Climate Change Adaptation, Link
[386] AGRA, (2021), Value 4 Her: Synthesis Report on Agri-enterprise event held in Bamako Mali, Available here
[387] Food and Business Knowledge Platform, (2016), Youth inclusiveness in agricultural transformation: The case of Mali, Available here
[388] World Agroforestry, (2023), Agroforestry: A pathway to harnessing nature-based solutions for ecosystems and livelihoods in Sub-Saharan Africa, Available here
[389] Land portal, (2022), Mali – Context and land governance, Available here
[390] Land links (2020), Country profile: Mali, Available here
[391] IAAT Field Data collection 2023 – Farmer and Organization respondents combined

6.7.1 Adaptation gaps exacerbated by gender and youth inequality

The problems associated with the lack of appropriate technologies are exacerbated for women. Few female producers can access agricultural inputs, machinery, and other factors of production required for agribusiness,[392] with an estimate that only 51% of the women engaged in agricultural activities have access to merchant equipment.[393] Women's limited access to inputs for production are even more acute in the case of fertilizers. Use of organic fertilizers in female managed farms ranges from 0% in Gao to only 30% in Mopti, compared to male managed farms, ranging from 35% in Kayes to 98% in Segou. Women also have significantly lower access to mineral fertilizers and pesticides.[394] Table 14: Use of inputs by gender and regionoffers detailed insights into the contrasting adoption rates of organic and mineral fertilizers, among women and men in Mali.

Table 14: Use of inputs by gender and region[395]

Region	Organic Fertilizer (Women)	Organic Fertilizer (Men)	Mineral Fertilizer (Women)	Mineral Fertilizer (Men)
Mali	14%	75%	12%	67%

Multiple reasons contribute to this reduced access to resources for female farmers and entrepreneurs. Women are constrained in terms of owning land, and those who do own land often receive smaller and less fertile parcels.[396] The land ownership challenges further limit the adoption of agroforestry. Women typically engage in agroforestry more than men e.g. cultivating shea butter which is a feminized activity. This means that cultural norms that exclude women from decision making positions over household or community land, serve to decrease the adoption of agroforestry, as the decision makers are less likely to directly benefit.[397]

Furthermore, access to finance as well as income parity is severely unbalanced in Mali which serves as a barrier for women. This is driven and reinforced by the educational (formal and informal) imbalances and social and cultural norms, which hinder women in agricultural entrepreneurship. With high levels of female illiteracy and innumeracy, many women lack the tangible skills required to set up businesses or to access or interact with services (e.g., extension services or financial service institutions).[398] Furthermore, cultural decision-making norms have typically excluded women, and this means that many women lack the confidence to start businesses or expand production.[399]

A similar pattern exists for young farmers in Mali as banks (microfinance institutions included) require collateral, which is often an insurmountable barrier to disadvantaged youths who do not have savings to serve as collateral, nor possess any land or other resources. This is also true when social capital (as opposed to assets) is used to secure a line of credit. Informal credit (e.g., through communities) requires high stocks of social capital (in terms of a broad network and a status of reliability and creditworthiness) which youths generally do not have. [400] See Annex 8 plan for addressing gender gap through IAAT. The best approches for taking action to inclue and empower women and girls include:

- **Increasing access to resources needed for climate adaptation and mitigation.** The gender assessment shows that women in the project locations have less access to finance, technologies, and knowledge for better management of climate change-related risks. IAAT needs to support them to increase women's access to finance by increasing their involvement in VSLAs, linking them to financial institutions, training them on financial management, and

[392] AGRA, (2021), Value 4 Her: Synthesis Report on Agri-enterprise event held in Bamako Mali, Available here
[393] WFP/UN Women/USAID, (2017), Gender, Access and Use of Credit, Capital and Insurance Services in Mali, Available here
[394] INSTAT, (2019), Enquête Agricole de Conjoncture Intégrée aux Conditions de Vie des Ménages 2019-2020, Available here
[395] INSTAT, (2019), Enquête Agricole de Conjoncture Intégrée aux Conditions de Vie des Ménages 2019-2020, Available here
[396] World Bank, (2019), Climate Smart Agriculture Investment Plan, Available here
[397] Kennedy Muthee et al., (2022), A quantitative appraisal of selected agroforestry studies in the Sub-Saharan Africa, Available here
[398] AGRA, (2021), Value 4 Her: Synthesis Report on Agri-enterprise event held in Bamako Mali, Available here
[399] AGRA, (2021), Value 4 Her: Synthesis Report on Agri-enterprise event held in Bamako Mali, Available here
[400] Food and Business Knowledge Platform, (2016), Youth inclusiveness in agricultural transformation: The case of Mali, Available here

providing knowledge on financial resources available to them. IAAT should also strongly advocate community leaders, including elected representatives, traditional chiefs, religious leaders, and administrative authorities, for greater women's access to and control of resources and benefits by bringing them into the CACs process. Gender equality must be implied while selecting beneficiaries and distributing project resources such as CSA technologies (e.g. solar pumps, biodigesters, improved seeds/breeds, etc.) and agroforestry inputs (e.g. planning materials and equipment).

- **Creating space for women:** gender assessment shows that women have low decision-making roles in choosing production inputs and marketing activities compared to men. In addition, women's involvement in entrepreneurship is very low. IAAT's capacity-building activities can strengthen women's capabilities by increasing their access to information (both market and climate information), and building entrepreneurship skills for the selected businesses (such as value addition and post-harvest management, market gardens, agro-forestry products, etc.). Creating space for women in business environments across the agriculture and agroforestry value chain can improve their decision-making ability at the household and community levels.
- **Linking with the private sector:** our assessment indicates that men are more engaged with the private sector service providers such as agriculture product collectors and aggregators and input suppliers (e.g. seed, feed, animal health services, and tools/equipment). Equal access and engagement by men and women with the private sector service provider can increase their participation in the existing market and new value chains. IAAT's should facilitate linking women with the private sector through integration into the value chains as key actors.
- **Access to extension services :** Women's access to extension services as well as their involvement in extension service provision is limited. IAAT can develop a gender-sensitive CSA curriculum to integrate into the existing agriculture extension system (for both public and private). The gender-sensitive CSA curriculum can focus on gender rôle in input use, production and marketing in agriculture and agroforestry sectors. Currently, women's involvement in agriculture extension services is very low in Mali due to their low education rate and socio-cultural barriers as discussed in this gender assessment report. In the training and capacity building of extension service providers, women should be included as much as possible. This will help IAAT to reach more women farmers through women extension officers in Mali's cultural setting where women are less engaged with men extension officers.
- **Empowering women in early warnings and climate action:** In Mali, women are placed at greater risk through a lack of timely and relevant information about climate risks and a lack of equal access to information services and technologies. Moreover, women's voices are often absent in designing and provisioning information services and technologies. Increasing women's access to early warning systems and climate information services can empower them for informed decision-making in climate action. IAAT can increase women access to existing early warning systems and climate information services, build their capacity to use this information for climate change adaptation and mitigation decisions at their farm and communities.

6.9 Summary: Barriers to Adaptation and Mitigation in Mali

The adoption gaps summarized above in chapter 0 and 0 create adaptation and mitigation gaps. These gaps and their contributory factors have been consolidated into seven barriers that IAAT will attempt to overcome. These barriers draw on the four adaptation gaps identified (i.e., suitability and availability of technologies and practices, information availability, availability and accessibility of finance, and institutional capacity), the cross cutting intersectional issues which exacerbate adaptation challenges (gender and youth exclusion, and conflict), and the mitigation gaps. The barriers and how they relate to the adaptation and mitigation gaps are summarized in **Error! Reference source not found.**.

Table 15: The project barriers and adaptation and mitigation gaps

Barrier	Focus of Gap				
	Technologies and Practices	Information	Finance/ markets	Institu-tions	Inter-sectional issues
B1: Awareness, technical know-how and capacity gaps amongst smallholder farmers to implement and integrate CSA and low emissions land management technologies and practices	X	X			
B2: Limited development of public and private extension services at the local level to promote access to inclusive and reliable agro-advisory services on climate resilient practices.		X			X
B3: Lack of access for smallholder farmers to mature, connected and transparent local markets and value chains for CSA compatible crops			X		
B4: Inability for smallholder and subsistence farmers to invest in inputs for climate change adaptation (seeds, fertilizer, labour, equipment) due to limited financial resources.	X		X		
B5: Limited consideration of the specific and distinct needs of women and youth in the development and management of agricultural and agribusiness systems, leading to significant bottlenecks for their empowerment (e.g., limited access to finance and land, exclusion from decision-making processes).			X		X
B6: Immature markets (for relevant inputs and outputs) for low-carbon agriculture technologies/ practices such as agroforestry, solar irrigation, and biodigesters, alongside cultural barriers	X	X	X		
B7: Public sector institutions and community governance mechanisms lack the capacity to sufficiently include adaptation and mitigation considerations in their work, particularly with regards to planning, and remain uncoordinated across levels and with other stakeholder groups		X	X	X	

VII. ADDRESSING CLIMATE CHANGE VULNERABILITY

7.1 Theory of Change

What does IAAT seek to achieve?

This project seeks to achieve a paradigm shift in Mali's agricultural system by increasing the food security, climate resilience, adaptive capacity, and utilization of low-carbon methods of Mali's largest and most vulnerable farming group: smallholder farmers. As outlined in the *Climate Change Projections and Hazards* section, Mali's agricultural system and the smallholder farmers that make up the majority of producers are increasingly exposed and sensitive to climate risks, with increasing incidences of drought, floods and corresponding high levels of food insecurity. Further, as outlined in the

Climate Change Adaptation Gaps in Agriculture and Agroforestry section, despite the tradition of utilizing techniques to adapt to these climate risks (for example through the development of a Climate Information and Early Warning System in the 1980s or the use of traditional practices such as Zai pits for water conservation), these have increasingly been insufficient to adapt to the evolving climate context. This project therefore seeks to support Mali's smallholder farmers and proposes the following paradigm shift:

IF smallholder farmers in highly vulnerable regions in Mali can access and adopt climate resilient technologies, knowledge, and low carbon agricultural practices, **THEN** their food, nutrition and water security will be improved **BECAUSE** their adaptative and mitigation capacities including improved technical skills, access to finance, markets and sustainable livelihoods, and that of public and private institutions, will be strengthened to respond to and reduce the climate change risk and impacts

Smallholder farmers (both sedentary pastoralists and sedentary crop farmers) will therefore be supported by the project to increase their adaptive capacity and utilization of low-carbon technologies. IAAT will do this by increasing smallholder farmer awareness of, understanding of, incentives for and access to climate-smart agricultural (CSA) practices, techniques and technologies, ultimately resulting in an increased production of low-carbon and climate-resilient agricultural products. Specifically, the following outcomes will be achieved:

- Increased climate-resilient agricultural crop and food production in the targeted regions in Mali
- Improved and inclusive access to finance and markets for vulnerable communities to enhance sustainable livelihoods
- Reduced GHG emissions from agricultural system
- Adaptation and mitigation considerations and best practices are embedded in institutional agriculture and agroforestry planning

How will it achieve this?

The project's impact pathways are designed to reduce the largest barriers to smallholder adoption of climate-resilient and adaptive practices in agriculture in Mali. Based on stakeholder consultation and secondary literature review, the most relevant barriers have been identified as:

- B1: Awareness, technical know-how and capacity gaps amongst smallholder farmers to implement and integrate climate-smart agriculture and low emissions land management technologies and practices
- B2: Limited development of public and private extension services at the local level to promote access to inclusive and reliable agro-advisory services on climate-resilient practices
- B3: Lack of access for smallholder farmers to mature, connected and transparent local markets and value chains for CSA-compatible crops
- B4: Inability for smallholder and subsistence farmers to invest in inputs for climate change adaptation (seeds, fertilizer, labour, equipment) due to limited financial resources

- B5: Limited consideration of the specific and distinct needs of women and youth in the development and management of agricultural and agribusiness systems, leading to significant bottlenecks for their empowerment (e.g., limited access to finance and land, exclusion from decision-making processes)
- B6: Immature markets (for relevant inputs and outputs) for low-carbon agriculture technologies/ practices such as agroforestry, solar irrigation, and biodigesters, alongside cultural barriers
- B.7: Public sector institutions and community governance mechanisms lack the capacity to sufficiently include adaptation and mitigation considerations and best practices in their work, particularly with regards to planning, and remain uncoordinated across levels and with other stakeholder groups

The project will seek to overcome these barriers through 4 components which together work across all core levels of Mali's agricultural system to bring about a paradigm shift, including: directly with smallholder farmers and agri-entrepreneurs; agro-extension services; private sector businesses in CSA compatible value chains; local financial providers and local and national government bodies. Recognizing, as per barrier 5, that women and youth smallholder farmers face additional barriers the select parts of the 4 components are also exclusively targeted at these beneficiary groups.

Component 1: Improving Extension Services & increasing On-farm CSA Adoption

Relevant Barriers Addressed: Smallholder farmers are constrained in their ability to mitigate and adapt to climate change due to limited technical knowledge and capacity to implement and integrate climate smart agriculture and low emissions land management technologies and practices. Despite being generally aware of existing technologies, smallholder farmers lack opportunities to improve their knowledge and technical capacities required to enhance on-farm adoption of CSA technologies. Extension services, which are the key knowledge dissemination channel for new agricultural practices in Mali, have limited reach and up-to-date knowledge of CSA technologies, leading to limited access to and low quality of education and information for smallholder farmers. (barriers 1 and 2 in the ToC)

Activities Conducted: Component 1 will focus on i) increasing the awareness of climate risks and ii) the understanding and technical capacity of smallholder farmers to adopt CSA techniques by firstly building the capacity of agro-advisory services, the key educational service for smallholder farmers, and secondly by supporting the on-farm adoption of CSA techniques. This will be achieved by:

- Activity 1.1.1, component 1 will enhance the pathways for CSA knowledge dissemination and awareness by first building the capacity of public and private extension services through the development of a new locally tailored CSA curriculum provided through a "train the trainers approach", and supporting the adoption of inclusive practices and use of digital tools to improve their capacity to target and reach more people, especially women and youth
- Activity 1.2.1, component 1 will also support the on-farm adoption of CSA techniques in crop and livestock rearing by leveraging public and private extension services, including farm schools and innovation platforms, to disseminate locally tailored training packages to smallholder farmers. Other local organizations such as Early Warning Groups will also be strengthened and extended to improve their operational capacity and ability to provide accurate and timely information to smallholder farmers.

Core Outputs Achieved: Component 1 will therefore deliver outputs 1.1 *"Improved technical capacities and inclusivity of extension services in climate-smart agriculture and agroforestry production* " and output 1.2 "*Increased use of climate resilient practices in the production of CSA crops, livestock and agroforestry by smallholder farmers".*

Component 2: Supporting the development of CSA and agroforestry value chains

Barriers Addressed: Limited knowledge and capacity coupled with restricted access to well-organized and sustainable value chains impede the ability of smallholder farmers to acquire high-quality inputs such as seeds, fertilizer, and labor, as well as productive assets like solar irrigation and biodigesters. These challenges arise from insufficient connectivity between value chain actors, including farmers, input providers, aggregators, and processing services, and the underdeveloped nature of agricultural markets. Additionally, smallholder farmers face difficulty in investing in these solutions due to limited availability and high prices, and inadequate access to financial support. The prevailing business models of private sector companies and financial institutions often fail to cater to the specific needs of farmers, particularly women and youth, thereby creating significant barriers to their empowerment. This includes limited access to finance and land, as well as exclusion from decision-making processes. Consequently, opportunities for revenue generation are constrained, and the necessary skills for effective agricultural business management remain out of reach. *(Primarily barriers 3 4, 5 and barrier 6 in the ToC)*

Activities Conducted: Component 2 aims to create sustainable markets for Climate Smart Agriculture and agroforestry products and ultimately more diverse and sustainable livelihoods for the target communities by fostering the development of connected value chains (from input stage, including financing and technologies, to product sales and distribution) and lifting the barriers disproportionately faced by women and youth entrepreneurs for starting and running businesses, including access to finance. This will be achieved by

- Activity 2.1.1, component 2 will enhance smallholder farmer's access to value chains for CSA and agroforestry solutions and outputs by (i) improving connectivity between smallholder farmers and relevant actors of the value chain (service providers, processors, etc.), leveraging digital marketplaces and innovation platforms, (ii) supporting private sector businesses, including solar irrigation and biodigester providers, to develop service and product offerings as well as business plans inclusive of women and youth, and (iii) enhance the capacity of producer groups to support their members and increase the attractivity of their products in the market
- Activity 2.2.1-2.2.2, component 2 will contribute to creating more opportunities for women and youth to engage in revenue-generating activities by (i) strengthening the operational and management capacity and reach of existing local financial institutions and replicating models in other villages to enhance financial inclusion of women and youth and improve their capacity to collectively save money and apply for loans, and (ii) improving the business capacities of women and youth through training and financial support

Core Outputs Achieved: Component 2 will therefore deliver outputs 2.1 "CSA and agroforestry VCs are more connected and reach more smallholder farmers" and 2.2 "Smallholder farmers, especially youth and women, can more easily overcome barriers to entrepreneurship in CSA and agribusiness"

Components 1 and 2: Reducing emissions from agricultural systems

Barriers addressed: Although low-carbon agriculture technologies (e.g., irrigation and biodigesters) and practices (e.g. agroforestry) exist in Mali, their adoption is still low among smallholder farmers, mainly due to the immaturity of markets as well as cultural and governance barriers. The market foundations for solar irrigation and biodigesters are still in the early stages of development, with a scarcity of capital posing a significant obstacle for smallholder farmers. Limited knowledge and access to installation, operations, and maintenance services further impedes their interest in these technologies. Similarly, agroforestry faces additional hurdles related to land ownership uncertainties and cultural norms associating tree planting with land ownership. Despite efforts to increase access to

land ownership, patchy implementation, and mixed interest at the local government level hinder widescale adoption of agroforestry. *(Primarily barrier 6, also barrier 7 in the ToC)*

Activities Conducted: Component 1 and 2 will work to enhance on-farm adoption of low-carbon CSA technologies and agroforestry to reduce the carbon emissions of the agricultural system whilst simultaneously supporting increased productivity in the regions targeted by the project. This will encompass distributing solar irrigation and biodigester systems, supporting the cultivation and plantation of tree saplings for agroforestry, as well as strengthening the associated value chains, infrastructure, and operational capacities. This will be achieved by:

- Activity 2.3, component 2 will install 1000 solar irrigation systems (50 large ones with 5 HP capacity and 50 small ones with 300W capacity pilots with 100% cost coverage, and 900 additional pumps with 10-15% initial installment cost support to the farmers) systems for smallholder crop farmers and 5,000 biogas systems for smallholder livestock farmers, whilst also supporting the development of both smallholder capacity to utilise this technology in a long-term sustainable manner and the supporting services, such as O&M, required to maintain its useful life. Both technologies deliver significant mitigation, adaptation, and productivity benefits. Solar irrigation pumps are focused on replacing the existing polluting diesel irrigation pumps present in Mali; biogas systems will deliver both a clean source of energy (creating time and financial savings, particularly for women farmers) and an additional income stream through the creation of manure/fertilizer as a byproduct.
- Activity 1.3.1-1.3.2, component 1 will enhance the development of agroforestry by supporting national and local authorities to map land types and uses and clearly select and classify agroforestry lands. This will allow the project to plant 91,285 ha of agroforestry in collaboration with nurseries and farmers, and support communities to manage samplings and growing trees. Moreover, Component 1 will enhance the capacity of public and private extension services to provide tailored advisory to smallholder farmers by establishing a land use map, which will also contribute to improving access to data at a national level for future policy design and research.

Core Outputs Achieved: Components 1 and 2 will therefore deliver outputs 2.1 “Increased adoption of low-carbon agriculture technologies by smallholder farmers” and 1.3 “Increased land area under agroforestry”

<u>Component 3: Increasing Institutional Capacity and Knowledge</u>

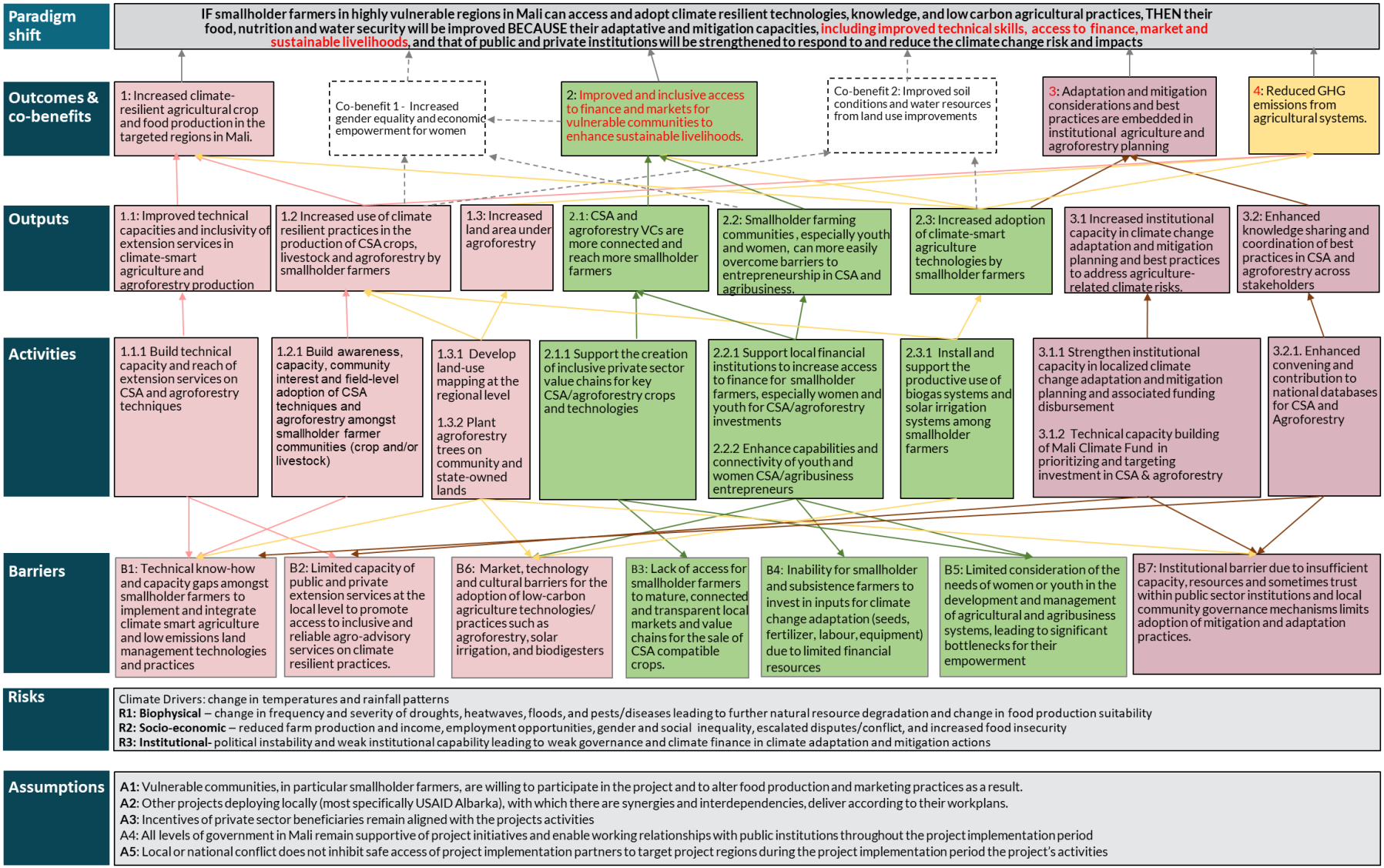
Barriers Addressed: The capacity of public sector institutions and community governance mechanisms to include adaptation and mitigation considerations is limited, resulting in uncoordinated efforts across levels. This hinders the implementation of low-carbon climate resilience programs and practices. Commune and community-level development plans, such as the PDESC, have the potential to boost adaptive capacity but challenges such as limited climate change knowledge, competing local priorities, and exclusion of women and youth, hinder the capacity to leverage them as effective planning tools for climate change adaptation and mitigation. Furthermore, budgetary limitations at the national level further impede effective planning and implementation of climate policies, creating disparities and excluding vulnerable communities. Coordination between the national and local levels is also a barrier to implementing CSA and agroforestry policies, with a disconnect between national policies and local conventions.

Activities Conducted: Component 3 will work to strengthen the institutional capacities of government entities at the local, regional, and national level, as well as communities through Community Action Cycles (CACs), improving their adaptation planning capacities and management systems and procedures. Component 3 for will also enhance stakeholder collaboration for knowledge-sharing for scaling out CSA, enhancing the impacts and reach of the Components 1-2. This will be achieved by:

- Activity 3.1.1-3.1.2, Component 3 will enhance institutional capacity and coordination at the local level by integrating climate change adaptation and mitigation planning into community action plans and the Economic, Social, and Cultural Development Plans (PDESC) for effective scaling-out of CSA and agroforestry. Component 4 will also support national climate funding institutions, such as the Mali Climate Fund, to improve their capacity for allocating, managing, and monitoring funds for climate-related projects in Mali, and foster stronger co-financing partnerships with development partners through streamlined funding disbursement processes.
- Activity 3.2.1, Component 3 will also contribute to strengthening knowledge-sharing and coordination among stakeholders by compiling and disseminating insights from the IAAT project to national and regional actors, actively participating in gatherings, conferences, and knowledge networks, and engaging traditional knowledge groups to ensure diverse perspectives and expertise are considered.

Core Outputs Achieved: Component 3 will therefore deliver outputs 3.1 “Increased institutional capacity in climate change adaptation and mitigation planning and best practices to address agriculture-related climate risks” and 3.2 “Enhanced knowledge sharing and coordination of best practices in CSA and agroforestry across stakeholders”. These four project components combine to deliver the impact pathways of the project, as illustrated below in ***Error! Not a valid bookmark self-reference.***. Further details on the activities and sub-activities that contribute to each component are provided below in *Table 16: Detailed Activity Packages for Components 1, 2, and 3*

Figure 29: Theory of Change Diagram



7.2 Detailed Activity Packages

Table 16: Detailed Activity Packages for Components 1, 2, and 3

Activities	Description	Sub-activities
Component 1: Improving Extension Services & increasing On-farm CSA Adoption		
Output 1.1: Improved technical capacities and inclusivity of extension services in climate-smart agriculture and agroforestry production		
Activity 1.1.1 Build technical capacity and reach of extension services on CSA and agroforestry techniques	This activity seeks to improve and expand extension services to support the transfer of climate-smart agriculture (CSA) and agroforestry knowledge and skills to smallholder farmers., The activity will develop a tailored curriculum of practices that address climate risks and deliver productivity, mitigation, and adaptation benefits and implement it through a "train the trainers" approach to refine public and private extension services. It will also involve local organizations and leverage digital platforms to increase the reach and inclusivity of training practices, ultimately enhancing the effectiveness and accessibility of extension services in promoting CSA and agroforestry among smallholder farmers.	1.1.1.1 Develop an updated curriculum for public and private extension services including Rural Resource Centers (CRRs), and Farmer Field Schools in project regions (Gao, Mopti, Koulikoro, Segou and Tombouctou) and tailor to the circle level via workshops
		1.1.1.2 Train extension agents on the new curriculum through a "train the trainer" approach
		1.1.1.3 Train extension services on inclusivity practices and expand utilization of existing resources, in particular digital tools and educational platforms
Output 1.2: Increased use of climate resilient practices in the production of CSA crops, livestock and agroforestry by smallholder farmers		
Activity 1.2.1 Build awareness, capacity, community interest and field-level adoption of CSA techniques and agroforestry amongst smallholder farmer communities (crop and/or livestock)	This activity focuses on the promotion and adoption of CSA and agroforestry practices among smallholder farmers by increasing their awareness, interest, and capacity through locally tailored training packages developed as part of 1.1.1. Several channels will be leveraged to increase the potential to reach more farmers through extension services (including farmer field schools, and Rural Resource Centers (CRRs)) as well as innovation platforms such as "Djoloko Nafama". This activity will also provide technical support to local community organizations, notably by (i) enhancing the capacity of Early Warning Groups to support the implementation and dissemination of national EWS and (ii) strengthening Community Action Cycles (CACs) established by Albarka and replicating the model in other regions. Adopting the CAC model will provide an opportunity to promote collective resource management, .	1.2.1.1 Deliver tailored local CSA and agroforestry training packages through extension agents and associated dissemination networks, including field schools, and Rural Resource Centers (CRRs), and cooperative leaders trained by Albarka
		1.2.1.2 Strengthen operational capacities of key local organizations (such as GAP-RUs (Early Warning Group/Emergency Response) to support the implementation and dissemination of the national Early Warning Systems - Albarka
		1.2.1.3 Strengthen the 250 Community Action Cycles (CACs) established by Albarka to ensure their sustainability beyond project implementation and enhance their capacity to manage community assets for CSA technologies - Albarka
		1.2.1.4 Extend the Albarka CAC model in other communes in Gao, Mopti, and Tombouctou, and replicate in Segou and Koulikoro
Output 1.3: Increased land area under agroforestry		
Activity 1.3.1 Develop land-use mapping at the regional level	This activity aims to facilitate the adoption and effective utilization of regional-level land use mapping to support the development of agroforestry and inform the	1.3.1.1 Create land-use maps at the regional level to identify best suited areas for agroforestry production to improve land-use planning of communes in 3.1.1.1, and

	implementation of locally relevant (CSA) and agroforestry practices. By assisting regional authorities in mapping and classifying land types and uses in the target regions, it seeks to enhance their understanding of land resource distribution, enabling improved land-use planning and decision-making at the commune level. Additionally, a land-use database will be developed to enhance the knowledge of extension services regarding land characteristics, allowing them to provide tailored advisory services to farmers on suitable crops and techniques for enhanced productivity. This land-use database will also be shared with national authorities to promote wider access to agriculture and agroforestry data in Mali	support the selection of areas for activity 2.3.1 (biodigesters and solar irrigation systems) 1.3.1.2 Establish a project land use database to i) improve the quality of information provided to farmers by public and private extension services regarding the most adapted crops and techniques to increase productivity and ii) enhance access to data in line with 4.2.1.2
Activity 1.3.2 Plant agroforestry trees on community and state-owned lands	This activity seeks to promote enhanced adoption of agroforestry by supporting the on-farm planting of 91,285 Ha of agroforestry, specifically relating to acacia senegal, moringa, mango and fodder trees. The capacities of several stakeholders will be leveraged to ensure the successful implementation of this activity (e.g., nurseries for production and distribution of inputs, farmers for planting, and communities for the management of trees and shared resources). The efficient management of these planted areas by communities will be critical to ensure sustainability after project implementation.	1.3.2.1 Support the production and distribution of agroforestry tree saplings (acacia Senegal, moringa, mango and fodder) in partnership with nurseries – Albarka 1.3.2.2 Plant 91,285 Ha of agroforestry (fodder, fruits, and wood trees) in collaboration with smallholder farmers – Albarka 1.3.2.3 Develop plans to manage samplings and growing trees in crop, grass/pasture, and community lands in partnership with CACs – Albarka
Component 2: Supporting the development of CSA and agroforestry value chains		
Output 2.1: CSA and agroforestry VCs are more connected and reach more smallholder farmers		
Activity 2.1.1 Support the creation of inclusive private sector value chains for key CSA/agroforestry crops and technologies	This activity will support the development of smallholder accessible value chains across CSA and agroforestry outputs by improving connectivity in the value chains and fostering access to markets for smallholder farmers. This will be achieved by leveraging digital marketplaces and existing innovation platforms, improving access to market information (e.g., prices) and fostering the development of a network of community-built service providers. Additionally, the activity seeks to enhance the capacity of businesses and producer organizations to reach a larger market through the development and adoption of inclusive business models, capturing the needs of smallholder farmers, women, and youth. The activity will mainly target businesses that deliver added productivity and climate mitigation/adaptation benefits, and are willing to invest in reaching smallholders, offering job opportunities for women and youth, and/or are connected to the mitigation	2.1.1.1 Increase linkages in CSA value chains by connecting service providers (including community-built service providers embedded in cooperatives) and processors with producer groups and cooperatives using digital marketplaces and existing innovation platforms - Albarka 2.1.1.2 Deliver technical assistance to private sector businesses that are involved in CSA and agroforestry value chains, to enhance ability to develop youth and gender inclusive service/product offering and business plans 2.1.1.3 Develop technical guidance for private sector technology companies working in solar irrigation and biodigester systems on inclusive business growth 2.1.1.4 Implement trainings to producer associations to support them to deliver aggregation and value addition services to their members, for example cleaning, grading,

	and adaptation technologies prioritized in component 2 (solar irrigation, biodigester systems)	and quality control, to support access to broader markets for crops
Output 2.2:-Smallholder farming communities, especially youth and women, can more easily overcome barriers to entrepreneurship in CSA and agribusiness.		
Activity 2.2.1 Support local financial institutions to increase access to finance for smallholder farmers, especially women and youth, for CSA/agroforestry investments	This activity will increase access to finance for women and youth smallholder farmers and/or agribusiness entrepreneurs by working directly with financial institutions. This will be achieved by enhancing the contribution of women and youth in savings groups, especially VSLAs, which will provide opportunities to receive micro-loans to invest in revenue generative activities. The activity will develop and strengthen VSLAs in the five target regions and enhance their capacity to make informed investments, especially in CSA techniques. VSLA facilitators will be established and trained to extend support and ensure sustainability beyond implementation. Furthermore, existing microfinance organizations active in CSA and agroforestry will be targeted to increase their reach by delivering investment guidelines that are inclusive of women and youth entrepreneurs and supporting the expansion of risk adjusted lending (e.g., through crop and weather insurance and land-use mapping).	2.2.1.1 Support the sustainability and capability of Albarka established VSLAs by training VSLA facilitators and members on best management practices and income opportunities - Albarka 2.2.1.2 Extend and replicate the Albarka VSLA model (particularly in Segou and Koulikoro which are not addressed by Albarka), with a particular emphasis on youth such as youth associations to increase participation of youth in savings initiatives 2.2.1.3 Support extension of microfinance reach by developing investment guidelines that are inclusive of women and youth entrepreneurs and smallholder farmers
Activity 2.2.2 Enhance capabilities and connectivity of youth and women CSA/agribusiness entrepreneurs	This activity will build the capacity and connectivity of women and youth smallholder farmers and/or agribusiness entrepreneurs to improve their capacity to efficiently manage their business and enhance their capacity to access finance and contribute to a sustainable supply chain. The activity will deliver core business skills training and connect beneficiaries to local financial institutions in 2.2.1, funding programs from complementary projects (PRAPS II) and other value chain actors supported in 2.1.1.	2.2.2.1 Strengthen the business capacity of youth entrepreneurs - Albarka 2.2.2.2 Strengthen the business capacity of women entrepreneurs, including woman-led processing units 2.2.2.3 Connect youth and women entrepreneurs with the local financial institutions and private sector businesses supported in 2.2.1, and other programs in the region offering financing opportunities, in order to increase access to finance, productions services and distribution networks.
Output 2.3: *Increased adoption of low-carbon agriculture technologies by smallholder farmers*		
Activity 2.3.1 Install and support the productive use of biodigester systems and solar irrigation systems amongst smallholder farmers	This activity will increase the productivity and revenue of smallholder farmers whilst reducing GHG emissions of farms by supporting the adoption of mitigation and adaptation technology and their associated markets in Mali. The activity will install 1000 solar irrigation systems (50 large ones with 5 HP capacity and 50 small ones with 300W capacity pilots with 100% cost cover and 900 additional scaling with 10-15% initial installment cost support to the farmers) to replace existing diesel	2.3.1.1 Install 1000 solar irrigation systems from the providers supported in Component 2 to smallholder farmers that are currently using diesel pumps for irrigation 2.3.1.2 Install 5000 biodigester and improved stoves systems from the providers supported in component 2 to smallholder livestock farmers 2.3.1.3 Deliver targeted training for those receiving new technologies in 2.3.1.1 and 2.3.1.2 on the use of

	generator irrigation pumps and 5000 biodigester systems and improve stoves for livestock farmers to provide an additional income source (slurry, manure, or fertilizer) and an alternative source of energy. IAAT will scale solar irrigation (a combination of small, medium and large size solar irrigation systems) and biodigester systems by using a Pay-As-You-Go (PAYG) approach in collaboration with private sector technology suppliers (e.g., ECOTECH, EnDev, EKOenergy, and Bboxx (previously called PEG Africa)). In this model, technology suppliers cover initial investment, and customers pay for electricity and biogas supply on an instalment basis.[401, 402] IAAT will cover 100% of the costs for installing the 100 solar irrigation systems and 10-15% initial installation cost support for 900 solar irrigation systems. It will also cover the initial start-up cost of the biodigester systems for beneficiaries (10-15% depending on farmers' income status) and technical backstopping. The activity will ensure that the full potential of these technologies is harnessed by (i) developing the understanding and knowledge of farmers, and (ii) fostering the creation of sustainable value chains. To enhance the development of supply, the project will organize existing operators into Economic Interest Groups. This will allow them to collaborate and pool their resources to provide a tailored and high-quality services to smallholder farmers	biodigester and solar irrigation systems via local farm schools and extension agents supported in component 1
		2.3.1.4 Generate technical guidance and deliver commune-level workshops on the installation of and O&M for the long-term productive use of equipment for local tradespeople and construction companies, building on the experience of the MERIT Biodigester project
Component 3: Increasing Institutional Capacity and Knowledge		
Output 3.1: Increased institutional capacity in climate change adaptation and mitigation planning and best practices to address agriculture-related climate risks		
Activity 3.1.1 Strengthen institutional capacity in localized climate change adaptation and mitigation planning	This activity will strengthen institutional capacity for scaling out CSA by enhancing climate change adaptation and mitigation planning at the local level, leveraging community action plans and the Economic, Social, and Cultural Development Plans (PDESC) as the main entry points for improved adaptation planning. At the commune level, the activity will provide tools to local community groups for an effective and timely review of community action plans to foster efficient management of local	3.1.1.1 Organize regional workshops with stakeholders who participate in the development of the PDESC at the commune level to improve their understanding of CSA and adaptation planning
		3.1.1.2 Support new and existing Community Action Groups in the five regions to periodically review and update community action plans for the management of local resources and adaption planning - Albarka

[401] AICCRA. 2023. Pay-as-you-go model. Available here.
[402] USAID. 2017. Pay-as-you-go solar as a driver of financial inclusion. Available here.

	resources and inclusion of adaptation planning. The activity will also seek to bridge the knowledge gap preventing communal councils and other local stakeholders to efficiently coordinating initiatives at the local level, by embedding adaptation and mitigation planning into the Economic, Social, and Cultural Development Plans (PDESC)	
Activity 3.1.2 Technical capacity building of national climate funding institutions for disbursements management	This activity seeks to streamline the funding disbursement processes of national climate funding institutions. The National Climate Fund and other climate funding institutions will be supported to improve their capacity to allocate funds to climate-related projects in Mali and efficiently manage and monitor these funds post-allocation. The activity will also aim to improve the contribution of the public sector in co-financing schemes with development partners through the refinement of funding disbursement processes.	3.1.2.1 Enhance the capacity of national climate funding institutions such as the National Climate Fund on disbursement and impact assessment through the development of technical guidance
Output 3.2: Enhanced knowledge sharing and coordination of best practices in CSA and agroforestry across stakeholders		
Activity 3.2.1 Enhanced convening and contribution to national databases for CSA and Agroforestry	This activity aims to enhance knowledge-sharing and coordination of best practices among relevant stakeholders. The activity will compile the insights gained from the IAAT project and disseminate them to national and regional stakeholders, extending the reach of valuable knowledge and lessons learned. This will involve active participation in regional and local gatherings, conferences, and knowledge networks, while also organizing new events as needed. A special emphasis will be placed on involving traditional knowledge groups to ensure a diverse range of perspectives and expertise are included in the knowledge-sharing process.	3onferences and organize regional stakeholder convenings to share lessons on project implementation, and insights as they emerge for overall collaborative learning
		3.2.1.2 Join existing knowledge sharing and academic networks and contribute to existing databases (e.g., with land use data) to allow project data and findings to be leveraged in academic research
		3.2.1.3 – Organize annual knowledge sharing event to report best-practices on CSA learnt from project

7.3 Technologies and Techniques Options Assessment

7.3.1 Selection of CSA techniques

22 Climate Smart Agriculture techniques and technologies have been selected to be included in the CSA packages for this project because they deliver high CSA impacts for the relevant climatic and livelihood context in the Malian regions in which IAAT will be implemented.

The CSA techniques were selected using two main inputs: i) existing research on the adaptation, mitigation and productivity impact of CSA techniques and their suitability for the selected regions in Mali, and ii) consultations with project stakeholders. CSA packages and practices have been identified separately for sedentary crop farmers and sedentary livestock farmers on the understanding that both livelihoods are critical for Mali's food security and are highly vulnerable to climate change but require different techniques for CSA (see section above, ***"Error! Reference source not found."***). In addition, CSA practices related to agroforestry have been identified separately because they have an overlapping benefit across livestock and crop farming and are a core part of component 1.

Options Analysis Part 1

Two research studies provide the primary inputs for part 1 of the options analysis of CSA technologies and techniques: Andrieu et al, 'Prioritizing Investments for Climate-Smart Agriculture: Lessons Learned from Mali'[403] and CIAT, ICRISAT, BFS/USAID "Climate-Smart Agriculture in Mali".[404]

By including the two most relevant studies in the options analysis, the analysis starts by including a broad range of practices already present or relevant to Mali (27 separate CSA techniques). The long list of options is then refined based on i) their impact on climate-smart agriculture (productivity, mitigation, and adaptation) and ii) their suitability to the specific regions of the project. This approach selected 17 unique techniques for inclusion in the project.

Detailed methodology

Both studies follow a similar approach: both assess a broad number of CSA practices present or relevant to Mali against the core pillars of climate-smart agriculture (productivity, mitigation, and adaptation) to determine an overall "climate-smart" score (see Table 17: Scoring Criteria for "Climate Smartness"). They also both determined the suitability of each technique by climatic region/zone in Mali. Both studies undertook a scoring scale from -10 to +10, with each technique able to have a negative/ positive/ zero impact on a selected CSA indicator, with 10 (+/-) indicating a 100% change (positive/ negative), and 0 indicating no change. Regarding inputs to the analysis, Andrieu et al first scored each technology/technique using expert input. These scores were then validated and assessed for geographic relevance within Mali through participatory workshops with relevant actors at national, sub-national, and community levels, as necessary, to validate the selection of CSA practices, indicators, and analyses conducted by the experts during the previous phase. To undertake their analysis, CIAT, ICRISAT, BFS/USAID scored each technology using inputs from a wide range of stakeholders and CSA experts.

To select the CSA techniques most pertinent for this project, the long list of CSA techniques covered by these analyses were first separated into 3 categories: livestock, crop and agroforestry. Within each of these areas, CSA techniques were initially selected for this project on the basis that they scored above +4 or above out of -/+10 on the CSA score (the top quintile of possible scores) and were identified by the studies as relevant to the Sudanian or Sahelian zone in which this project will primarily be active. See *Table 18: Prioritized CSA Practices for Crop Farmers, by geographic relevance and CSA score* for the results of this analysis.

[403] Adrieu N. et al., (2017), Prioritizing investments for climate-smart agriculture: Lessons learned from Mali, Available here
[404] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here

This results in 5 agroforestry techniques, 5 livestock techniques and 11 crop techniques. Note that as some techniques are applicable to multiple categories this results in 17 unique techniques.

Table 17: Scoring Criteria for "Climate Smartness"

CSA pillar	Selected indicators - Andrieu et al, 'Prioritizing Investments for Climate-Smart Agriculture: Lessons Learned from Mali'	Selected indicators - CIAT, ICRISAT, BFS/USAID. 'Climate-Smart Agriculture in Mali. CSA Country Profiles for Africa Series'
Productivity	Yield Variability Labor Income	Yield
Adaptation	Food access Efficient use of water Efficient use of fertilizer Efficient use of other agrochemicals Use of non-renewable energy Gendered impact (labor by women)	Income Water Soil impact Risk
Mitigation	Emission intensity	Energy Carbon Nutrients

Table 18: Prioritized CSA Practices for Crop Farmers, by geographic relevance and CSA score

CSA Technique	Selected for GCF IAAT	Description of the technique	Relevant to the Sahelian or Soudanian Zone	Relevant to Sahelian Zone	Relevant to Soudanian Zone	CSA score of >/= 4 (either scoring approach)	CSA Score	
							(Andrieu et al, "Prioritizing investments for climate-smart agriculture: Lessons learned from Mali")	(CIAT/ICRISAT CSA Profile, Mali)
Contour bunding	selected	A form of micro-catchment technique, a simple and cheap form of water control. The bunds are created along the contour lines. There are also small earth ties, perpendicular to the bunds, that subdivide the system into micro-catchments.	TRUE	1	1	TRUE	4.6	8.3
Cultural sowing technics	selected	Enhance rational use of soil water by deploying specific sowing techniques	TRUE	1	1	TRUE	n/a	5.4
Improved varieties adapted to different agro-climatic conditions	selected	Use of seeds that are specifically adapted to offer higher and more stable yields and deliver greater tolerance to stressors (e.g. flood, pests)	TRUE	1	1	TRUE	4.7	7.8
Production and use of on-farm compost	selected	Farm effluent and manure along with left over materials such as wasted feed, wood chips, rice hulls, are used to produce a compost and be recycled back on the farm.	TRUE	1	1	TRUE	4.5	5.9
“Rational” management of land (management of flooded and dewatered areas)	selected	Management of flooded and dewatered areas	TRUE	0	1	TRUE	6.5	n/a
Development of inland valley for rice cultivation	selected	Creation of simple, low-cost water management structures (weirs, dykes, canals, drains and basins/ plots) for growing rice in inland valleys	TRUE	0	1	TRUE	6.3	n/a
Half-moon technique	selected	A water harvesting intervention that consists of half-moon shaped basins dug in earth.	TRUE	1	1	TRUE	5	n/a
System of rice intensification (SRI)	selected	Rice cultivation practice that includes the early establishment of healthy	TRUE	1	0	TRUE	5	n/a

CSA Technique	Selected for GCF IAAT	Description of the technique	Relevant to the Sahelian or Soudanian Zone	Relevant to Sahelian Zone	Relevant to Soudanian Zone	CSA score of >/= 4 (either scoring approach)	CSA Score	
							(Andrieu et al, "Prioritizing investments for climate-smart agriculture: Lessons learned from Mali")	(CIAT/ICRISAT CSA Profile, Mali)
		plants; low plant density; soil enrichment; and the sparing application of water. Provides mitigation and adaptation benefits.						
Zaï pit technique	selected	Small basins in which seed of annual or perennial crops are planted. They are beneficial for soil conditions because they increase termite activity which leads to a higher water infiltration when it rains.	TRUE	1	1	TRUE	6	5.9
Crop diversification	selected	Reduce risk to crops from threats (e.g. pests, climate events), increases productive and improve water use efficienct	TRUE	1	1	TRUE	n/a	4.5
Integrated pest and diseases management	Selected	Use a combination of techniques such as biological control, habitat manipulation, modification of cultural practices and use of resistant varieties	TRUE	1	1	TRUE	n/a	n/a
Fertilization of fields by animal corralling	selected	Penning livestock into a field so that their waste fertilizes the field	TRUE	1	1	TRUE	4.3	n/a
Aflatoxin management	not selected	Reduction of the contamination of crops by aflatoxin mould	TRUE	1	1	FALSE	n/a	3
Contour stone bunds	not selected	Stones grouped in the shape of a line and placed along contours. The stones can be of different sizes. The goal of these lines is to conserve the soil and reduce runoff, as they are used to slow down water runoff and break its velocity.	TRUE	1	1	FALSE	3	n/a
Direct and early sowing of millet and sorghum	not selected	Early and direct sowing of millet and sorghum to increase productivity	TRUE	0	1	FALSE	3.2	n/a

CSA Technique	Selected for GCF IAAT	Description of the technique	Relevant to the Sahelian or Soudanian Zone	Relevant to Sahelian Zone	Relevant to Soudanian Zone	CSA score of >/= 4 (either scoring approach)	CSA Score	
							(Andrieu et al, "Prioritizing investments for climate-smart agriculture: Lessons learned from Mali")	(CIAT/ICRISAT CSA Profile, Mali)
Drip irrigation	not selected	Dripping water onto the soil at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wetted and provides a very favourable high moisture level in the soil in which plants can flourish.	FALSE	0	0	TRUE	6.1	n/a
Industrial bio-fertilizer	not selected	Biofertilizers comprise of living or latent cells, which are applied either to soil, seed or seedlings for improving nutrients availability and uptake from soil (alternative to chemical fertilizers)	FALSE	0	0	TRUE	5	n/a
Intercropping(sorghum/cowpea)	not selected	Planting of sorghum and cowpea in the same field within one season to reduce risk and increase land efficiency	TRUE	1	1	FALSE	3.7	n/a
Land charters for community management of natural resources	not selected	Formal communal ownership of shared natural resources	FALSE	0	0	TRUE	5.7	n/a
Short cycle varieties	not selected	Crop varieties that have a short-growth periods	TRUE	1	1	FALSE	n/a	3.8
Soaking of seeds to reduce dormancy	not selected	Soaking seeds in lukewarm water for 8-24 hours to help the seed to break dormancy and germinate faster.	FALSE	0	0	FALSE	2.2	n/a

Table 19: Prioritized CSA Practices for Livestock Farmers, by geographic relevance and CSA score

CSA Technique	Selected for GCF IAAT	Description of the technique	Relevant to the Sahelian or Soudanian Zone	Relevant to Sahelian Zone	Relevant to Soudanian Zone	CSA score of >/= 4 (either scoring approach)	CSA Score	
							(Andrieu et al, "Prioritizing investments for climate-smart agriculture: Lessons learned from Mali")	(CIAT/ICRISAT CSA Profile, Mali)
Production and use of on-farm compost	selected	Farm effluent and manure along with left over materials such as wasted feed, wood chips, rice hulls, are used to produce a compost and be recycled back on the farm.	TRUE	1	1	TRUE	4.5	5.9
Fertilization of fields by animal corralling	selected	Penning livestock into a field so that their waste fertilizes the field	TRUE	1	1	TRUE	4.3	n/a
Fodder crops	selected	Planting of crops that serve as food for livestock	TRUE	1	1	TRUE	n/a	4.9
Feed supplements	selected	Feed supplements are phosphate, calcium and trace mineral mixtures that can be given to grazing animals to supplement grazing when it is deficient in minerals and trace minerals.	TRUE	1	1	TRUE	n/a	5.7
Dual purpose crops (Food and fodder)	selected	Planting of crops that serve as food for livestock and people	TRUE	1	1	TRUE	n/a	4.3
Cattle fattening	not selected	Reduce animal activities thereby fattening cattle more quickly	TRUE	1	1	FALSE	2.3	n/a

Table 20: Prioritized CSA Practices in Agroforestry, by geographic relevance and CSA score

CSA Technique	Selected for GCF IAAT	Description of the technique	Relevant to the Sahelian or Soudanian Zone	Relevant to Sahelian Zone	Relevant to Soudanian Zone	CSA score of >/= 4 (either scoring approach)	CSA Score	
							(Andrieu et al, "Prioritizing investments for climate-smart agriculture: Lessons learned from Mali")	(CIAT/ICRISAT CSA Profile, Mali)
Assisted natural regeneration of trees	selected	Increase the number of trees by protecting and pruning living tree stumps, and by creating the environmental conditions for tree seeds to sprout	TRUE	1	1	TRUE	4.6	n/a
Fodder crops	selected	Planting of crops that serve as food for livestock	TRUE	1	1	TRUE	n/a	4.9
Dual purpose crops (Food and fodder)	selected	Planting of crops that serve as food for livestock and people	TRUE	1	1	TRUE	n/a	4.3
Hedgerows	selected	Planting of wild shrubs and occasional trees, typically bordering a road or field.	TRUE	1	0	TRUE	4.2	n/a
Tree nursery and transplanting	selected	An area where trees are grown for use as stocks for budding and grafting. At the appropriate maturity trees are then transplanted to the destination location.	TRUE	1	0	TRUE	4.1	n/a

Options Analysis Part 2: Additional Priority CSA techniques and technologies

Further literature review and stakeholder consultations were also conducted with community beneficiaries, academic researchers, private sector actors and government departments to determine stakeholder attitude towards the prioritised CSA techniques.

Based on this additional research, the 4 techniques and technologies outlined in *Table 21: Additional CSA Techniques* were additionally selected to add to the overall CSA portfolio.

Table 21: Additional CSA Techniques Prioritised

Technique / Technology/ Practice	Description	Farming Type		Core CSA impact areas		
		Crop	Livestock	Productivity	Adaptation	Mitigation
Biodigester Systems	A system for that uses anaerobic digestion to convert organic matter into gas (for fuel) and create additional valuable outputs (e.g. slurry, manure and fertilizer). The organic matter is inserted into a sealed digester and, in the absence of oxygen, anaerobic bacteria consume the organic matter to multiply and produce biogas and other bi-products.		✓	✓	✓	✓
Solar Pumps for Enhanced Irrigation	Solar panels provide a clean energy source to power pumps; this forms part of an irrigation system for crops	✓		✓	✓	✓
CIEWS	Climate information and early warning systems share information on climate hazards and observed trends in climate, supporting smallholder farmers as well as public officials to anticipate and prepare for climate risks.	✓	✓	✓	✓	
Crop insurance	Crop insurance provides a risk mitigation mechanism for farmers by insuring crops against risks such as flooding or pests.	✓	✓	✓	✓	

Solar Pumps

Selection Rationale

Enhanced crop irrigation has been identified by the Government of Mail as a key priority for increasing the adaptive capacity of Mali. As outlined in *section*

Climate Change Adaptation Gaps in Agriculture and Agroforestry , Mali's potential for irrigation is underexploited. Further, techniques for water management and irrigation are prioritised by existing research on CSA adoption and in part 1 of the options analysis (see *Table 18: Prioritized CSA Practices for Crop Farmers, by geographic relevance and CSA score).* Irrigation pumps can support more efficient, less labour-intensive, and further reaching irrigation than the more manual means of water management (such as Zai pits and contour bunding).

Irrigation pumps are particularly crucial for crop farmers compared to livestock farmers because crop farmers have limited options for accessing alternative water sources. Unlike livestock farming, which may have more flexibility in finding water for animals, crop farmers heavily rely on rainfall to nourish their crops. As a result, irrigation pumps play a vital role in ensuring a consistent water supply for crop irrigation, offering a reliable solution to mitigate the impact of climate events, including unpredictable or insufficient rainfall, thus supporting crop farmers in sustaining their agricultural activities.

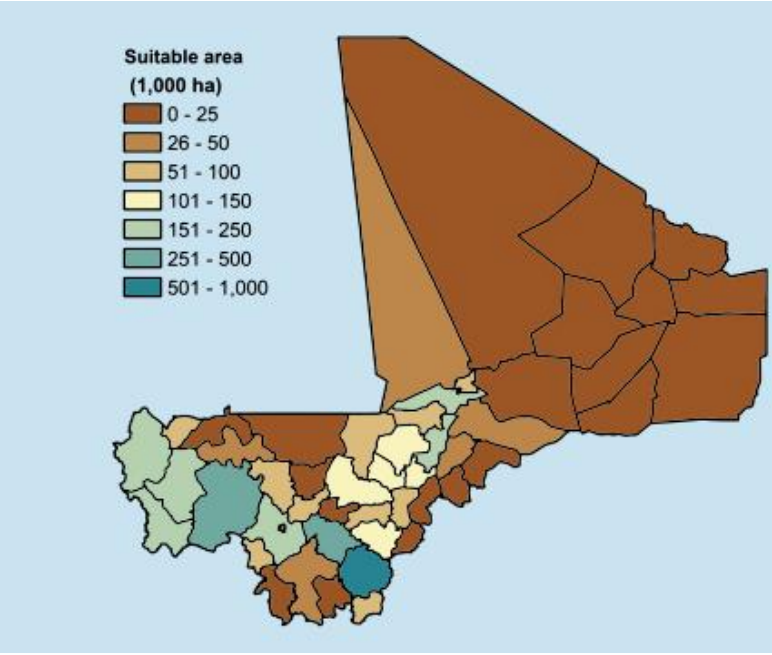
In many locations, small-scale diesel fuel-based pumps are irrigating 30-50 hectares of croplands. The villagers usually grouped in an association are entirely responsible for the installation and maintenance of the pump. These smaller pump systems have been extraordinarily successful, both in the persistence of established schemes and in their spread to new areas. However, whilst diesel fuel

based systems increase the adaptive capacity of smallholder farmers, they also increase the GHG emissions of the farms. Solar PV pump irrigation provides an alternative fuel source that reduces the GHG emissions of the farm, delivering a mitigation benefit. (see section ***Error! Reference source not found.*** above for more information).

As the price of solar photovoltaic panels is decreasing rapidly, solar water pumps are potentially able to become an affordable, climate-smart solution for small-scale farmers across Mali. However, barriers to solar irrigation pumps remain such as high upfront cost, low equipment availability, and limited O&M services driving low existing adoption. Despite this, many households in Mali have small panels of 50-100 watts to generate electricity for lighting their homes, powering a TV, and charging mobile phones. While these panels are not big enough to attach a pump to, their widespread use indicates that there is existing awareness of the benefits of solar power, providing a foundation for increasing the uptake of solar pumps.[405]

The promotion of solar water pumps also encourages the private sector to develop and extend their markets. The Feed the Future Innovation Lab for Small-Scale Irrigation (ILSSI) project and the CGIAR Research Program on Water, Land, and Ecosystems (WLE) carried out suitability mapping to identify areas in Mali where there is a high potential for scaling solar water pumps for developing irrigation[406]. For this project, the regions of Mopti, Koulikoro, and Segou are all compatible with solar irrigation pumps due to the levels of surface and groundwater. Importantly, Tombouctou and Gao are not considered initially relevant for solar irrigation as they do not have sufficient and easily accessible groundwater (see *Figure 30: Map of Mali showing surface water, small reservoirs and groundwater ≤ 25 m, (favorable water access for solar irrigation)*).

Figure 30: Map of Mali showing surface water, small reservoirs and groundwater ≤ 25 m,[407] (favorable water access for solar irrigation)



Equipment Specifications:

Based on consultations with solar pump providers, academic researchers and literature the following specifications are preliminarily identified as the most appropriate for this project:

[405] IWMI, (2022), New Market Research Captures the Potential of Mali's Solar-Powered Irrigation Sector, Available here
[406] IWMI, (2019), Suitability for farmer-led solar irrigation development in Mali, Available here
[407] IWMI, (2019), Suitability for farmer-led solar irrigation development in Mali, Available here

Table 22: Estimated Solar Irrigation Pump Specifications

Pump Size	Land area irrigated, HA	Price
5 HP	10	USD $18796 (solar pump system)
		USD $496 (installation cost)
0.4 HP (300 W)	1	USD $1,100 (solar pump system and installation cost)

Table 23: Estimated Solar Irrigation Pump Solar Energy and Lift Capacity Requirements by Region

Location	Energy Requirements	Lift Capacity
Mopti	0.5 kWh m−2	7m
Koulikoro	0.5 kWh m−2	7m
Segou	0.5 kWh m−2 or 1 kWh m−2	7m or 25m, depending on location

Biodigester Systems

Selection Rationale

As outlined in the *5.3.2 Emissions projections and mitigation* **potential** section above, Biodigester systems provide both an adaptation and mitigation benefit to smallholder households by providing a reduced emissions source of fuel, increased productivity by saving time required to collect firewood, and provide an alternative source of income (bi-products of biogas include valuable manure and fertilizer).

Firewood and charcoal account for about 78% of energy use in Mali's households. The country's environment ministry states felling of trees for fuel, building materials, and other purposes account for the loss of approximately 100,000 hectares of forest each year. Rural households also use charcoal and energy from non-renewable fuels, such as kerosene and LPG. The energy produced by biogas can be used to displace energy from other firewood, charcoal, and other non-renewable sources. In addition, by collecting the animal waste and using it as an input in the biodigester, there are additional mitigation benefits from reducing emissions from "manure left on pasture", the 2nd largest source of emissions in agriculture (see section *5.3.1 Current emissions levels in Mali and the breakdown by* **sector** for more information). Therefore, when properly utilized and assuming no increase in household energy consumption, the adoption of biogas can reduce the emission of methane from manure management, reduce CO2 emissions from the combustion of fuel wood and charcoal, and GHG emissions from the combustion of other non-renewable fuels.

In addition, for smallholder farmers, the byproducts of biogas systems and fertilizer are considered to be as, if not more, valuable. 100kg of cow dung generates approximately 100kg of fertilizer through a biodigester system.[408] This fertilizer provides a productivity enhancing input for crop farming and reduces the barriers associated with limited supply and access of fertilizer to for smallholder farmers. It also provides an additional income stream with farmers able to sell any fertilizer they do not use on their own farms. Biodigesters provide significant value addition specifically for livestock farmers. Technology is highly relevant in livestock farming operations, offering effective solutions to manage

[408] Interview with Daouda Diallo and Oumar Thiocary, IFAD's MERIT project, Mali (May 2023)

the substantial amounts of organic waste produced. For more information, please see *5.3.2 Emissions projections and mitigation* **potential** section above.

In line with the ambitions of existing projects in the region (such as MERIT), this project will seek to support the installation of 5000 biodigester systems over the course of the project.

Equipment Specifications[409] [410]

Table 24: Size, suitability and price of biodigeser

Size & Type	*Suitability & Inputs needed*	*Lifespan*	*Bi-products*	*Price*
$4m^3$-fixed dome	11-15 cows	25 years	Fertilizer *(valued at an estimated 380k CFA / month)*	USD 650
$2m^3$-fixed dome	2-4 cows (or 20-30kg dung) plus similar quantities of water	25 years	Fertilizer	

Scaling Approach

Most smallholder farmers in Mali depend on rain-fed agriculture for food and income. Using irrigation to supplement rainfall during dry season could help farmers against weather-related shocks and boosts their yield and income. The falling price of solar systems in recent years has seen solar-powered pumps emerge as a climate-smart irrigation technology in Mali with low access to the national grid. In Mali, despite developing institutional and programmatic commitments, the government's ambitious plan to advance its irrigation capacity in the past decade was hampered by the worsening socio-economic, political crises and Covid-19 pandemic.

Recently, private sector solar technology suppliers have increasingly focused on expanding solar-based irrigation systems in Mali. The market for solar-powered irrigation pumps in Mali is gradually growing and expanding, with solar panels and pumps being imported from all over the world. For solar pumps, Grundfos (Denmark) and Lorentz (Germany) dominate the high-quality end of the market, while various Chinese brands dominate other market segments. Grundfos and Lorentz pumps cost ~1 million CFA ($1,745) but can last for a decade or more while Chinese pumps are cheaper but have to be replaced after a couple of years.[411] While local manufacturing of solar pumps is not yet established in the country, local technicians have begun assembling pumps using second-hand spare parts from imported pumps, e.g., some technicians combine the lift mechanism of a Grundfos or Lorentz pump with the motor of a Chinese pump as the lift mechanisms of Grundfos/Lorentz pumps are much more durable than their Chinese Counterparts'.[412] For solar panels, local manufacturing has been established in Mali. Locally produced panels cost ~90,000 CFA ($155), but their high price has led to the emergence of a thriving and important second-hand solar panel market.[413] Second-hand panels are mainly made in Germany and imported to Mali after being used for several years in neighbouring countries (like Morocco), and on average, a second-hand 250-watt panel costs between 40,000 and 50,000 CFA ($70-85) - almost half the price of a new locally produced panel.[414]

Despite this momentum from the private sector, the solar irrigation market is facing challenges, including a demand-supply mismatch, that prevents realizing its potential.[415] For smallholder farmers (demand), one central challenge is the high initial cost of investing in solar pumps and the limited access to affordable credit.[416] In similar markets (e.g., Ghana), the lack of domestic production of solar pumps has significantly added to the cost of purchasing a solar irrigation system (as importation costs

[409] *IBID*
[410] Felix ter Heegde, (2019), Technical potential for household biodigesters in Africa, Available here,
[411] IWMI, (2022), New Market Research Captures the Potential of Mali's Solar-Powered Irrigation Sector, Available here
[412] IWMI, (2022), New Market Research Captures the Potential of Mali's Solar-Powered Irrigation Sector, Available here
[413] IWMI, (2022), New Market Research Captures the Potential of Mali's Solar-Powered Irrigation Sector, Available here
[414] IWMI, (2022), New Market Research Captures the Potential of Mali's Solar-Powered Irrigation Sector, Available here
[415] Agrilinks, (2022), Closing the demand-supply gap in Mali's solar-powered irrigation value chains, Available here
[416] Agrilinks, (2022), Closing the demand-supply gap in Mali's solar-powered irrigation value chains, Available here

need to be factored in) and further exacerbates affordability challenges for smallholder farmers.[417] The manager of EMICOM solar technology supplier mentioned that *"even if farmers are aware that solar technology exists for irrigation pumping, few of them can afford the up-front investment".* For solar pump suppliers (supply), many have an incomplete picture of who their customers are and how to reach them.[418] They also have limited ability to provide maintenance services and rely on local technicians who are a crucial link between pump suppliers and farmers.[419] Local technicians (enablers) identify customers, advise farmers on where and what to buy, and provide maintenance services, but some of the advice given is intended to maximize the technicians' profit and does not necessarily provide farmers with the most suitable irrigation equipment.[420] In general, smallholder farmers in Sub-Saharan Africa are highly price-sensitive and suppliers face a trade-off between supplying a customized durable pump at a higher cost or developing a generic modest-quality, and affordable pump that may require more maintenance and operational expenditures over time.[421]

To combat some of the challenges faced by the solar irrigation market, some organizations, such as the International Water Management Institute (IWMI), have tested an approach to establish strong market linkages in neighbouring countries like Ghana, and are planning on accelerating progress in Mali by involving and connecting as many actors in solar pump value chains.[422] In addition, a new financing model Pay-As-You-Go (PAYG) has been piloted and tested in Mali with the support from the USAID and World Bank. This financial model allows farmers to pay for solar irrigation and biodigester systems in installments, with each payment contributing to the total purchase price of the system.[423] Farmers pay in cash or via a mobile payment after selling agricultural products at each harvest. This allows farmers to use the pump while making small, regular payments until the total cost of the solar pumps and biodigester systems is paid off. Private sector solar companies in Mali such as ECOTECH, EMICOM, and Bboxx (previously called PEG Africa) offer PAYG financing.[424,425] A workshop conducted by the International Water Management Institute (IWMI) with the technology suppliers in Mali indicates that private solar technology suppliers are very keen to expand this PAYG model across Mali. In addition to ECOTECH, EMICOM, Bboxx, Horonya Solar, Sonikara Solar Electro, EnDev, and EKOenergy are keen to expand this financial model in Mali.

Table 25: Examples of Existing PAYG Facilities for Solar Irrigation and their Impact

Company(ies)	*Description of PAYG Offering*	*Impact/Success*
ECOTECH and AICCRA[426]	• AICCRA and ECOTECH enable access to solar-powered irrigation systems through a PAYG system. The system allows farmers to pay for solar irrigation systems in instalments, with each payment contributing to the total purchase price of the system. Farmers pay in cash or via a mobile payment after selling agricultural products at each harvest. When the system is fully paid, it is permanently unlocked and provides free energy. The functionality of the solar-powered system can be cut off or locked if payments are not made on time	• AICCRA Mali reached 6,255 farmers in the Sikasso and Niono communities, just over a quarter of whom were women • Farmers who used the solar-powered irrigation pumps increased their income by USD 5,262 per hectare • The use of solar-powered irrigation has enabled farmers to produce cash crops such as onion, tomato, cabbage, and potato during the dry season when fields had previously been abandoned due to water scarcity

[417] N. Durga et.al., (2024), Barriers to the uptake of solar-powered irrigation by smallholder farmers in Sub-Saharan Africa: A review, Available here
[418] Agrilinks, (2022), Closing the demand-supply gap in Mali's solar-powered irrigation value chains, Available here
[419] IWMI, (2022), New Market Research Captures the Potential of Mali's Solar-Powered Irrigation Sector, Available here
[420] IWMI, (2022), New Market Research Captures the Potential of Mali's Solar-Powered Irrigation Sector, Available here
[421] N. Durga et.al., (2024), Barriers to the uptake of solar-powered irrigation by smallholder farmers in Sub-Saharan Africa: A review, Available here
[422] IWMI, (2022), New Market Research Captures the Potential of Mali's Solar-Powered Irrigation Sector, Available here
[423] AICCRA, (2023), Pay-as-you-go model in Mali. Available here
[424] Agrilinks, (2022), Closing the demand-supply gap in Mali's solar-powered irrigation value chains, Available here
[425] Persistent Energy, (accessed September 2024), PEG Africa, Available here
[426] AICCRA, (2023), Pay-as-you-go model makes solar-powered irrigation affordable for farmers in Mali, Available here

Bboxx (previously called PEG Africa)[427,428,429]	• Bboxx enables access to solar water pumps to smallholder farmers in Mali, Senegal, Côte d'Ivoire, and Ghana through a PAYG system. Customers make monthly installments via mobile phones to use and finally own the solar system. The non-collateralized financing enables women to pay for the pump over 17 months, with flexible installments where lower payments are made in lean seasons and higher payments in harvest seasons • To reach rural women, Bboxx leverages women groups like VSLAs to disseminate information about solar pumps and drive awareness	• Bboxx has managed to obtain over 700,000 daily users of its solar products (including solar irrigation systems) through the PAYG system in Ghana, Côte d'Ivoire, Senegal, and Mali • 10% of the total number of clients who have financed water pumps from Bboxx report increased crop yields and higher incomes • Women have seen improvements in household health owing to access to clean water and less exposure to pollution from fuel pump emissions

While the PAYG model offers significant potential for increasing the accessibility of solar irrigation systems to smallholder farmers, it also faces some challenges. Some of these include: (i) PAYG bundled with solar irrigation pumps requires a 20–25 % upfront investment cost, which remains high for smallholder farmers, (ii) PAYG requires creditworthiness assessments of smallholder farmers, but with the complexity of irrigated agriculture, suppliers and third-party financial organizations offering these innovative financing arrangements often lack the capacity to assess the creditworthiness and estimate default rates of farmers, and (iii) existing credit scoring assessments are often gender-blind.[430]

CIEWS and Crop insurance

Selection Rationale

Climate Informational and Early Warning Systems (CIEWS) and Crop Insurance have also been selected for the CSA portfolio. However, they are recommended to be deployed solely through awareness raising and information dissemination by leveraging the existing materials and system-enhancing work undertaken by complementary projects in Mali. Both techniques are proven to enhance the adaptive capacity of smallholder farmers and will also create complementarity with existing GCF projects in the region.

Crop insurance allows farmers to be financially protected against unexpected loss of crops from increasingly prevalent climate hazards, amongst other risks. By reducing the risk taken on by smallholder farmers, they also allow farmers to obtain multiple secondary benefits that support the overall adoption of CSA techniques including: i) improved access to other finance, for example obtaining loans on less stringent terms and with fewer collateral requirements and ii) associated with increased likelihood of adopting new techniques as producers are able to take on a "high-risk, high-reward" mindset.[431] Information dissemination through IAAT will help to overcome one of the largest barriers to adoption in Mali: low awareness of insurance. [432] Crop insurance is provided at various prices depending on the specific location and crop cultivated. However, the average premium price ranges between USD 13 to USD 22.[433]

Existing CIEWS in Mali provide "locally-adapted seasonal weather forecasts on various aspects, including beginning of the rainy season, length of the growing season, daily weather information, 10-day forecast, among other parameters."[434] CIEWS can support both short- and long-term planning, and reactions to climate risks such as drought – and at both the smallholder and institutional level.

[427] REPP Energy, (2022), PEG Africa, Available here
[428] IWMI, (2020), How Connecting Innovators and Implementers Can Catalyze Solar Irrigation Scaling in Ghana, Available here
[429] CGAP, (2022), Savings at the Pump: Financing Solar Irrigation to Support Rural Women, Available here
[430] N. Durga et.al., (2024), Barriers to the uptake of solar-powered irrigation by smallholder farmers in Sub-Saharan Africa: A review, Available here
[431] Ada Microfinance, (2022), Index-based agricultural insurance, Available here
[432] GSMA, (2020), Agricultural insurance for smallholder farmers: Digital innovations for scale, Available here
[433] OKO Finance, OKO Crop Assurance, Link
[434] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here

However, although Mali has a long history of supporting CIEWS, including dating back to the 1984 launch of agro-meteorological assistance to rural communities through Mali Meteo, there are multiple limitations experienced by the existing system. These include a limited range of services and ineffective communication of early warning and actions directly to the affected population. [435] Improved use of CIEWS to manage on-farm decisions as well as develop informed adaptation and mitigation plans at the community and regional level will be achieved by working in close partnership with existing GCF projects, outlined below.

Mali Meteo is the main provider of freely accessible seasonal weather forecasts, which are broadcasted through national TV, radio, and partner networks. However, not all farmers have access to these communication channels. To address this, private services like Wati Yelema Labenw offer SMS-based information to farmers at a small fee of approximately USD 0.04. Through these SMS services, farmers can receive crucial weather updates directly on their mobile phones, enabling them to make informed decisions about their agricultural practices.[436]

To achieve complementarity and avoid duplication, IAAT will be working closely in implementation with existing GCF projects in Mali: The Hydromet Project (FP012) and Africa Integrated Climate Risk Management Program (FP162). IAAT will leverage the existing materials generated for information dissemination by FP012 and FP162 and include these in the CSA portfolio.

For reference, relevant activities within these GCF projects include:
Hydromet Project FP012 delivers the following activities to beneficiaries:

i) receiving advice from agro-meteorological information systems about the optimal date for cropping, the most profitable crops, how to avoid crop losses from drought, pests and diseases, as well as yield and post-yield conservation techniques;
ii) being identified more accurately as vulnerable through the food security and nutrition warning system, and subsequently receiving support in terms of cash, vouchers, free food or subsidized food;
iii) receiving flood warnings along with various types of support, ranging from preventive evacuation, and protection of livelihoods from flooding damages to emergency rescue and humanitarian support. "[437]

Africa Integrated Climate Risk Management Program FP162 delivers the following relevant activities in support of CIEWS and crop insurance[438]:

- Strengthen climate weather information to support decision making and planning in agro-forestry, livestock, agricultural insurance products and services
- Training of meteorological experts in the country on impact-based forecasting methodologies, data collection and interpretation
- Training smallholder farmers on the timely use of early warning products (including agro-climatic information) to improve their understanding of climate variability
- Training extension agents on early warning systems for droughts, floods or extreme precipitation
- Promoting the use of adaptation and mitigation techniques and technologies on agro-pastoralism to address the water deficit
- Training modules on financial literacy, marketing and business management
- Developing micro-insurance schemes tailored to each country's context.

[435] Green Climate Fund, (2016), Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Mali Country Project, Available here
[436] Kirbyshire A. and Wilkinson E., (2018), What impact are NGOs having on the wider development of climate services?, Link
[437] Green Climate Fund, (2016), Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Mali Country Project, Available here
[438] Green Climate Fund, (2021), The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW), Available here

VIII. VULNERABILITY AND TARGETING ASSESSMENT

8.1 Determining community vulnerability to climate change

8.1.1 Introduction and definitions

At the national level, Mali is extremely vulnerable to climate change, ranked the 7th most vulnerable country to the effects of climate change globally.[439] This project has the aspiration to target the most vulnerable communities within Mali to build resilience. Therefore, it will select where the project will operate, and ultimately its beneficiaries as a function of vulnerability.

To identify the most vulnerable people and guide beneficiary selection, a vulnerability assessment was undertaken as part of the feasibility study. The vulnerability assessment was conducted at the circle level[440] for the five regions within the scope of the project (Goa, Koulikoro, Mopti, Segou, and Tombouctou[441]). A semi-quantitative method that is guided by the IPCC structured framework was applied and it drew on available data for climate and non-climate hazards, and knowledge on which community-level factors increase sensitivities or undermine adaptive capacity.

8.1.2 Assessment framework

Climate vulnerability, as defined by the IPCC, is a function of three components: exposure, sensitivity and adaptive capacity.[442] The risk **exposure** indicates how much a household or community is at risk from climate change, measuring exposure to climate trends e.g. precipitation decrease and events e.g. droughts. The **sensitivity** component refers to the degree to which a household or community is affected by changing climate. **Adaptive capacity** refers to the ability of a household or community to cope with and recover from the effects of climate change.[443] Exposure and sensitivity both increase community or household vulnerability to climate change, whereas adaptive capacity protects against vulnerability to climate change.

The three components are formed from a subset of indicators that follow other vulnerability assessments but are tailored to the local context.[444]

- **The exposure component** assesses the circle's exposure to climatic trends and hazards that have been defined as significant threats in Mali. It is therefore a function of indicators that measure the severity and frequency of occurrence of specific hazards e.g. droughts. This includes current and future exposure.[445]
- **The sensitivity component** aims to quantify how reliant that circle is on agriculture, acknowledging that agriculture, and therefore communities that depend on it, is highly affected by changing climate conditions. In addition, it identifies key metrics that serve as proxies to identify heightened strain on the agricultural system, namely population density and levels of displacement, with the logic flowing that a high number of IDPs or high population density would add additional strain onto resources.
- **The adaptive capacity component** assesses how well-equipped the circle is to deal with climate stress. This is made up of socio-economic indicators including poverty levels, unemployment, and female illiteracy which decrease adaptive capacity.

[439] NDC Gain index, (2002-2021). Mali, Available here
[440] There have been changes to the administrative boundaries in Mali. Due to availability of data, this analysis follows historic boundaries, acknowledging that some of the circles may have changed categorization.
[441] The five regions were selected in the GCF approved IAAT concept note.
[442] IPCC, (2007), Climate change 2007: Impacts, adaptation and vulnerability. Available here
[443] IPCC, (2022), Glossary, Available here.
[444] Fellman T., (2012), The assessment of climate change-related vulnerability in the agricultural sector: reviewing conceptual frameworks, Available here
[445] The exposure indicators have all been taken directly from the World Bank's Think Hazard portal available here. It assesses current and projected exposure to hazards and categorizes 'High', 'Medium', 'Low' and 'Very Low'.

8.1.3 Component indicators

For further information on the selected indicators that make up these components, please see below which includes the full list included in our analysis, grouped by category (Table 26). This table includes the indicator name, the short description, the source, the data granularity* (region, circle), the year of publication*, and the data treatment which explains any analysis that has been performed, and how the data has been categorised into 'High', 'Medium' or 'Low' for this analysis. Different forms of data treatment have been applied to different indicators depending on the type of data available but broadly the data has been translated raw data into High, Medium and Low based on the distribution of scores. Stakeholder engagement at national and regional level helped to identify and finalize the indicators for exposure, sensitivity and adaptive capacity of the vulnerability analysis (see Annex 7 Summary of Consultations and Stakeholder Engagement)

** Please note that there are data availability constraints impacting several indicators. The most up to date and most granular datasets available for all indicators have been included.*

Table 26: Climate vulnerability indicator information

Indicator category	Indicator name	Description	Source	Data granularity	Year	Details on data and treatment applied
Exposure						
Exposure	Water scarcity	Projected vulnerability to water scarcity and droughts.	ThinkHazard (World Bank)[446]	Circle	2023	Raw High, Medium and Low categorization taken directly from ThinkHazard analysis aggregates multiple data sources and provides a 'High', 'Medium', 'Low', and 'Very Low' ranking. There were no instances of 'Very Low' for this indicator in Mali and so this has been excluded from the categorization. The categorization refers to how frequently droughts are likely to occur. High = every 5 years. Medium = up to a 20% chance in the coming 10 years. Low = 1% chance in the coming 10 years.
Exposure	Extreme heat vulnerability	Projected vulnerability to extreme heat.	ThinkHazard (World Bank)[447]	Circle	2023	Raw High, Medium and Low categorization taken directly from ThinkHazard analysis. There were no instances of 'Very Low' and so this has been excluded from the categorization. The categorization refers to how frequently prolonged exposure to extreme heat, resulting in heat stress, is expected to occur. High = at least once in the next five years. Medium = >25% chance at least one period in the next five years. Low = 5% - 25% chance in the next five years.
Exposure	Wildfire vulnerability	Projected vulnerability to wildfires.	ThinkHazard (World Bank)[448]	Circle	2023	Raw High, Medium and Low categorization taken directly from ThinkHazard analysis. There were no instances of 'Very Low' and so this has been excluded from the categorization. The categorization refers to how likely it is to encounter weather that could support a significant wildfire that is likely to result in both life and property loss in any given year. High = >50% chance. Medium = 10%-50% chance. Low = 4%-10% chance.
Exposure	River flood vulnerability	Projected vulnerability to river floods.	ThinkHazard (World Bank)[449]	Circle	2023	Raw High, Medium and Low categorization taken directly from ThinkHazard analysis. There were no instances of 'Very Low' and so this has been excluded from the categorization. The categorization refers to hoe likely damaging and life-threatening river floods are expected to occur. High = at least once in the next 10 years. Medium = at least once in the next 50 years. Low = at least once in the next 10000 years.
Sensitivity						
Sensitivity	% grassland lost	Percentage of forest land lost from 2004 to 2019 per region.	OECD Land cover in countries and regions[450]	Region	2021	Raw percentage of grassland lost categorized into High Medium and Low based on distribution of scores. This speaks to the mitigation objectives of this project.

[446] World Bank, Think Hazard Mali profile, Available here
[447] World Bank, Think Hazard Mali profile, Available here
[448] World Bank, Think Hazard Mali profile, Available here
[449] World Bank, Think Hazard Mali profile, Available here
[450] OECD, (2021), Land cover in countries and regions, Available here

Indicator category	Indicator name	Description	Source	Data granularity	Year	Details on data and treatment applied
Sensitivity	% cropland lost	Percentage of forest land lost from 2004 to 2019 per region.	OECD Land cover in countries and regions[451]	Region	2021	Raw percentage of grassland lost categorized into High Medium and Low based on distribution of scores. This speaks to the mitigation objectives of this project.
Sensitivity	Grassland and cropland area	Area of grassland and cropland added together per circle (thousand km squared).	OECD Land cover in countries and regions[452]	Circle	2019	Raw area of grassland and cropland added together, categorized into High, Medium, and Low based on distribution of scores. These metrics have been combined as there is a higher presence of grassland in the North, where agricultural activities are dominated by animal husbandry, whereas cultivation activities dominate in areas where there is more cropland. Combining them together gives an indication on the amount of agricultural land in the circle.
Sensitivity	Prominence of agriculture	Percentage of households who cultivate cereals and/ or rear livestock.	Institut National de la Statistique du Mali (General Census of Population and Housing)[453]	Circle	2021	Established % of local population that cultivate cereals and/ or practice livestock rearing by dividing total number of households that cultivate cereals by population of the circle. Assumption taken here that the ratio of households to population is the same in different circles. Percentage categorized into High, Medium, and Low based on distribution of scores with the top third as High, middle third as Medium and bottom third as Low.
Sensitivity	Volume of production (SDG 2.3.1)	Estimates of volume of agricultural production	Food and Agriculture Organization (FAO) of the United Nations - Disaggregating SDG indicators at subnational level in Mali[454]	Circle	2023	Took FAO Small Area Estimates on SGD 2.3.1 in Mali. Categorized their volumes into High, Medium and Low. High is categorized as volume of production >3750, Medium 2250-3750, and Low <2250 following their groupings. To estimate 2.3.1 the FAO produced (Fay-Herriot) small area estimates incorporating the covariates: levels of agricultural production (cotton, wheat, rice, sorghum) and soil health.
Sensitivity	Population density	Number of people per square km	ODHD, UNDP and UNICEF, (Pauvreté multidimensionnelle Pauvreté des 703 communes du Mali, edition 2022	Circle	2022	Established number of people dividing population of the circle[455] by the surface of the circle[456].

[451] OECD, (2021), Land cover in countries and regions, Available here
[452] OECD, (2019), Land cover in countries and regions, Available here
[453] INSTAT, (2021) Rapport sur les principaux résultats définitifs du module agriculture intégré dans la phase cartographie du recensement général de la population et l'habitat, édition 5, Available here
[454] FAO, (2023), Integrating surveys with geospatial data through small area estimation to disaggregate SDG indicators at subnational level, Available here
[455] OCHA (2022), Mali population estimates, Available here.
[456] Observatoire du Développement Humain Durable et de la Lutte Contre la Pauvreté, Available here

Indicator category	Indicator name	Description	Source	Data granularity	Year	Details on data and treatment applied
Sensitivity	Displacement	Internally Displaced People as a percentage of population	RSU (Matrice de suivi des déplacés)[457]	Circle	2022	Established Internally Displaced People as a % of local population by dividing total number of IDPs by population of the circle[458]. Percentage categorised into High, Medium, and Low based on distribution of scores with the top third as High, middle third as Medium and bottom third as Low.
Adaptive capacity						
Adaptive capacity	Poverty Rate	Percentage of poor and very poor communes.	ODHD, UNDP and UNICEF, (Pauvreté multidimensionnelle Pauvreté des 703 communes du Mali, edition 2022[459]	Circle	2022	Established % of poor and very poor communes out of total number of communes in the circle. Translated this % into High, Medium and Low based on distribution of scores with the top third as High, middle third as Medium and bottom third as Low.
Adaptive capacity	Youth unemployment	Percentage of young people (18-35) neither working nor at school (2020).	Afrobarometer (Unemployment report)[460]	Region	2020	Took raw data of % young people (18-35) neither working not at school as a proxy for youth unemployment. Raw data categorised into High, Medium, and Low based on distribution of scores with the top third as High, middle third as Medium and bottom third as Low.
Adaptive capacity	General unemployment	Percentage of people with no fixed income (2020)	Afrobarometer (Unemployment report)[461]	Region	2020	Took raw data of % people with no fixed income as a proxy for general job insecurity. Raw data categorised into High, Medium, and Low based on distribution of scores with the top third as High, middle third as Medium and bottom third as Low.
Adaptive capacity	Female Illiteracy	Sex disaggregated illiteracy rate	Institut National de la Statistique du Mali (Enquete modulaire et permanente aupres des ménages EMOP)[462]	Region	2022	Took raw literacy rate of girls and women aged 15 and over by region. Percentage categorised into High, Medium and Low based on distribution of scores with the top third as High, middle third as Medium and bottom third as Low.
Adaptive capacity	Educational attainment	Level of schooling attained by region (inverse)	Institut National de la Statistique du Mali (Enquete modulaire et permanente aupres des ménages EMOP)[463]	Region	2022	Took raw net school enrolment rate in 'Fondomental 1' by region as a percentage. Calculated 100%-answer to ensure that a low degree of schooling, corresponds to high vulnerability score. Percentage categorised into High, Medium and Low based on distribution of scores with the top third as High, middle third as Medium and bottom third as Low.

[457] RSU, (2022), Matrice de suivi des déplacés, Available here
[458] OCHA (2022), Mali population estimates, Available here.
[459] Observatoire du Développement Humain Durable et de la Lutte Contre la Pauvreté, Available here
[460] Afro Barometer, (2020), Au Mali, le chômage est un phénomène urbain, à visage jeune et éduqué, Available here
[461] Afro Barometer, (2020), Au Mali, le chômage est un phénomène urbain, à visage jeune et éduqué, Available here
[462] INSTAT, 2022, Enquête modulaire et permanente auprès des ménages (EMOP), Available here
[463] INSTAT, 2022, Enquête modulaire et permanente auprès des ménages (EMOP), Available here

Indicator category	Indicator name	Description	Source	Data granularity	Year	Details on data and treatment applied
Adaptive capacity	Health - child stunting	Percentage of children under five who are stunted	Institut National de la Statistique du Mali (2018 Demographic and Health Survey)[464]	Region	2018	Took raw percentage score of children under five who were stunted as a signifier of health by region. Percentage categorised into High, Medium and Low based on distribution of scores with the top third as High, middle third as Medium and bottom third as Low.
Adaptive capacity	Food insecurity	Percentage of population above IPC phase 3	IPC Mapping Tool (Acute food insecurity)[465]	Circle	2023	Took the categorisation of the IPC's food insecurity projections for June-August 2023. The IPC categorisation has five levels minimal, stressed, crisis, emergency, and famine. There are no circles in Mali projected to fall into 'famine' category, therefore translated 'minimal' to Low, 'stressed' to Medium and 'crisis' to High. There was one circle defined as 'emergency'. In this instance a special Very High categorisation has been used.
Conflict situation						
Conflict situation	Number of violent events	Number of violent events due to arm conflict situation	ACLED. 2023. Fact Sheet: Attacks on Civilians in Mali[466]	Circle	2023	This information is used to select the circle where conflict is low. IAAT project activities will be only implemented in the circles where conflict is low or no conflict at all.

8.1.4 Assessment method

To assess vulnerability, based on these three components, this analysis used a series of filters to identify the circles that had the highest exposure or sensitivity, or the lowest adaptive capacity. Within each component, each circle has been scored for each indicator (High = 3, Medium = 2, Low = 1). There is then an overall score which is derived from an average score across each of the indicators within the component.

For adaptive capacity, a 'high' ranking for each of the indicators e.g. female illiteracy actually serve to decrease adaptive capacity. Because of this, the average adaptive capacity score has been subtracted from 3 (max score) to give a more intuitive scoring. The circles with lower adaptive capacity have been progressed as this causes higher vulnerability.

To filter based on the components, this analysis has taken the scores in the top quartile (exposure and sensitivity) and bottom quartile (adaptive capacity) as the score to pass through the filter. The analysis first filters based on exposure, and then takes the top quartile from the sensitivity, and the bottom quartile from the adaptive capacity scores to give a list of the most vulnerable circles in Mali. This presents a shortlist of 16 circles that are the most vulnerable within Mali (see Annex 16- Maps of Proposed Locations for Interventions). However, due to the presence of active conflict which limits access, four of these circles have been removed as it is not possible to operate within these circles.[467]

[464] USAID/INSTAT, (2019), 2018 Demographic and Health Survey, Available here
[465] IPC, IPC Mapping Tool: Acute Food insecurity (2021-2023), Available here
[466] ACLED. 2023. Fact Sheet: Attacks on Civilians in Mali. Available here
[467] The security analysis was completed by the Save the Children Mali security expert. The analysis was completed at the circle level but will be continually assessed at the commune level for implementation.

8.1.5 Results

The final results have identified the 12 most vulnerable circles within the five regions, where conflict risk is at an acceptable level (low), seen in **Error! Reference source not found.**. Within the 12 circles, five circles overlap with the Albarka project which are indicated with an asterisk (Ansongo and Gao in the Gao region, Douentza and Koro in the Mopti region, and Gourma-Rharous in the Tombouctou region). This is beneficial in terms of conducting activities that have synergies with the IAAT project, and enabling compounding benefits for end beneficiaries.

Table 27: Shortlisted circles based on vulnerability (grouped by region)

Region	Circle
Gao	Ansongo*
Gao	Gao*
Koulikoro	Dioila
Koulikoro	Nara
Mopti	Bankass
Mopti	Djenne
Mopti	Douentza*
Mopti	Koro*
Mopti	Tenenkou
Segou	Bla
Segou	Segou
Tombouctou	Gourma-Rarhous*

Table 28: Full results vulnerability assessment by region (Selected circles in bold)

Region	Circle	Exposure						Sensitivity								Adaptive capacity								
		Security filter	Water scarcity	Extreme heat	Wildfire vulnera-bility	River flood vulnera-bility	Overall - Exposure	% grass land lost	% crop land lost	Area of grass land and crop land	Prominence of agricul-ture	Volume of produ-ction	Popul-ation density ranking	Displac-ement	Overall – Sensit-ivity	Poverty Rate	Youth unemplo-yment	General unemplo-yment	Female illiteracy	Educa-tional attain-ment	Health - child stunting	Food insecurity	Adaptive capacity (raw av)	Overall Adaptive capacity
Gao	**Ansongo**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Low**	**Low**	**Medium**	**Low**	**Medium**	**Low**	**Medium**	**1.43**	**Medium**	**High**	**High**	**Medium**	**Low**	**High**	**High**	**2.43**	**0.57**
Gao	Bourem	Go	Medium	High	High	High	2.75	Low	Low	Low	High	Low	Low	Medium	1.43	High	High	High	Medium	Low	High	Medium	2.43	0.57
Gao	**Gao**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Low**	**Low**	**Medium**	**Low**	**Low**	**Low**	**High**	**1.43**	**Medium**	**High**	**High**	**Medium**	**Low**	**High**	**High**	**2.43**	**0.57**
Gao	Menaka	No go	High	High	High	High	3.00	Low	Low	Medium	Low	Medium	Low	High	1.57	High	High	High	Medium	Low	High	High	2.57	0.43
Koulikoro	Banamba	No go	High	High	High	High	3.00	High	Medium	Low	Medium	Medium	Medium	Low	1.86	Medium	Low	Low	Medium	Medium	Low	Low	1.43	1.57
Koulikoro	**Dioila**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**High**	**Medium**	**Medium**	**Medium**	**Medium**	**High**	**Low**	**2.14**	**Low**	**Low**	**Low**	**Medium**	**Medium**	**Low**	**Low**	**1.29**	**1.71**
Koulikoro	Kangaba	Go	Medium	High	High	High	2.75	High	Medium	Low	Medium	Medium	Medium	Low	1.86	Medium	Low	Low	Medium	Medium	Low	Low	1.43	1.57
Koulikoro	Kati	Go	Medium	High	High	Low	2.25	High	Medium	Medium	Medium	Medium	High	Low	2.14	Low	Low	Low	Medium	Medium	Low	Low	1.29	1.71
Koulikoro	Kolokani	Go	Medium	High	High	Medium	2.50	High	Medium	Medium	Medium	Medium	Medium	Low	2.00	Medium	Low	Low	Medium	Medium	Low	Low	1.43	1.57
Koulikoro	Koulikoro	Go	High	High	High	High	3.00	High	Medium	Low	Medium	Low	Medium	Low	1.71	Low	Low	Low	Medium	Medium	Low	Low	1.29	1.71
Koulikoro	**Nara**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**High**	**Medium**	**High**	**High**	**Low**	**Low**	**Low**	**2.00**	**High**	**Low**	**Low**	**Medium**	**Medium**	**Low**	**Low**	**1.57**	**1.43**
Mopti	Bandiagara	Go	High	High	High	Low	2.50	Medium	High	Low	Low	Low	Medium	Medium	1.71	Medium	Medium	Medium	High	High	Medium	Medium	2.29	0.71
Mopti	**Bankass**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Medium**	**High**	**Low**	**Medium**	**Medium**	**High**	**High**	**2.29**	**Low**	**Medium**	**Medium**	**High**	**High**	**Medium**	**Medium**	**2.14**	**0.86**
Mopti	**Djenne**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Medium**	**High**	**Low**	**Medium**	**Medium**	**High**	**Medium**	**2.14**	**High**	**Medium**	**Medium**	**High**	**High**	**Medium**	**Medium**	**2.43**	**0.57**
Mopti	**Douentza**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Medium**	**High**	**Medium**	**Low**	**Medium**	**Low**	**Medium**	**1.86**	**High**	**Medium**	**Medium**	**High**	**High**	**Medium**	**High**	**2.57**	**0.43**
Mopti	**Koro**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Medium**	**High**	**Medium**	**Low**	**Medium**	**Medium**	**Medium**	**2.00**	**High**	**Medium**	**Medium**	**High**	**High**	**Medium**	**Medium**	**2.43**	**0.57**
Mopti	Mopti	Go	Medium	High	High	High	2.75	Medium	High	Low	Low	Medium	High	High	2.14	Low	Medium	Medium	High	High	Medium	Medium	2.14	0.86
Mopti	Tenenkou	Go	High	High	High	High	3.00	Medium	High	Medium	Medium	Medium	Low	Medium	2.00	Medium	Medium	Medium	High	High	Medium	Medium	2.29	0.71
Mopti	Youwarou	No go	High	High	High	High	3.00	Medium	High	Low	High	Medium	Low	Medium	2.00	High	Medium	Medium	High	High	Medium	Low	2.29	0.71
Segou	Baraoueli	Go	High	High	High	High	3.00	Medium	Low	Low	Medium	Medium	High	Low	1.71	Low	High	High	High	High	Medium	Low	2.29	0.71
Segou	**Bla**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Medium**	**Low**	**Low**	**Medium**	**Medium**	**High**	**Low**	**1.71**	**Medium**	**High**	**High**	**High**	**High**	**Medium**	**Low**	**2.43**	**0.57**
Segou	Macina	No go	High	High	High	High	3.00	Medium	Low	Low	Low	High	Medium	Low	1.57	Medium	High	High	High	High	Medium	Low	2.43	0.57
Segou	Niono	No go	High	High	High	High	3.00	Medium	Low	Medium	Medium	High	Medium	Medium	2.00	Low	High	High	High	High	Medium	Low	2.29	0.71
Segou	San	Go	High	High	High	High	3.00	Medium	Low	Low	High	Medium	High	Low	1.86	Low	High	High	High	High	Medium	Low	2.29	0.71
Segou	**Segou**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Medium**	**Low**	**Medium**	**Medium**	**Medium**	**High**	**Low**	**1.86**	**Medium**	**High**	**High**	**High**	**High**	**Medium**	**Low**	**2.43**	**0.57**
Segou	Tominian	No go	High	High	High	High	3.00	Medium	Low	Low	High	Medium	Medium	Low	1.71	Low	High	High	High	High	Medium	Low	2.29	0.71
Tombouctou	Dire	Go	Medium	High	High	High	2.75	Medium	Low	Low	High	High	High	Medium	2.14	Medium	Medium	Medium	Medium	Medium	Medium	Low	1.86	1.14
Tombouctou	Goundam	Go	High	High	High	Medium	2.75	Medium	Low	Low	High	Medium	Low	Low	1.57	High	Medium	Medium	Medium	Medium	Medium	Medium	2.14	0.86
Tombouctou	**Gourma-Rarhous**	**Go**	**High**	**High**	**High**	**High**	**3.00**	**Medium**	**Low**	**High**	**Medium**	**Medium**	**Low**	**High**	**2.00**	**High**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**High**	**2.29**	**0.71**
Tombouctou	Niafunke	Go	Medium	High	High	High	2.75	Medium	Low	Low	Medium	Medium	Low	Medium	1.57	High	Medium	Medium	Medium	Medium	Medium	Medium	2.14	0.86
Tombouctou	Tombouctou	Go	High	High	High	Low	2.50	Medium	Low	Low	Medium	High	Low	High	1.86	Medium	Medium	Medium	Medium	Medium	Medium	Medium	2.00	1.00

8.2 Beneficiary selection and targeting

8.2.1Targeting beneficiaries

The beneficiaries will be selected from the 12 circles that have been prioritized based on climate vulnerability (Ansongo and Gao in the Gao region, Dioila and Nara in the Koulikoro region, Bankass, Djenne, Douentza, Koro, and Tenenkou in the Mopti region, Bla and Segou in the Segou region and Gourma-Rarhous in the Tombouctou region).

The total population of these 12 circles is estimated at over 4 million people[468], with an estimated average population per commune of ~23,700. This project will aim to work in four communes per circle[469], resulting in 48 communes in scope for the IAAT project. In the 5 circles where there are overlapping activities with the Albarka project (Ansongo and Gao in the Gao region, Douentza and Koro in the Mopti region, and Gourma-Rharous in the Tombouctou region), the three communes selected by the Albarka project, plus one additional commune will be selected. The estimated total population in the 48 targeted communes is 1,138,900 people.[470]

During the implementation of the project, target communes will be selected in each circle based on consultations with circle and regional administrations. The consultations will be based on the initial criteria set out in the national validation workshop, which include:

- The potential for agroforestry techniques
- Prevalence of land degradation
- Existing support (ongoing initiatives)
- The integration of climate change in the PDESC (5-year planning document)
- Security analysis from the SCI Mali security team
- Geographical relationship to other implementation locations
- Known coverage of extension services

The specific households and services selected will also be determined during implementation, working with local leaders and agricultural groups to identify suitable people or services, and acknowledging the different structures, customs and norms in different parts of the country.

8.2.2 Direct and Indirect beneficiaries

The project aims to reach 431,700 direct beneficiaries' population in the project's 48 targeted communes, and a further 700,980 indirect beneficiaries across the project's 5 regions, as outlined in Table 29: Total targeted reach of IAAT interventionsDirect beneficiaries reached vary across the components and activities, as outlined in Table 30. Activity 1.2.1 is the primary input for the number of direct beneficiaries, as it corresponds to the number of smallholder farmers directly trained by the improved extension services in the project's 48 communes. For many other activities, the beneficiaries are a sub-set of the total reached in 1.2.1. The main exception is activity 2.2.2 which targets ~5,250 women and youth entrepreneurs who are considered additional to 1.2.1 as they are entrepreneurs rather than smallholder farmers.

[468] It is widely recognized that population estimates are not accurate in Mali as the last census was performed in 2009. The data here has been taken from the OCHA official estimate from 2022 which is available here.
[469] During the validation workshop it was raised that some circles have fewer communes than others (average of 14 communes per circle). Therefore in some circles it might be +/- 4 communes and will be defined during implementation phase.
470 It is widely recognized that population estimates are not accurate in Mali as the last census was performed in 2009. The data here has been taken from the OCHA official estimate from 2022 which is available here.

Within the direct beneficiaries, the project will target a 50:50 female:male gender split across all activities bar select sub-activities within component 2. In component 2 women and youth will be the focus of activities 2.2.1 and 2.2.2, resulting in the overall gender split of the direct beneficiaries population being: 215,850 male and 215,850 females, and 86,340 male farmers and 86,340 female farmers

beneficiaries are detailed in Tables 29 and 30 below, with further information detailed in the Vulnerability and Targeting Assessment.

Table 29: Total targeted reach of IAAT interventions

Beneficiary Segment	Total #	# as % of target region's Population	# as % of Mali's Population	Note
Total direct beneficiaries (Individuals)	431,700	4.4%	2.4%	Includes: Direct beneficiaries from the improvements to extension services (1.2), the direct beneficiaries from entrepreneur training (2.2) and private sector businesses guidelines (2.1). 50% of these direct beneficiaries will be from the Albarka Project and 50% will be in new locations
Total direct beneficiaries (farming households)	86,340	NA	NA	Total farming households is estimated based on an average family size of 5 persons per household (Latest Population and Health Survey 2018)[471]
Total direct beneficiaries (farmers/individuals)	172,680	NA	NA	At least two persons in farming households involve in farming activities (based on the Albarka Project experience in the targeted regions in Mali). 50% of total farmers will be from the Albarka Project who are participating in current activities and 50 will be in new locations. Among the total farmers, 50% will be women farmers
Female direct beneficiaries (farmers/individuals)	215,850	2.2%	1.2%	50% of beneficiaries from improved extension services and private sector businesses, 85% of entrepreneurs
Male direct beneficiaries (farmers/individuals)	215,850	2.2%	1.2%	50% of beneficiaries from improved extension services and private sector businesses, 15% of entrepreneurs
Total Indirect Beneficiaries (farmers/individuals)	700,980	7.0%	3.8%	Assumed that 40% of the region's population benefits from the improvement to extension services.[472] Studies on agriculture technology adoption in Mali (Segou, Mopti, Koulikoro) indicate adoption rates ranging from 10% to 95% depending on the type of technologies and practices. We have considered the median average adoption rate of 60% to estimate the indirect beneficiaries of IAAT project circles. The average adoption rate for IAAT-promoted CSA technologies is 60% in the project locations.

[471] Demographic and Health Survey 2018, Available here.

Table 30: Beneficiary reach of IAAT interventions, by intervention

Relevant activity	Intervention Summary	# of Beneficiaries	What other activity are these beneficiaries a sub-set of?	Assumptions
1.2.1	Farmers trained through improved extension services	172,680	N/A	At least two persons in a farming households involve in farming activities (based on the Albarka Project experience in the targeted regions in Mali). 50% of total farmers will be from the Albarka Project who are participating in current activities and 50 will be in new locations. Among the total farmers, 50% will be women farmers 50% women and 50% male target. Includes all members of the farming household, as assumed all will benefit from the training received.
1.2.1	Farmers trained through improved extension services: sub-set trained through farm field schools	45,556	1.2.1: Farmers trained through improved extension services	4% of total estimated population of 48 implementation communes[473]
1.2.1	Farmers receiving support through new and existing Community Action Cycles	17,540	1.2.1: Farmers trained through improved extension services	Leveraging the 250 CACs established by Albarka, and adding a further 627 by IAAT expansion to additional circles (1 per village). Assumes 20 members per CAC.
1.2.1	Farming households who are trained by the project and adopt at least 1 CSA technique and agroforestry	86,340	1.2.1: Farmers trained through improved extension services	The willingness of farmers to participate in project interventions new adoption rate based on USAID Albarka logframe target (+15ppts-20ppts) Cross-referenced w/ CGIAR achieved rate of increased adoption in CSV village in 5 year period
2.1.1.1	Farmers connected to broader services and markets through access to online platforms	22,778	1.2.1: Farmers trained through improved extension services	All farmers taking part in extension service training will be encouraged to sign up. The adoption rate of 5% of these farmers (assumes the same % interested (15% as adopting CSA practice) but reduced by 1/3 to consider internet availability in Mali)[474]
2.1.1.2	Private Sector Businesses Trained	100		Assumes 20 established private sector businesses are trained per year, in line with Albarka targets
2.2.1.2	Members of new women and youth-focused VSLAs	18,000	1.2.1: Farmers trained through improved extension services	Project aims to create the same density of VSLAs achieved by Albarka per commune (28) across the 33 new communes, resulting in ~900 new women and youth-targeted VSLAs (split 70:30, women: youth focus, with youth having 50% male: female gender split) Each VSLA includes on average 20 people.
2.2.2	Training delivered to women and youth entrepreneurs	5,250	N/A	Sum of 3750 women entrepreneurs trained (based on Albarka achieved precedent of 750/year, for 5 years)

[473] This follows the information from the (2021) Agra Mali Report Final - Alliance for a green revolution in Africa. Available here that 4% of people can access farmer field schools

[474] Latest WorldBank data reports that 34% of Mal's population is using the internet, 2021, accessible here

Relevant activity	Intervention Summary	# of Beneficiaries	What other activity are these beneficiaries a sub-set of?	Assumptions
				and 1500 youth entrepreneurs trained (planned by Albarka during the 2 years of overlapping projects) Youth entrepreneurs assumed to have a 50:50 Gender split
2.3.1	Individuals benefited from the introduction of biodigesters	35,000	1.2.1: Farmers trained through improved extension services	The beneficiary number corresponds to the number of biodigesters [5000] (identified during the feasibility study as in line with existing market size) multiplied by # of people per household (7)[475]
2.3.1	Individuals benefited from the introduction of solar irrigation pumps	7,632	1.2.1: Farmers trained through improved extension services	Beneficiary numbers correspond to 3,000 hectares of land that will be irrigated multiplied by the average size of land used by 1 farmer (which on average is 0.52 hectares of land but this varies across value chains)[476]
3.1.1	Institutional actors trained on integrating adaptation and mitigation into planning/processes	58	N/A	1 local government representative per commune is trained (48 commune-level beneficiaries) 10 national-level representatives are trained

8.3 Stakeholder Engagement During Implementation

Effective stakeholder engagement throughout the implementation phase is crucial for the seamless execution of project activities. This entails leveraging partnerships with diverse institutional partners and fostering close collaboration with communities to provide tailored and continuously enhanced support to project beneficiaries. The project will place significant emphasis on maintaining ongoing and meaningful engagement with stakeholders throughout the implementation process. This approach recognizes the wealth of knowledge and expertise held by key stakeholders and seeks to capture and harness their insights effectively. By adopting a collaborative approach and actively involving stakeholders, the project aims to ensure that activities remain adaptable and responsive to the evolving needs of beneficiaries. The project will actively solicit the perspectives of communities and integrate their valuable input into the decision-making and implementation processes.

Stakeholders engaged during implementation will demonstrate a strong capacity to provide support to key success enablers, including awareness raising, activity design, thought leadership, and community engagement. The project will continuously screen and select relevant stakeholders to enhance collaboration and maximize impact potential. All necessary resources will be mobilized, relying on the contributions of these stakeholders to achieve success. Through thoughtful discussions, the project will identify other organizations with valuable expertise and assess their capacity to bring added value, enabling the strategic utilization of their knowledge and technical capacity.

8.3.1 Key engagement principles

The GCF IAAT project will leverage a robust framework of stakeholder collaboration to identify and implement the most adequate solutions to lift the barriers hindering enhanced adaptation and mitigation capacity of smallholder farmers in Mali. This framework is guided by key principles including co-creation, two-way communication, inclusivity, transparency,

[475] This is a conservative estimate as biodigester systems may benefit multiple households

[476] This is a conservative estimate as in some circumstances solar irrigation pumps may benefit multiple households.

sustainable partnerships, and adaptive management, to engage stakeholders strategically. By actively involving stakeholders and leveraging their diverse expertise and knowledge, the project seeks to ensure their meaningful contributions throughout all stages of implementation. A strong emphasis will be placed on transparent and accurate communication, providing stakeholders with essential information about activities, roles, responsibilities, and expectations. Moreover, sustainable partnerships will be cultivated among various stakeholders, fostering collaboration and facilitating the exchange of resources, knowledge, and expertise to optimize the project's impact and long-term viability.

An adaptive management approach will underpin the project's implementation strategy, enabling the necessary adjustments based on stakeholder feedback, evolving circumstances, and lessons learned. Regular monitoring of progress and impact against predefined criteria will be carried out, with stakeholder input actively integrated into the decision-making processes. Recognizing the significance of community involvement, the project will prioritize ongoing engagement with communities, establishing a two-way communication channel to ensure their ideas and needs are consistently considered and integrated. The inclusion of women and youth in all consultation sessions will be a primary focus, empowering their organizations to play instrumental roles in stakeholder engagement. Ultimately, the project endeavors to foster a collaborative environment where stakeholder contributions are valued, their knowledge and experiences are effectively harnessed, and collective efforts propel the achievement of project objectives.

8.3.2 Engagement methods

Project implementation will adopt a comprehensive and dynamic approach, emphasizing collaboration and adaptability, strongly relying on stakeholder involvement. The project will actively seek feedback from key stakeholders and utilize their insights to continuously assess and refine the implementation plan. To ensure effectiveness, the engagement methods employed will be tailored to suit the characteristics and preferences of the target audience, considering several factors, including the desired outcomes of engagement, the diverse types of stakeholders involved, the specific geographic and cultural context, and the relevant topics to be discussed. This tailored approach will enable efficient utilization of stakeholders' capacities and maximize the potential impact generated by project activities. Their perspectives and voices will be given due consideration to ensure that their specific needs, challenges, and aspirations are adequately addressed throughout the project's implementation. To facilitate effective stakeholder engagement, the project will employ a range of methods, including:

- **Steering committee:** The steering committee, consisting of relevant ministries, will convene bi-monthly to assess project advancements, evaluate accomplishments, and identify opportunities for enhancement, serving as a vital platform to refine project implementation and maintain alignment with key objectives
- **Consultative workshops:** Workshops will bring together key stakeholders to share knowledge, exchange experiences, and gather insights that will inform project implementation, align strategies, enhance community engagement, and facilitate project monitoring and evaluation, while also serving as a platform for capacity building activities targeted at improving the understanding of local authorities regarding CSA and agroforestry technologies and practices
- **Community surveys:** The project will utilize diverse survey platforms to gather feedback from communities at crucial stages, enabling the review and update of activities to address emerging needs and mitigate risks, with a focus on inclusivity to capture insights from all stakeholders, including women and youth
- **Community Action Cycles (CACs):** The project will leverage CACs to include communities in the decision-making process, mitigate risks of conflict between communities, and navigate security concerns in specific locations.
- **Field visits and demonstration:** Field visits and demonstrations play a crucial role in promoting the adoption of CSA technologies by providing farmers with tangible evidence

of their efficiency, helping to overcome limited understanding and traditional practices, and creating an opportunity for farmers to shift towards more appropriate and sustainable agricultural methods.

- **Digital platforms:** The project will rely on digital platforms to enhance access to the market for producers by establishing links between stakeholders throughout the value chain. These platforms will also allow streamline the market of CSA and agroforestry and enhance adoption of innovative technologies.

The project will leverage tailored communication strategies for efficient stakeholder engagement, utilizing various channels such as social media, radios, Whats app groups and SMS, to facilitate transparent and inclusive communication, foster broader stakeholder participation, and enable ongoing feedback and information exchange, ultimately ensuring the smooth delivery of activities and avoiding any potential confusion or delays.

IX GOVERNANCE OF THE PROJECT

9.1 Accredited Entity Capacity: experience and track record

Save the Children is the world's leading independent organization for children, with 30 national organizations working together to deliver programs in more than 120 countries. In 2019, Save the Children delivered programs worth over USD 2.2 billion across 117 countries and directly reached over 38.7 million children. Our vision is a world in which every child attains the right to survival, protection, development, and participation. Our mission is to inspire breakthroughs in the way the world treats children, and to achieve immediate and lasting change in their lives. Globally, Save the Children is implementing a portfolio of 100+ resilience-related projects and programmes valued at more than USD 200 million, including those with explicit objectives to reduce climate and disaster risks, as well as to increase adaptive capacity and speed recovery from shocks and stresses, as well as those which seek the social and economic empowerment of women and youth and the amplification of the voices of the most marginalized.

Save the Children Australia (SCA) was accredited to the GCF in November 2019 on behalf of the global Save the Children movement. SCA were chosen to lead on the GCF for Save the Children due to our longstanding leadership role in climate change and Disaster Risk Reduction. The Accreditation Master Agreement (AMA) was made effective in May 2020.

9.2 Executing Entity Capacity: experience and track record

The Executing entities of the IAAT project are Save The Children Mali . Save the Children Mali has extensive experience in carrying out large-scale projects, and the evaluation concluded that it can implement activities that could be financed by the Green Climate Fund (GCF). The organization is authorized to operate in Mali and to receive funds directly from financial partners such as the GCF/SCA, enabling it to meet the legal conditions required to be the co-executing entity of the IAAT project.

Save the Children Mali benefits from a solid organizational structure throughout the country, as well as well-established policies on human resources, ethics, and professional conduct, enabling it to execute the GCF project effectively and efficiently. The organization applies international accounting standards (IFRS) (I and has implemented rigorous financial management and control measures. It is also equipped with high-performance software for optimal resource management. In addition, Save the Children Mali has qualified personnel in financial management. It has also adopted a zero-tolerance policy towards fraud, corruption, and bribery, as well as a policy of reporting any behavior that does not comply with its code of conduct. Its procurement policy is transparent, fair, honest, and responsible, covering all types of expenditure. Supplier evaluation criteria are rigorous and in line with national regulations.

Save the Children Mali has proven experience in implementing large-scale projects financed by international partners. The organization has a reliable, adaptable, and participative monitoring-evaluation system. It also has a proactive, integrated, and well-documented risk management system.

The NGOs designated as implementing partners of SC Mali in the implementation of the IAAT project have the necessary mandates and authorizations to work with and receive funds from Save the Children Mali. Each NGO benefits from a solid organizational structure in the regions where it operates, as well as its own policies in terms of human resources, code of conduct, ethics and anti-fraud measures. Although Save the Children Mali has demonstrated its ability to implement GCF-funded activities, it is essential to support certain NGOs to ensure compliance with relevant regulations and best practice in financial management.

Implementing Entity

AEDD has a proven track record in implementing projects financed by the Green Climate Fund, demonstrating its competence in this field. As reported on the GCF website, In recent years, AEDD has successfully completed six readiness activities to support national initiatives by strengthening their institutional capacities, governance mechanisms, and planning and programming frameworks. The aim was to help the institutions design transformational long-term climate action programme. This showcases AEDD familiarity with the processes and requirements of the Green Climate Fund, as well as its ability to manage and implement projects in line with its objectives. However, it should be noted that specific data on AEDD's financial management capabilities have not been made available by AEDD, for the moment. Without access to such data, it is difficult to make an accurate assessment of its financial management skills.

9.2.1 Overview

To meet the fiduciary requirements of certain donors, the government encourages the use of sector budget support (SBS) for implementing specific projects. Ministries, with the support of the Ministry of Economy and Finance, collaborate with development partners to overcome obstacles in sector programs.

Off-budget support is strongly discouraged by the Malian administration as it bypasses state control, is difficult to track, and may not align with national priorities. According to our sources, the Ministry of Environment, particularly the AEDD, uses the UNDP modality for financial management and procurement. While this modality works, its main weakness is that it does not strengthen the ministry's capacity since the UNDP directly manages funds and procurement instead of going through the ministry.

9.2.2 Legal Implications

National resources and budgetary support are deposited in the Single Treasury Account held at the BCEAO. Project support can also be deposited into specific bank accounts opened in commercial banks.

Mali has adopted the Single Treasury Account policy, which means that all funds transiting through public entity must be deposited in the Treasury, unless an exception is made. Article 5 of Ministerial Order No. 2016-2082/MEF-SG of 15 June 2016 laying down the rules for opening, closing and managing public bank accounts states that "Funds collected under agreements with lenders may be deposited in a commercial bank. The financing agreement will specify this derogation and the terms and conditions for managing the public account, in compliance with the national regulations in force".
Malian legislation allows for the creation of specific bank accounts in commercial banks for projects financed by partners. The creation of specific bank accounts makes it possible to monitor the use of allocated resources and check that they are only being used within the defined framework, which meets the criteria of the Green Climate Fund.

9.2.3 Transparency Implications

Donors have the option to use off-budget support to finance development in Mali. In this case, funds are directly channeled outside the government budgetary system to finance projects within local communities and NGOs. Although the Ministry of Economy and Finance has developed an Integrated System for Managing Aid in Mali (SIGAP), the exact amount of resources and expenses incurred by donors in project support can only be identified through a subsequent evaluation.

From this standpoint, the GCF funds would likely be categorized as off-budget project support. As a result, these funds are not subject to the government's usual payment or accounting processes. They are also not subject to the government's regular auditing

system but follow their own system approved by the government through the Ministry of Economy and Finance, the GCF, and executing entities.

The government has established a system for managing and controlling project support funds. However, when project support channels are used, obtaining detailed information on allocated funds can be challenging. Nonetheless, reports provided by donors and some NGOs provide an overview of the use of these funds.

9.2.4 Control

In 2019, the National Directorate of Accounting and the Public Treasury (DNTCP) developed an accounting software called the Automated Integrated Accounting Management System (SIGA-COMPTA). Its purpose was to enable public institutions to maintain accounting in accordance with their budgetary and accounting framework. In 2020, this software was implemented in 29 public institutions, and its implementation continues in 30 other public institutions.

All bank accounts of budgetary units, under the responsibility of direct Treasury accountants, undergo regular bank reconciliations, either daily, weekly, or monthly. Accountants of EPA, social security funds, and project/program accountants also perform monthly reconciliations for accounts under their responsibility.

9.2.5 Alignment with Government and Donor Policies

While it is recommended that all projects use government systems, it is still common for donors to manage their projects using their own systems when necessary to ensure project implementation success. This practice also reflects weaknesses and a lack of trust in the country's public financial management.

9.2. 6 Implementation Arrangement

This project will have two Executing Entities (EEs): Save the Children Federation, Inc. (SCUS), and Save the Children International (SCI) au Mali. SCUS will be a channelling EE with responsibilities for supervision and oversight of the utilisation of the funds they are channeling in line with the Save the Children Association ways of working. SCI Mali will serve as EE channelling funds in Mali and will be responsible for the project implementation in collaboration with the GoM. As implementing EEs, SCI Mali will be responsible for the execution and supervision of technical and minor infrastructure activities (e.g. solar irrigation system, biodigesters, etc). The project will be implemented in close consultations with the Government of Mali's ME&S through AEDD, which acts as Mali's NDA to the GCF. Save the Children Australia (SCA) as the Accredited Entity (AE), will maintain reporting channels to the GCF to ensure compliance with the fiduciary, environmental, social, and other relevant standards. SCI Mali will maintain reporting channels to ME&S to maintain and increase the country's project ownership. SCUS will provide account management support to SCI Mali by the account management system employed by the wider Save the Children movement to ensure compliance and high-quality delivery of the project and financial management and reporting.

All field-level activities that need direct engagement with farmers and communities, local government and civil society organizations, and the private sector will be implemented by the local NGOs. Implementing partners (local NGOs) will be procured through the open bid process. SCI Mali will be the procuring entity, and the procurement will be done in accordance with the requirements under the AMA. For, technology supply (i.e solar irrigation, biodigesters, and other CSA technologies) SCI Mali will follow an open bid process to purchase from the private suppliers/companies.

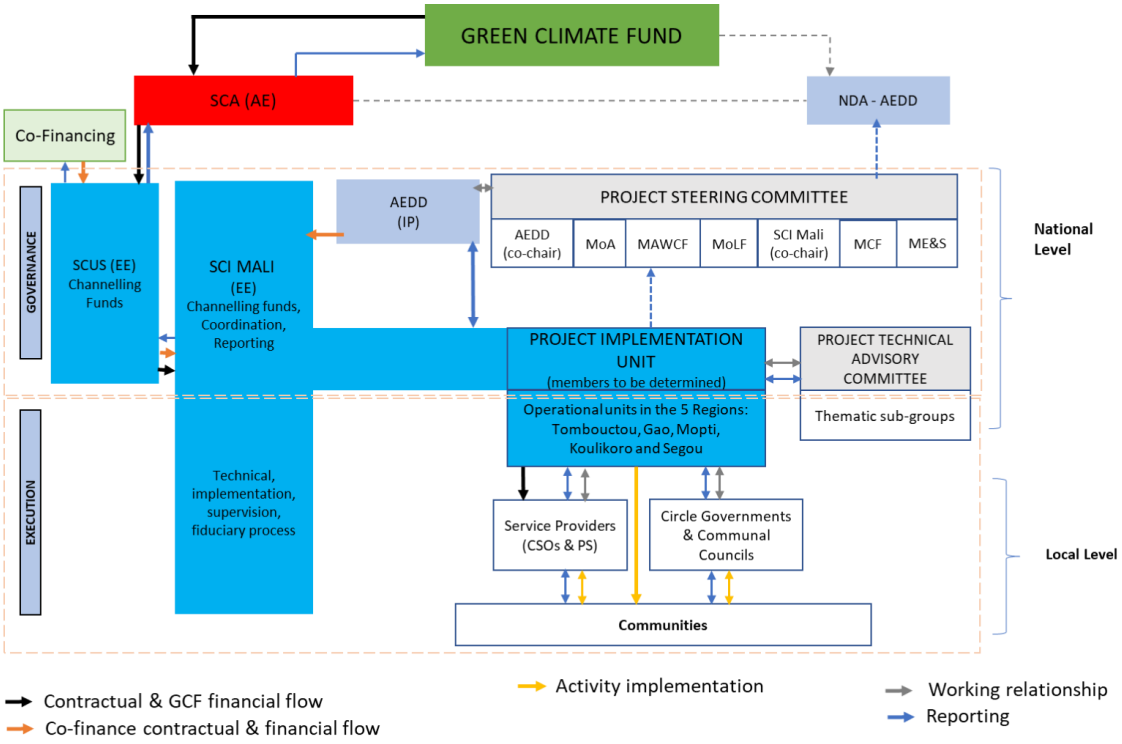
A high-level Project Steering Committee (PSC) will be responsible for the project's strategic direction and oversee activity implementation, including steering activities implemented by the Project Implementation Unit (PIU), which will manage day-to-day operations. Representatives of SCI Mali and the AEDD will co-chair the PSC, which will also include representation of senior officials from ME&S. Ministries represented on the PSC will include the Ministry of Environment and Sanitation, Ministry of Agriculture, Ministry of Livestock and Fisheries, Ministry of the Advancement of Women, Children, and Families, Mali Climate Fund. No financial flows will take place between SCI Mali and the PSC; the working relationship will be solely based on reporting and consultation. The PSC will also consult with and report to ME&S as the Mali NDA. While the wider group co-chairs will make decisions, consensus will be required for any key decisions with contractual ramifications. The AE will ensure that decisions taken by the PSC are consistent with the AMA, FAA, and FP by regularly holding meetings with the core project team, including the PIU team lead and the Country Director of SCI Mali. The AE will also run a learning and knowledge session during the project inception period on the AMA and the FAA so that all partners understand their responsibilities ahead of project implementation and understand what amendments may need AE and/or donor prior approval. This is no different from the delivery of any other donor-funded project

The PIU will be led by the Team Leader, who will hold decision-making authority and co-managed in partnership with the AEDD and SCI Mali. The PIU will manage project implementation, support implementing entities, and be supported by a technical supervisory team, including a Team Leader, Deputy Team Leader, Finance Director, Monitoring and Evaluation Advisor, Technical Leads, and support staff. It will work directly with the technical implementing teams of the AEDD, SCI Mali, SCUS and local NGOs, and directly manage the implementation of the project at circle and commune levels. The PIU will draw on technical expertise from the broader SC movement (specifically climate change adaptation and mitigation in agriculture and NRM) as well as from executing and implementing entities. The PIU will report to SCI Mali and will also have accountability to the PSC. The technical advisory committee will include subject matter specialist in agriculture, climate change, agroforestry, gender and social inclusion, conflict management, market system development and other experts from SCI Mali, SCUS, and AEDD. This committee will provide technical backstopping to the PIU to implement the IAAT project activities.

The PIU will monitor and oversee technical and financial implementation, fiduciary processes, auditing, measurement reporting and verification system, and internal evaluation of the project. The PSC will oversee the PIU and provide it with guidance and direction while receiving regular reports on project implementation. The PIU will receive funds (both GCF and co-financing) distributed according to the Subsidiary Agreements with the EEs and procurement contracts for the provision of goods and services. The PIU will operate according to the Annual Work Plan approved by the PSC of the project. All the administrative matters of the project: project implementation plans, procurement plans, financial plans, periodic reports, will be approved by the PSC. The funds will be distributed to EE and implementing partners, based on work plans and budgets approved by the PSC. The PIUs will collaborate closely with national ministries and implementing partners to ensure efficient use of resources, in line with project objectives

The management oversight of the PIU will be held by SCI Mali, which has the legal standing necessary to implement GCF activities in Mali. The implementing partners, including AEDD, local NGOs, Solar and Biodigester Suppliers, have no discretion in implementing funded activities or in the usage of GCF funds. All such discretions shall lie with SCI Mali, the Executing Entity.

Figure B.4.1: Management, Financial and Coordination Flows



AEDD = Agency for Environment and Sustainable Development, **ME&S** = Ministry of Environment and Sanitation, **MoA** = Ministry of Agriculture, **MoLF** = Ministry of Livestock and Fisheries, **MCF** = Mali Climate Fund, **MAWCF** = Ministry for the Advancement of Women, Children and Families, **NDA** = National Designated Authority, **SCA** = Save the Children Australia, **SCI Mali** = Save the Children Mali, **CSOs** =Civil Society Organizations, **PS** = Private Sector

To meet the fiduciary requirements and standards of the GCF, legal and management oversight of the PIU will be held by SCI Mali, which has the legal standing necessary to implement GCF activities in Mali. It is also legally and organizationally bound to SCA, which acts as AE and holds the AMA with the GCF on behalf of the SC movement. Based on the assessment of the Financial Management and Capacity Assessments (FMCAs), as AE, SCA will channel GCF resources to a project-specific bank account managed by the PIU in Mali. The PIU will use these resources and co-financing to manage project governance and implementation and will manage all downstream flows implementing partners (local NGOs), and any other procured partners. (Note: Implementing partners will be selected and subcontracted as procured parties by the AE's procurement guidelines).

The PIU will deliver results through a combination of direct and indirect interactions with the 48 communities in 12 circles across 5 regions. The operational units in the five regions will be responsible for overseeing the daily operations of IAAT activities in the field. They will organize trainings, meetings, and conferences; liaise with service providers and communities; conduct monitoring and evaluation (M&E) activities; and engage with local stakeholders to ensure the smooth implementation of project activities. While the PIU will deliver technical and project assistance directly to the beneficiary communities, it will rely on the AEDD, SCI Mali, and local NGOs for the delivery of specific outputs (as depicted in Figure B 4.1).

X. ALIGNMENT WITH THE GCF INVESTMENT CRITERIA

IAAT is aligned with GCF's investment criteria across impact potential, paradigm shift potential, sustainable development, needs of the recipient, country ownership, and efficiency and effectiveness.

10.1 Impact potential

The project will contribute towards the GCF's mitigation and adaptation goals of supporting climate-resilient sustainable development and reduced GHG emissions by supporting its direct and indirect beneficiaries, 86,480 (farming households) and 700,980people respectively, whilst achieving an estimated mitigation reduction of 2,446,543 tCO2eq in 15 years.

The project will support the development of low-carbon, climate-resilient and sustainable livelihoods amongst communities in Mali that are increasingly climate-vulnerable and food, nutrition and water insecure. As a result, the project will support smallholder farmers to be increasingly resilient to climate-related disasters, such as drought, heat stress, floods and pests and diseases which are increasingly common in Mali due to climate change, whilst also lowering the GHG emissions of the agricultural systems. The project will aspire to reduce loss of life related to climate impacts primarily through food security improvements, help to increase and diversify climate-resilient livelihoods, and restore environmental assets through i) the planting of trees in agroforestry which will create a carbon "sink" and ii) improve land management practices through CSA techniques such as zai pits, increasing soil fertility and reducing desertification. The project will also reduce GHG emissions through the installation of biodigester systems and solar irrigation, which provide both adaptation and mitigation benefits for smallholder farmers.

As a mitigation and adaption project, IAAT will contribute to 4 results areas:

- ARA 1: most vulnerable people and communities, *through adaptation support delivered to smallholder farmer direct beneficiaries, identified as the most vulnerable to climate change in Mali*
- ARA 2: health, well-being, food and water security, *through support delivered to smallholder farmer direct beneficiaries on increased agricultural productivity resulting in increased food and nutrition security.*
- MRA 4: forestry and land use, *through the dissemination and planting of agroforestry and other CSA techniques*
- MRA 1: energy generation and access, *through the installation of biodigester systems and solar pumps*

By delivering outputs against the following results indicators, with further detail provided below:

- Core indicator 2: Direct and indirect beneficiaries reached.
    - Supplementary 2.1: Beneficiaries (female/male) adopting improved and/or new climate-resilient livelihood options.
    - Supplementary indicator 2.2: Beneficiaries (female/male) with improved food security
- Core indicator 4: Hectares of natural resources brought under improved low-emission and/or climate-resilient management practice.
- Core indicator 1: GHG emissions reduced, avoided or removed/sequestered.

The estimated direct beneficiary population will be 431,700 people across 48 communes, corresponding to 4.2% of the population in the five regions and about 2.4% of the national

population.[477] The project will directly target women in component 2 through activities that support women entrepreneurs and their access to finance, including additional support for a sub-set of the female direct beneficiaries (4,633 women). In addition, the project will include an estimated indirect beneficiary population of 770,000.

- Communities in 48 communes across 12 circles in the 5 targeted regions will receive locally tailored inputs based on their evolving needs and local context. Direct beneficiaries have been selected primarily on the basis that they are the most vulnerable to climate change, combining an assessment of climate risk, exposure, and adaptive capacity. Smallholder farmer direct beneficiaries will benefit from select activities in components 1, 2 and 3 that will increase the resilience of their farms to climate change. This is primarily achieved through increased awareness, understanding, technical capacity and on-farm utilization of CSA practices and technologies. In addition, women and youth direct beneficiaries will also benefit from select activities in component 2 resulting in increased capacity to use and access to finance for CSA and agroforestry businesses, resulting in a diversification of climate-resilient livelihood options. Beneficiary numbers were calculated via a systematic approach to beneficiary identification at the Circle level based on published statistics and data, with further detail on beneficiary selection and targeting provided in the section *8.2 Beneficiary selection and* targeting.
- The 700,980 indirect beneficiaries account for 40% of the total population of the region who will benefit indirectly from the updated curriculum for public extension services and Farmer Field Schools in the project regions (Gao, Mopti, Koulikoro, Segou and Tombouctou). Component 3 will also further increase the capacity of national and local institutions to adapt to and mitigate climate change, resulting in long-term indirect benefits.

An estimated 21,585 Ha of improved agroforestry will be developed in the farmer's private lands through GCF's direct funding in component 1, through the production and distribution of agroforestry tree saplings (acacia Senegal, mango and fodder), planting and management samplings and growing trees in crop, grass/pasture, and community lands, this corresponds to 1,668,656 tCO2eq of emissions reduction in 15 year lifetime.

Further, 42,632 individuals (>6,000 households) will obtain increased access to clean energy sources through biodigester and solar pump systems, which will also provide a further mitigation outcome of 131,566 tCO2eq of emissions reduction. Further 646,320 tCO2eq of mitigation due to the adoption of CSA techniques.

The project will directly contribute to the adaptation and mitigation priorities of the Government, engage in design and implementation with local communities and in particular marginalized groups, and fosters engagement by the private sector through local value-chain development.

10.2 Paradigm shift potential

As outlined in the theory of change, this project seeks to achieve a paradigm shift in the agricultural system of Mali away from a system that is both highly vulnerable to climate change and food insecure, and towards one where smallholder farmers have climate-resilient livelihoods, food and nutrition security, and a reduced GHG footprint.

As outlined in the theory of change, the project's paradigm shift statement states that:

***"IF** smallholder farmers in highly vulnerable regions in Mali can access and adopt climate resilient technologies, knowledge, and low carbon agricultural practices, **THEN** their food, nutrition and water security will be improved **BECAUSE** their adaptative and mitigation capacities including improved technical skills, access to*

[477] It is widely recognized that population estimates are not accurate in Mali as the last census was performed in 2009. The data here has been taken from the OCHA official estimate from 2022 which is available here.

finance, markets and sustainable livelihoods, and that of public and private institutions will be strengthened to respond to and reduce the climate change risk and impacts"

Across components, the project proposes solutions that are commensurate to the climate risks and impacts identified and promotes sustainable system-level changes in agricultural and agroforestry practices that facilitate wider adoption by farmers of appropriate climate-resilient technologies. In tandem, the project develops institutional arrangements to apply and to scale out actions from the farm to the landscape level. Therefore, the project has considerable potential to catalyze impact beyond its intervention cycle and create a paradigm shift. Further detail on how IAAT will achieve a paradigm shift are outlined below and include i) support for low-emission and climate resilience development pathways, as well as their replicability and consistency with Mali's existing adaptation and mitigation strategies and plans, ii) potential for knowledge sharing and exchange, iii) contribution to the creation of an enabling environment.

10.2.1 Potential scale up and replication

- The project will effectively contribute to low-emission and climate-resilient development pathways in Mali by increasing the long-term capacity of smallholder communities and their surrounding environment to recognize and respond to climate risks, increasing sustainable and low-carbon crop and livestock production and land management by smallholder farmers, and hence, both increase the resilience and reduce the GHG emissions of the agricultural system.
- IAAT will facilitate building a strong partnership between private solar and biodigester technology suppliers through a PAYG financial and technology transfer model in the IAAT locations. This approach will bring a large amount of private sector finance from technology suppliers and financial institutions. The private sector will continue scaling up and replicating this business model in and beyond IAAT locations during and after the project completion.
- IAAT's approach is consistent with Mali's existing policy priorities and devolved governance approach increasing its long-term paradigm shift potential as well as its support within the country. For example, the project's emphasis on Climate Smart Agriculture is directly aligned with NDC, NAPA, and PDESC.
- IAAT also has strong institutional foundations for scale-up within Mali. The USAID Albarka project, IAAT's co-founder and co-implementing partner has existing field infrastructure and already established relationships with the AEDD - the Executing Entity, the Ministry of Agriculture, other governmental and non-governmental entities, and vulnerable communities. These existing relationships will provide a platform for the project to scale-up actions effectively and efficiently both during and after the project implementation. Replication examples include the establishment of CACs and development of Community Action Plans, the development process for contingency plans for EWS information dissemination and response, extension officer curriculum, national land use database, youth and women business and financial training, guidelines for financial institutions (including microfinance), establishment and capacity building of private sector to engage and provide services to small holder farmers.

10.2.2 Potential for knowledge exchange and sharing lessons learned

- IAAT seeks to enhance the knowledge and data environment around climate-smart agriculture and agroforestry at the community, regional and national level in Mali. The project will also enhance the local knowledge network including communities, public and private extension agents, and market agents. This knowledge exchange directly supports the scale-up of climate-resilient agricultural practices and reinforces the resilience of farmers' livelihoods. For example, the CSA curriculum, social

mobilization, and integration of traditional knowledge and experience in climate change adaptation are key tools for scaling up CSA and agroforestry.

- At the regional and national level, IAAT explicitly targets knowledge exchange, and the sharing of lessons learned through yearly forums for all key actors (national, regional and local bodies, other agricultural and climate change projects, researchers and traditional knowledge groups) to share and discuss the key technical learnings of the project and how these could be broadened to additional areas.
- The IAAT project will also create an enhanced land use database and deliver training on the interpretation of land use data to extension services. By increasing access to reliable information at the extension service level, the project will facilitate improved climate adaptation by improving the tailoring of adaptive techniques to the circle level. In addition, the land use database will enhance the national data environment for future mitigation and adaptation planning and research at the local and national level, including for policies, research and interventions.
- In support of this knowledge sharing, the Monitoring and Evaluation Plan (see Annex 11) will also develop a detailed view on the realized outputs of the project during implementation to support the ongoing development of implementation insights and "lessons learnt". The project's knowledge management and learning activities will therefore develop and enhance knowledge availability and knowledge resource management competence at the national level, as well as farmers' ability to propose solutions to changing climate circumstances.

10.2.3 Contribution to the creation of an enabling environment

- IAAT will contribute to the creation of an enabling environment for a low carbon and climate-resilient agricultural system in Mali by i) addressing existing systemic barriers to adaptation and mitigation at the farm and community levels, ii) closing market-level knowledge gaps on how private sector businesses can serve smallholder farmers with low-carbon and climate resilient products and services and iii) building institutional capacity for long-term adaptation and mitigation planning and implementation. The project will address a broader range of systemic barriers as outlined and shown in the ToC diagram, including financial, informational, social, market, and technical as discussed in section B. 2 (a). Addressing these barriers will also help to create the enabling environment for scaling up CSA and agroforestry.
- IAAT will significantly contribute to institutional capacity building. The institutional capacity building at the community, regional and national level for mitigation and adaptation planning and implementation will contribute to shift in the institutional priorities to address climate change challenges across the country.

10.3 Sustainable development potential

The IAAT will make direct and indirect contributions to Mali's efforts to meet the Sustainable Development Goals, particularly in addressing SDG13 "strengthen resilience and adaptive capacity to climate-related disasters, integrate climate change measures into policies and planning, build knowledge and capacity to meet climate change"; and SDG 2 "End hunger, achieve food security, improve nutrition, and promote sustainable agriculture". It will also support the following SDGs:

- SDG1 (end poverty in all its forms everywhere)
- SDG2 *(end hunger and achieve food and nutrition security)
- SDG8 (promote inclusive and sustainable economic growth, employment, and decent work for all)
- SDG12 (ensure sustainable consumption and production patterns)
- SDG15 (sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss).
- The project activities will result in the following 4 co-benefits:

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- *Environmental co-benefits*: Increased resilience of ecosystems and ecosystem services in the project locations because of i) agroforestry-driven tree plantation (fodder, fruits, and wood trees), and ii) the promotion of agricultural practices that contribute to improved soil and water conservation (for example, soil, nutrient, and water management practices). Cleaner land, water and air are therefore co-benefits of improved food production and forestry management. In addition, several recent studies show that sustainable intensification of agroforestry and agriculture systems have positive impacts on diversification of pollination, pest control, nutrient cycling, GHG emissions reductions, water regulation, and soil health.[478, 479]

- *Gender co-benefits*: Women who are involved in smallholder farming have a disadvantaged position in comparison to men due to systematic gender discrimination. IAAT will deliver gender co-benefits by transforming broader gender dynamics in the home and the community because of reducing gendered access to resources and to decision-making power and opportunities. Women will be specifically targeted as direct beneficiaries across activities and exclusively in activity 2.2.1, which will specifically seek to increase their access to finance and enhance their capacity for setting up agribusinesses. Component 1 will also seek to increase the gender inclusivity of existing education channels for smallholder farmers, by increasing the gender awareness of agricultural extension services. Component 2 will create time-saving benefits for women, with the biogas systems deployed reducing the need to collect wood for fuel, an activity primarily conducted by women. Combined, IAAT's activities will result in co-benefits for women that include raising the standard of living, overall quality of life and agency for female smallholder farmers. The project will recognize and differentiate the roles played by women and men and contribute to filling gaps in gender equality and will improve participation in decision-making, increased agency and directly build leadership capacity.

10.4 Needs of the recipient

10.4.1 Vulnerability Profile of Mali

Mali is one of the "Least Developed Countries", a group that has been identified by the GCF as a strategic priority for supporting adaptation. Mali is highly exposed to the impacts of climate change with GAIN ranking it as the 24th most vulnerable to climate change and the 47th least ready for climate change out of 197 countries[480]. The country's climate change vulnerability stems from its limited rainfall throughout the country, and the hot climate, with an average mean temperature of ~28°C.[481] These climatic conditions impact Mali's agricultural productivity and contribute to a high level of food insecurity, as evidenced by the high levels of acutely malnourished children aged 6-59 months which reached 1.2 million children between September 2021 and August 2022, an increase of ~53% 2020-2021.[482] Extreme poverty is also widespread throughout Mail which and has recently increased to reach 19.1% in 2022 (up from 15.9% in 2021).[483]

With agriculture being the main source of livelihood for 75% of the population, Mali has a high dependence on small-scale, rainfed, subsistence agriculture and agropastoralism. Agriculture is threatened by increasingly adverse climatic conditions (72% of Mali's

[478] Snapp et al., (2021), Agroecology and climate change rapid evidence review: Performance of agroecological approaches in low- and middle- income countries, Available here
[479] Biswas et al., (2022), Agroforestry offers multiple eocsystem services in degraded lateritic soils, Available here
[480] GAIN (2021), Vulnerability Index, available here
[481] World Bank, (2023), Climate Knowledge Portal Mali profile. Available here
[482] ReliefWeb. (2022), Breaking the spiral of the Food and Nutrition Crisis in Mali Available here
[483] World Bank, Mali Presentation, Link

population live in medium to high climate vulnerability. The erratic rainfall and rising temperatures seen in the last 30 years and forecast to increase in variability have exacerbated the magnitude of floods and droughts, which are the main climate hazards in Mali. According to the World Bank, droughts and floods have affected nearly 7 million people in the 1980-2014 period and generated an economic cost of USD 140 million. As the frequency and longevity of floods and droughts increase, they are forecasted to generate losses of up-to USD 300 million per year from 2030 onwards (around 15% of the value created by agriculture and breeding). [484]

Food insecurity is a key challenge for Mali. The continuous cycle of droughts, floods, and hotter temperatures referenced above, combined with the proliferation of pests, have generated severe impacts on crop production, decreasing yield and agricultural land, and reducing the nutritional value of some crops. Due to recurrent droughts, more than 3.5 million people were food insecure and almost 1 million people in need for food assistance in 2017, and 40% of livestock was estimated to be lost in the 1972-1974 droughts. The potential decrease of cereal yield will likely generate major food tensions in Mali, due to their predominance in farms and nutrition (68% of all daily caloric intake and 70% of cultivated area. According to the Center of Africa-Europe relations, the predicted losses in livelihoods due to declining resource availability could generate an overall loss of welfare ranging from USD 70 to 142 million and increase the share of the population at risk of hunger from 44% to over 70%. In addition, Mali's growing population compounds food security challenges. (For further information on Mali's overall vulnerability please see sections *Mali Context* and *Climate Change Projections and Hazards* in Mali*.)*

Accordingly, IAAT is designed to meet the needs of Mali's smallholder farmers by promoting climate-resilient agriculture and agroforestry by strengthening farmer and institutional capacities, improving extension and advisory services, applying sustainable agricultural technologies that promote climate adaptation and mitigation co-benefits, implementing agroecological practices both on-farm and at the landscape level, supporting the development of inclusive CSA value chains and markets, and increasing the incorporation of climate risks and vulnerabilities in long-term planning at an institutional level. These actions will provide important incentives for changing the practices of smallholder farmers and improving the relationships they have with other players in various food value chains, which is critical for making a transformational change towards livelihood security, food production, and climate resilience. Women and youth are further specifically targeted by this project to bring about transformational change in access to finance, CSA practices and diverse and climate resilient livelihoods.

10.4.2 Mali's Financing Needs and Absence of Alternative Sources of Finance

As a result of its high vulnerability to climate change and food insecurity, Mali has large financing needs. Mali has no viable source of domestic financing and is not a current focus for many other donors. The exact level of funding needed for climate-resilient, smallholder agriculture and agroforestry in Mali is hard to determine but estimates of the general needs in the sector indicate the magnitude of climate investments required. The Growth and Poverty Reduction Framework estimates that an additional investment of US$307 M will be needed to address current needs to improve land management strategies and infrastructure, increase access to technologies, structured partnerships, and advisory services, especially for women. Major investments are also needed in research and institutional capacity building to address systemic issues related to the design and delivery of climate-resilient interventions that fit local needs and conditions. The estimated cost for the National Agricultural Sector Investment Plan (PNISA) implementation for agricultural transformation is US$6.7 billion, of which more than 80% budget is anticipated from donors. Similarly, the estimated cost of Mali's NDC implementation is US$1.257 billion for water management and

[484] Makougoum C. T. P., (2020), Changement climatique au Mali : Impact de la sécheresse sur l'agriculture et stratégies d'adaptation, Available here

system of rice intensification (US$590 M), soil erosion control through tree plantation (US$500 M), sustainable crop nutrient management (US$2.5 M, and GHG emissions reduction from the livestock sector (US$165 M). The implementation of Mali's NDC is conditional on technical and financial support from international donors and financial institutions.

In addition, despite the urgent need for such large-scale funding, climate finance to smallholder agriculture in Mali is disproportionately low when compared with the importance of agriculture to the economy. The low-profit and high-risk nature of smallholder agriculture has made lending conditions onerous, created limited exposure to external investment, and attracted higher interest rates and high collateral requirements, which severely impact agricultural production and weakens small-scale agribusinesses.[485] The relatively weak capacity among smallholder producers means that alternative funding options for supporting investment at the scale proposed by IAAT project are limited outside of donors such as the GCF.

10.5 Country ownership

IAAT was developed and designed in collaboration with stakeholders from across all 5 regions of the project (Gao, Tombouctou, Segou, Koulikoro and Mopti), including farmers and farmer organisations, private sector businesses, local and international NGOs, and national and regional government departments.

The project builds upon a letter submitted by the NDA to the GCF in 2021 endorsing the submission of this project idea. It has been designed in collaboration with the Malian government, in particular the Environmental and Sustainable Development Agency, Mali's NDA and the Executing Entity for IAAT (in combination with Save the Children). Throughout project design, over 350 stakeholders were engaged to collaboratively design the project, including government ministries, private sector businesses, local community beneficiaries and local NGOs. These stakeholder consultations have significantly shaped the project (with further detail provided in Annex 7: Stakeholder Engagement Plan) and will continue to be engaged to refine the project during project implementation.

The project is a high priority for the Government of Mali because of its high potential to contribute towards meeting national priorities for climate-resilient agricultural development as espoused in the NDC, Growth and Poverty Reduction Strategic Framework 2012 to 2017, the Agricultural Orientation Law, the National Food Security Strategy, the Strategic Framework for Economic Recovery and Sustainable Development in Mali 2016 to 2018, National Adaptation Programme of Action (NAPA), National Agricultural Sector Investment Plan (PNISA), National Climate Change Policy (PNCC) and the National Climate Change Strategy (SNCC) and the 2019 Climate-Smart Agriculture Investment Plan. Together, these policies and plans call for improving institutional development and governance, enhancing food security and nutrition, fostering national and regional integration processes, and promoting intensive, diversified, and sustainable agriculture.

In addition, in its updated Nationally Determined Contribution (NDC), Mali committed to reducing emissions by 25% for agriculture, 31% for energy, 39% for LUCF, and 31% for waste by 2030 compared to projected business-as-usual emissions.[486] Priority actions in Mali's NDC include agroforestry, sustainable rice cultivation, and crop nutrient management, all of which are actively included in this project.

The project will be executed by Save the Children Australia and the Environmental and Sustainable Development Agency (AEDD). AEDD's involvement will continue to enable

[485] *op. cit*, footnote **Error! Bookmark not defined.**
[486] Ministry of The Environment, Sanitation and Sustainable Development, (2021), Revised Nationally Determined Contributions, Available here

strong country ownership, further supported by the project's steering committee which includes the Ministry of Environment and Sanitation, the Ministry of Agriculture, the Ministry of Livestock and Fisheries, Mali Climate Fund, the Ministry for the Advancement of Women, Children and Families, civil society organisations as well as AEDD in its capacity as the NDA and the EE. Section *IX Governance of the* Project presents a summary of AEDD's capability and capacity to co-drive the execution of the project.

XI. EFFICIENCY AND EFFECTIVENESS

An Economic and Financial Analysis has been completed for the IAAT – please see Annex 3 for more detail. The proposed project activities are efficient with climate-resilient agricultural practices and agroforestry being relatively low-cost, and delivering benefits across mitigation, adaptation and productivity as well as a range of additional co-benefits.[487] The project design is effective because it prioritizes smallholder farming communities that are amongst the most vulnerable to climate change in Mali. It promotes more productive and resilient agriculture and agroforestry to ensure the efficient and sustainable use of natural resources while contributing to making the changes needed in national and local governance. At the same time, the project will strengthen knowledge management and lesson sharing from the farm to the national level, which helps to generate the evidence needed to guide future investments by the government and other development agencies. Its design, therefore, allows for providing demand-driven knowledge outputs to policymakers, practitioners, and smallholder farmers - men and women - for improving the effectiveness and efficiency of climate-resilient development interventions at various scales.

During implementation, the project activities will be guided by a high-level Project Steering Committee, including the NDA, to ensure the Project Management Unit remains aware of relevant upcoming projects and can work collaboratively with them to avoid duplication and overlap. In addition, activities will draw on existing relevant project results, resources and networks. The project is also designed to deliver the following metrics, outlined in the table below.

Table 31: Efficiency and Cost Metrics of IAAT

	Project Total Metric	GCF funding-specific metrics
Total project cost per direct beneficiary (USD)	102.44	78.1
Total project Project cost per tonne of Carbon Dioxide equivalent (USD)	18.07	13.78
Ratio of co-financing (GCF: co-financing ratio)	3:2.1	n/a
Expected economic internal rate of return	*15% (at USD 0 per ton of CO2)*	n/a
	51% (at USD 60 per ton of CO2)	n/a

[487] Kiptot and Franzel, (2012), Gender and agroforestry in Africa: a review of women's participation, Available here

XII. SUSTAINABILITY AND EXIT STRATEGY

Long-term sustainability and systems-level change is fundamental to the approach underlying the project design and implementation (see *2.1 Introduction to the design approach*). IAAT will provide the building blocks of a shift in the agricultural and agroforestry system in Mali and an opportunity to create transferable learnings and models across communities and regions in Mali, as well as neighboring countries with similar contexts. The long-term sustainability of IAAT is present across components and built into project design through the inclusion of: capacity building and institutional strengthening; beneficiary ownership; investment in suitable and sustainable technologies; and compatibility with existing government policies.

12.1 Capacity Building, Strengthening of Institutions and Knowledge Sharing

Capacity building is at the heart of the project, and forms part of all components, supporting the long-term sustainability and impact of IAAT's outcomes. The project directly works with the national government, national extension services, local financial institutions, private sector businesses and smallholder farmers to help them build capacity in techniques, technologies, and processes directly or indirectly relevant to the delivery of climate-smart agriculture. Capacity will be built up at three levels: community (e.g. women and youth entrepreneurs, producer associations, VSLAs), private sector (e.g. solar irrigation and biogas companies) and institutional (e.g. extensions services, National Climate Fund).

In addition, within this capacity building, there are a number of activities and sub-activities from the GCF IAAT project that are easily transferable beyond both the direct beneficiaries of the project during and after project implementation. This is a particular focus for components 1 and 2 which include, amongst other activities, the development of: modular training packages for subsistence and smallholder farmers and including women, youth, and men; private sector engagement techniques and development of inclusive business offerings for CSA businesses; inclusivity workshops and training for extensions services; and technical guidelines for businesses working in solar irrigation and biogas systems to support extension.

Institutional strengthening is a corresponding component to capacity building, with both local and national institutions supported to develop their capacity and therefore strengthen their influence. At the national and regional government level, activities in component 3 include the organization of best practice regional government workshops on adaptation plan development and capacity building of the NCF on disbursement and impact assessment. At the local level, components 1 and 3 support the capacity building of and, where absent, the establishment of local institutions such as VSLAs and Community Action groups. By enhancing the opportunities for collaborative community engagement with CSA, climate change and the development of sustainable value chains, these new or enhanced institutions are likely to lead to the increased sustainability of the project activities.

In addition, increased creation and sharing of climate data and knowledge is specifically targeted in Component 3 and Component 1. For example, Component 3 includes the organization of twice-yearly forums for all key actors (national, regional and local bodies, other agricultural and climate change projects, researchers and traditional knowledge groups) to share and discuss the key technical learnings of the project and how these could be broadened to additional areas. In these forums, and other activities across Component 3, organizations will be invited from both the regions of the project and the regions not covered to extend the reach of the findings and build synergistic relationships. Component 1 will also serve to create long-term sustainability of the project through its focus on land use mapping which will provide an enhanced data environment and understanding of land use in Mali. This can support the creation of future climate and agricultural policies, research, and interventions.

12.2 Beneficiary Ownership

12.2.1 Beneficiary ownership at both the community and institutional level is integrated throughout the project design.

At the institutional level, the Environment and Sustainable Development Agency of Mali (also known as the AEDD in Mali) is both the NDA and one of the executing entities. The AEDD is therefore at the heart of the project and offers a critical opportunity for institutional beneficiary ownership that will support the smooth exit and long-term outcomes of the project. Furthermore, as outlined in the chapter *119IX Governance of the* Project, the Project Steering Committee also includes 6 government ministries and directorates, representing a broad range of government areas and supporting government ownership.[488]

At the community level, all activities implemented within communities have been designed in collaboration with beneficiaries and will be informed by community stakeholder engagement during implementation (components 1, 2 and 3). For example, within the target community's stakeholder engagement will be conducted to collectively determine the distribution and fair use of all new technologies, equipment and practices distributed (e.g. solar irrigation systems, biogas systems, on-farm agroforestry planting) increasing beneficiary ownership. Communities will also be supported to design their own forward-looking management plans which will include long-term targets that will outlast the project implementation period. For example, Community Action Groups will be supported to develop plans for local adaptation practices and the management of local community assets as part of component 3. Similarly, in the support delivered to extension services, linkages between extension services and local community organisations are developed and supported in order to ensure extension services are collaborative, and locally adjusted as well as able to leverage local community knowledge. Beneficiary ownership over project activity implementation at both the institutional and community level will therefore increase the likelihood that activity outputs and outcomes will be sustained beyond the life of the project. In addition, there will be many occasions for stakeholder and beneficiary engagement during the project implementation (see section *8.3 Stakeholder*), providing opportunities for the project to be updated and course-corrected if beneficiary ownership is not satisfactorily achieved and presents a risk to the long-term outcomes of the project.

12.2.2 Investment in Sustainable and Suitable Technology

IAAT invests in technologies and their supporting value chains that have been selected as sustainable and suitable for the local context, specifically solar irrigation systems, and biodigester systems. Component 2, and part of Component 1, support the installation of solar irrigation and biogas systems. Through stakeholder consultation and a review of the existing academic literature, these technologies have been identified as particularly suitable for the regions of Mali where the project is being implemented (for more information see *7.3 Technologies and Techniques Options* Assessment*).* IAAT supports their deployment in a long-term, sustainable way by ensuring that: i) beneficiaries are selected carefully for technical compatibility (for example, applicable livestock ownership for biogas systems, applicable groundwater for solar irrigation), ii) beneficiaries are knowledgeable of best practices for the equipment's usage through the delivery of targeted training to beneficiaries on usage at each stage in the technology deployment (installation requirements, relevant inputs, opportunities to create businesses with the technologies, and required maintenance practices), and iii) the supporting infrastructure has the capacity to ensure the equipment's long-term productive use through capacity building for local tradespeople on construction

[488] The PSC provides project oversight and strategic guidance, and members may comprise: Save the Children Mali as a executing entity, the Ministry of Environment and Sanitation (ME&S is mandated to coordinate climate change action in Mali) as co-executing entity, Environment and Sustainable Development Agency (ESDA, as an executing entity), the Ministry of Agriculture, the Ministry of Livestock and Fisheries, Ministry for the Advancement of Women, Children and Families, regional government and Mali Climate Fund.

and operations and maintenance. In addition, the technology providers will be supported through component 2 to expand their businesses further and develop women and youth inclusive business models, supporting the development of the technology market and the long-term expansion of the technologies in Mali. Farmland use mapping and monitoring techniques will also be supported by component 1 by training on usage for farmer associations, and the creation of project land use database, integrated into the existing databases and connected to researchers through component 3.

12.3 Support for and compatibility with Mali's policies and regulations

In addition, the project supports and is in turn strengthened by existing climate change, agricultural and environmental policies in Mali**.** Agriculture is at the core of Mali's climate policies, and vice versa, with prominence placed on practices at the IAAT across policies such as: climate smart agriculture, sustainable land management practices and reforestation. Specifically, the project is aligned with and supports Mali's Nationally Determined Contributions (NCD), National Adaption Programme of Action (NAPA), National Climate Policy (PNCC) and National Climate Change Strategy (SNCC). For example, the NDC highlights the importance of "climate-smart and resilient agriculture" practices to mitigate climate change and mentions forestry, energy, and agriculture as the priority areas to improve adaptation and resilience capacities.[489] Agriculture is also identified by the National Adaptation Programme of Action (NAPA) as a priority sector for investments, especially for the promotion of CSA technologies, including the adoption of climate-resilient inputs and livestock species, the development of irrigation infrastructures as well as agro-meteorological advisory systems.[490] The government aims to leverage CSA practices and technologies to increase the productivity and incomes of Malian farmers and improve the livelihood of populations.[491] The PNCC and SNCC also encourage participatory and decentralized management of natural resources, facilitating planning, implementation, and coordination across sectors and stakeholders.[492] Within the SNCC's eight strategic pillars, the following key topics are included: mainstreaming climate change into sectoral policies, capacity building, climate finance, and private sector engagement in climate change mitigation efforts. Various actions are outlined within these pillars, including reforestation, enhancement of weather and climate information systems for agriculture, climate resilience in the agriculture and forestry sectors, agricultural diversification, and sustainable land management, among others.[493]

IAAT is closely aligned with the above policies across its components which collectively seek to increase the climate resilience of Mali's agricultural system and increase the adoption of low-carbon livelihoods. IAAT will achieve this through activities that deliver increased awareness and usage of Climate Smart Agriculture techniques and technologies *(highlighted in NAPA, NDC),* the corresponding on-farm production of CSA crops/livestock, agroforestry *(SNCC)* and the creation of integrated and inclusive CSA value chains – ultimately generating an adaptive and mitigation shift in Mali's agricultural system. For example, component 1 focuses on increasing the awareness of climate risks and adoption of CSA techniques amongst smallholder farmers by firstly building the capacity of agro-advisory services, the key educational service for smallholder farmers, and secondly by supporting the on-farm adoption of CSA techniques, with a particular emphasis on agroforestry. This component also includes integrating existing work from the Malian government, NGOs and the GCF on climate information and early warning systems to broaden awareness and usage *(highlighted in SNCC and NAPA).*

[489] CIAT, ICRISAT, BFS/USAID, (2020), Climate Smart Agriculture in Mali, Available here
[490] IBID
[491] IBID
[492] IBID
[493] IBID

XIII. CONCLUDING STATEMENT

Mali is one of the most vulnerable and highly exposed countries in the world to climate change: it is is ranked the 11th most vulnerable country and the 23rd least ready country to the impacts of climate change, out of 192 countries.[494] Historical climatic trends, such as increasing temperatures and more erratic, reduced volumes of rain in the wet season have been observed over the last 60 years, and are forecast to continue. Mali is highly exposed to climate hazards including drought and flooding with Mali ranked among the countries that are most vulnerable to drought according to the Intergovernmental Panel on Climate Change,[495] with a drought severity index of -5.[496] It is estimated that in Mali, four hundred thousand people are currently affected by droughts that 500,000 people are currently affected by floods each year.

These hazards are present against a backdrop of high levels of poverty and food insecurity, compounded by a fast-growing, young population placing increasing strain on Mali's natural resources. Most of the population lives rurally, with the agriculture sector accounting for many livelihoods. As agriculture is predominantly based on smallholder, rainfed, subsistence agriculture and agropastoralism, this inherent reliance on the landscape and climate makes Mali's population highly exposed to climate risks. In October-December 2022, 3.4 million people were food insecure (15% of the population) of which 617k were in the "crisis" phase; with overall food insecurity forecast to increase to 18% of Mali's population during June-August 2023.[497] Extreme poverty is also widespread throughout the Mail and has recently increased to reach 19.1% of the population in 2022 (up from 15.9% in 2021).[498]There is limited adaptive capacity across Mali's smallholder farmers, with the adoption of irrigation, and modern seed varieties remaining low. Smallholder farmers face barriers to adaptation including lack of knowledge and capacity to implement CSA techniques and lack of access to transparent markets to sell their crops, compounded by limited support from extension services and limited capacity at the local government level. In addition, although Mali's greenhouse gas emissions remain very low relative to global averages, agriculture represents 70-80% of Mali's total emissions, and the government has committed to reduce the sector's emissions by 25% in its revised NDC. It is therefore important that adaptation to the changing climate is combined with low-carbon development pathways.

The project will focus on the challenges faced by smallholder farmers in the highly climate-vulnerable regions of Tombouctou, Gao, Mopti, Koulikoro and Segou through 4 interlocking components. These components address the barriers faced by smallholder farmers to increase their climate resilience and support low-carbon agricultural development by working at the on-farm, market, and institutional levels. The project will work towards the achievement of i) increased climate-resilient agricultural crop and food production in the targeted regions in Mali, ii) improved and inclusive access to finance and markets for the vulnerable communities to enhance sustainable livelihoods; iii) reduced GHG emissions from agricultural system and iv) adaptation and mitigation considerations and best practices are embedded in institutional agriculture and agroforestry planning. In addition, the project will deliver the following co-benefits because of its activities: i) improved health outcomes from increased food security, ii) increased gender equality and economic empowerment, iii) increased income and job diversification and iv) improved soil conditions and water resources from land use improvements.

[494] NDC Gain index, (2002-2021). Mali, Available here
[495] Makougoum C. T. P., (2020), Changement climatique au Mali : Impact de la sécheresse sur l'agriculture et stratégies d'adaptation, Available here
[496] Makougoum C. T. P., (2020), Changement climatique au Mali : Impact de la sécheresse sur l'agriculture et stratégies d'adaptation, Available here
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World Bank, (2021), Regional Sahel Pastoralism Support Project II (P173197), Available here
World Bank, (2022), Population growth (Annual percentage – Mali), Available here
World Bank, (2023), Climate Knowledge Portal Mali profile, Available here
World Bank, (2023), Mali Presentation, Available here
World Bank, (2023), Total greenhouse gas emissions, Available here
World Bank, (2023), West Africa Food System Resilience Program (FSRP) Phase 2, Available here
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World Bank, Think Hazard Mali profile, Available here
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ANNEXES TO THE FEASIBILITY STUDY

A: FOOD SECURITY AND LIVELIHOOD SECTOR ANALYSIS

Introduction

Agriculture is one of the most important sectors within Mali, representing ~36% GDP[499] and the serving as the dominant livelihood for much of the population. More specifically, Mali has a high dependence on small-scale, rainfed agriculture and agropastoralism which represent the main source of livelihood for 80% of the population.[500]

Due to the significance of agriculture in Mali for employment and food consumption, the impacts of climate change on crop suitability, yields, water availability etc. can have significant knock-on effects on food security. This chapter identifies that, at the national level, the most significant agricultural livelihoods are centered around the production of cereals (maize, rice, millet, and sorghum) and the rearing of livestock. Climate events (hazards and trends) are already and will continue to have an impact on agricultural production and as a result food insecurity is increasing. The experience and the impact of climate events on livelihoods and food security is different depending on the exposure to risks (climate and other) in the different livelihood zones throughout Mali.

Agricultural production in Mali

The agricultural sector is predominantly based on subsistence farming, with smallholder farmers who work on small parcels of land (less than 10 ha, mostly less than 5 ha) representing over 86% of farmers.[501] Smallholder subsistence farmers produce crops and rear livestock predominantly for household consumption and generate household income by selling a small proportion of their total production. The importance of agriculture is particularly pronounced in rural areas, where more than 80% of the population depend on the smallholder production system of staple crops (maize, rice, millet, sorghum and cowpea), vegetables, and fishing for survival.[502]

The most dominant sources of agricultural production are crop production, representing 45%, and livestock production, representing 28%.[503] Within crop production, the primary crops in terms of land use are maize, rice, millet, and sorghum,.[504] **Error! Reference source not found.** shows that overall cereal production has been increasing dramatically since 2000, but plateaued in from 2018-2020 and declined from 2020-2021. This trend is mirrored by all of the four dominant crops other than maize which remained stable in 2021. Within livestock production,[505] the most significant animals as a factor of production are cattle, chickens, goats and sheep, with cattle and chicken alone representing almost 70% of the meat produced nationally.[506] Figure 21 shows that overall meat production has increased significantly since 2015, but also declined from 2020-2021 with cattle showing more variability than the other animals.

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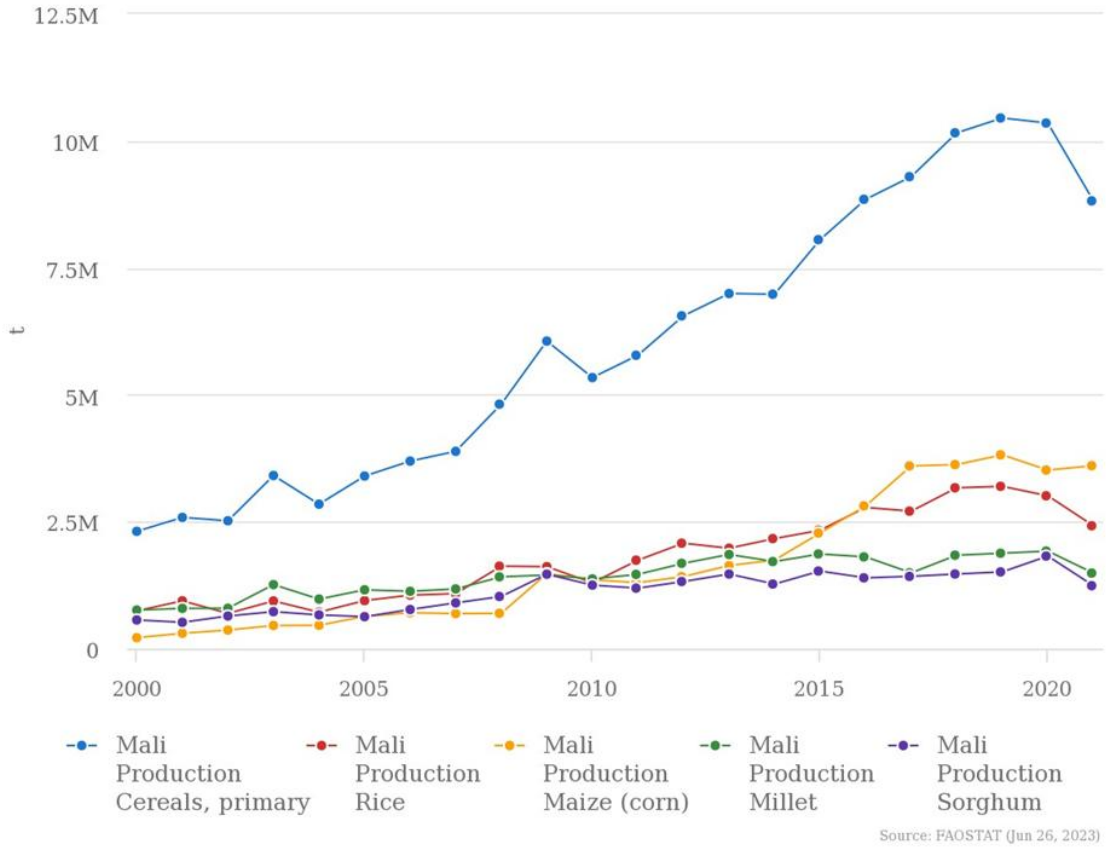
[499] Douyon A, Worou ON, Diama A, Badolo F, Denou RK, Touré S, Sidibé A, Nebie B and Tabo R (2022) Impact of Crop Diversification on Household Food and Nutrition Security in Southern and Central Mali, Available here
500 N'Diaye, I., Aune, J.B., Synnevåg, G., Yossi, H., & Hamadoun, A. (Eds.). (2020) Adaptation de l'Agriculture et de l'Élevage au Changement Climatique au Mali: Résultats et leçons apprises au Sahel. Available here

[501] CIAT, ICRISAT, BFS/USAID, (2021), "Climate-Smart Agriculture in Mali", Available here
[502] Douyon A, Worou ON, Diama A, Badolo F, Denou RK, Touré S, Sidibé A, Nebie B and Tabo R (2022) Impact of Crop Diversification on Household Food and Nutrition Security in Southern and Central Mali, Available here
[503] CIAT, ICRISAT, BFS/USAID, (2021), "Climate-Smart Agriculture in Mali", Available here
[504] FAO Statistics, (2021), Crops and Livestock production data, Available here
[505] Livestock can contribute in a number of ways to livelihoods with meat, animal products e.g. milk, and products e.g. leather contributing. Here meat production is being used as a proxy for livestock.
[506] FAO Statistics, (2021), Crops and Livestock production data, Available here

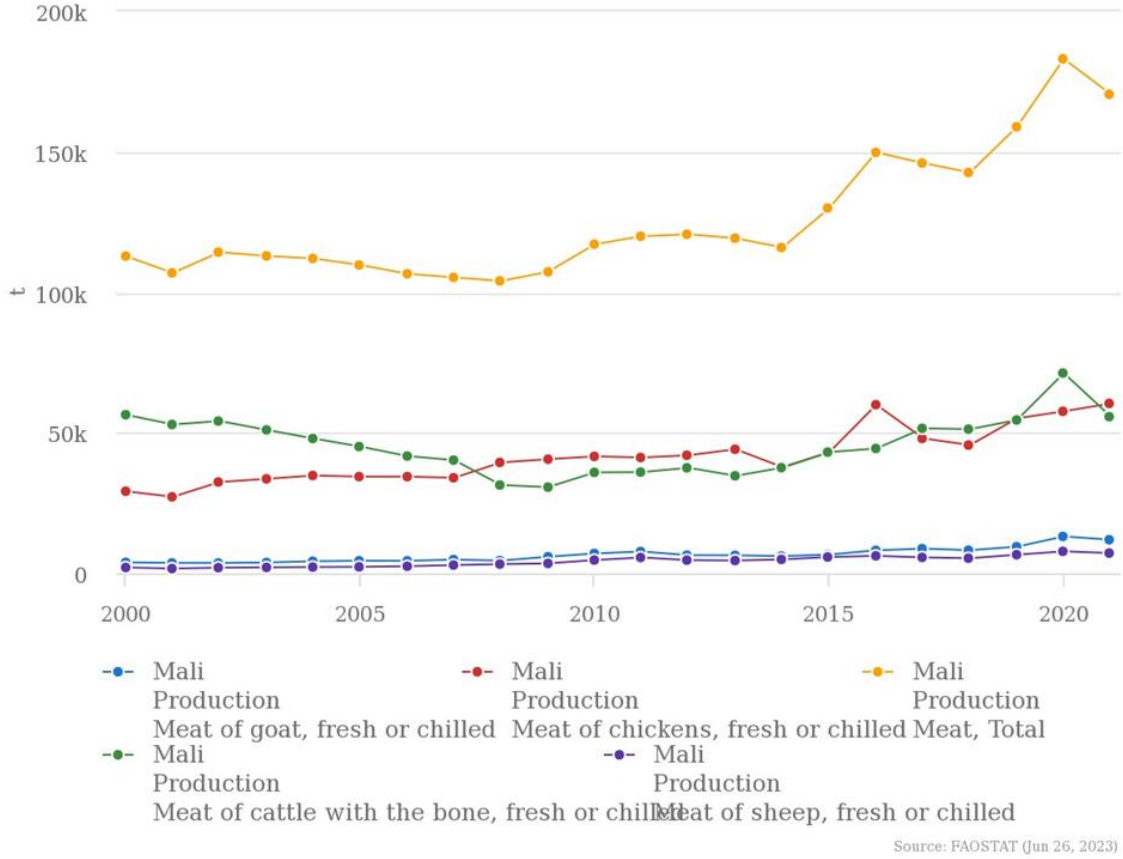
Mali has experienced continued population growth since 1955, with growth of 3.2% from 2020 to 2021,[507] which increases the pressure to maintain and increase food production. Consequently, although domestic food production has increased over the last 20 years, as shown by Figure 1 and 2, it is not able to keep pace with demand and declines in production, such as that seen in 2020-2021, further increase Mali's dependence on food imports. For example, during 2021-22, cereal import requirements were up 10% on the previous 5 year average, reflecting significantly higher year-on-year imports of rice due to Mali's need to bolster availabilities following the sharp decline in rice production in the 2021 cropping season. [508]

Figure 20: Primary crop production (M t) over time[509]



[507] World Bank, (2022) Population growth (Annual percentage – Mali), Link
[508] FAO, (2022), GIEWS Country Brief Mali 17-October-2022, Available here
[509] FAO Statistics, (2021), Crops and Livestock production data, Available here

Figure 21: Primary livestock production (k t) over time[510]



The impact of climate change on agricultural production

Climate events (hazards and trends) impact different agricultural value chains differently. The primary climate events that will be discussed were identified in *Chapter 53V*. For the purpose of this analysis, the climate trend of precipitation decreases, and the climate event of droughts will be examined together.

Precipitation decreases and droughts

Dependence on rainfall has been a major constraint on crop and livestock production, generating stress and failure.[511] Mali is a water scarce country, and it has experienced a steady decline in precipitation levels in the wet months (June, July, August, September) since the 1950s.[512] Furthermore, Mali is ranked among the countries that are most vulnerable to drought according to the Intergovernmental Panel on Climate Change.[513] This has an impact on both crop and livestock production.

As most crops in Mali are rainfed, with limited irrigation, crop survival and yields depend on the water availability from precipitation.[514] Whilst crop production has increased, yields have started to decline particularly for yam and maize which are the crops that are most vulnerable to drought.[515] This trend is evident across Sub-Saharan Africa where maize yields

[510] FAO Statistics, (2021), Crops and Livestock production data, Available here
[511] USAID, Climate risks in food for peace geographies: Mali
[512] World Bank Climate Knowledge Portal, (2023), Mali profile. Available here
[513] Makougoum C. T. P., changement climatique au Mali : Impact de lasécheresse sur l'agriculture et stratégies d'adaptation, 2015
[514] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here
[515] Derbile E. K., Bonye, S. Z., Yiridomoh G. Y., (2022), Mapping vulnerability of smallholder agriculture in Africa: Vulnerability assessment of food crop farming and climate change adaptation in Ghana, Available here

have decreased dramatically, with the decrease in yield being attributed to the increased droughts in the 2016-2020 period. [516]

In addition, precipitation changes can change the growing patterns of crops, with individuals needing to sow and harvest at different times of year so as to optimize for the water levels. The shortened growing period in Mali has reduced the productivity of cereals across Mali, and increased farmers reliance on bulletins and knowledge sharing platforms to disseminate weather information.

Livestock production is also vulnerable to drought and changes in precipitation, as water scarcity affects health and productivity both through direct access to water, and due to decreased vegetation and fodder. On a small scale, this has already changed livelihoods with some individual farmers shifting from larger animals (e.g., cows) to smaller animals (e.g., goats) that require less food and water to sustain milk production.[517] Furthermore, to mitigate against the risk of water scarcity, nomadic pastoralist farmers have been forced to remain near permanent water sources, disrupting their habitual migration patterns. This in turn is leading to considerable overgrazing which could further strain livestock production.[518]

Floods

Floods further threaten crop production, and therefore result in livelihood vulnerability. Excessive rainfall and floods can result in waterlogging and soil erosion. This damage crops and washes away fertile topsoil, reducing agricultural productivity. Standing water can drown crops, leading to complete losses in some cases.[519] This is particularly significant for yam, soybean, millet, and rice, which are the crops most sensitive to floods in Mali. [520]

Floods also impact livestock rearing. Grazing areas can be submerged, making it challenging to find adequate forage for animals. Floodwater can wash away livestock shelters, barns, and feed storage facilities, disrupting livestock management practices. Animals may drown or suffer from waterborne diseases due to contaminated floodwaters.[521]

In addition, floods can also reduce access to land, impacting all forms of agricultural production. When fields are flooded, or access is reduced due to roads etc. being damaged it is difficult for farmers to sow seeds, tend to crop, harvest their produce, or tend to or move animals.[522] This is made worse as access challenges also reduce the ability to secure inputs e.g. fertilizers, seeds, and machinery, which can further constrain agricultural production.

Temperature increases and extreme heat

Since the 1960s, the mean annual temperature in Mali has increased by 0.7°C, an average rate of 0.15°C per decade.[523] These rising temperatures in Mali have direct and indirect effects on crops and livestock. Higher temperatures can increase the evaporation rate, leading to increased water requirements for crop irrigation and livestock drinking water. This can strain already limited water resources, particularly in arid and semi-arid regions.

High temperatures can negatively impact the photosynthetic process in plants, reducing their productivity.[524] Crops like millet and sorghum, which have developed tolerance to hot and dry conditions, are relatively more resilient. However, other crops such as maize and rice,

[516]Derbile E. K., Bonye, S. Z., Yiridomoh G. Y., (2022), Mapping vulnerability of smallholder agriculture in Africa: Vulnerability assessment of food crop farming and climate change adaptation in Ghana, Available here
[517] Rahimi, J., Fillol, E., Mutua, J.Y. et al. (2022) A shift from cattle to camel and goat farming can sustain milk production with lower inputs and emissions in north sub-Saharan Africa's drylands. Nat Food 3, 523–531. https://doi.org/10.1038/s43016-022-00543-6
[518] CIAT, ICRISAT, BFS/USAID, (2021), "Climate-Smart Agriculture in Mali", Available here
[519] USAID, Climate links: Mali, (2023). Available at: https://www.climatelinks.org/countries/mali
[520]Derbile E. K., Bonye, S. Z., Yiridomoh G. Y., (2022), Mapping vulnerability of smallholder agriculture in Africa: Vulnerability assessment of food crop farming and climate change adaptation in Ghana, Available here
[521] Makougoum C. T. P., (2015) Changement climatique au Mali : Impact de la sécheresse sur l'agriculture et stratégies d'adaptation
[522] CIAT, ICRISAT, BFS/USAID, (2021), "Climate-Smart Agriculture in Mali", Available here
[523] Climate change / Mali: Interactive country fiches. Available at: https://dicf.unepgrid.ch/mali/climate-change
[524] CID Bio Science (2020), How is Climate Change Affecting Photosynthesis?

which are more sensitive to heat stress, can experience significant yield reductions under prolonged heatwaves.[525]

Livestock rearing is also affected by temperature increases with the crop strain impacting the availability of food, and heat having an impact on the animals themselves. Decreasing yields are likely to decrease fodder availability which is predicted to decline by 5%-36% from 1940-69.[526] Changes to fodder availability is likely to put additional pressure on livestock farmers and pastoralists. In addition, heat stress is a major concern for animals, as it affects their feed intake, milk production, and reproductive efficiency, and it can increase the risk of diseases and parasitic infections in livestock.[527]

Food consumption patterns and food insecurity in Mali

The impacts of climate change on agricultural production are significant in Mali for several reasons. Firstly, with such a high rate of subsistence farming, the primary cereal and livestock value chains in terms of production are the primary value chains in terms of consumption, with rice, maize, millet, and sorghum constituting the basic staple foods for the majority of the Malian population.[528] This means that crop failure and yield reduction has an immediate and direct impact on the availability of food for consumption for households. Secondly, this drastically increases the import burden for Mali which was projected to import 10% more food than the previous five-year average.[529]

Declines in food production increase the cost of food. Due to the 10% decrease in cereal production in 2021, the prices for the main cereals and pulses in 2022 rose by an average of 79% for millet, 95% for sorghum and 55% for maize compared to the same period in 2021.[530] This is particularly significant in Mali as food represents the primary household expenditure. In 2021, food as a share of the household budget reached over 55%,[531] and this figure did not take into account the food produced by a household for personal consumption. This is particularly stark by noting that rice, millet and beef alone contribute to 33.6% of the food bill of the average household in Mali.[532]

Furthermore, household economic analysis (HEA) in Bourem, Bandiagara, and Koro (of which Koro is a shortlisted circle for IAAT implementation) has charted how food insecurity has increased and how it plays out at a household level. HEA suggests that the total income needed to meet the survival threshold has increased by between 38-48% from 2021 to 2022.[533] This means that the minimum cost to meet the food consumption requirements have increased dramatically, in line with the reduced availability and increased costs, which is resulting a reduction of food consumption (when measured in monetary and caloric values).[534]

This has contributed to Mali's food insecurity which is evidenced both by the increase in malnutrition, as well as the reduction in food stocks, which is likely to cause a second wave of increased malnutrition.[535] The levels of acutely malnourished children aged 6-59 months increased by ~53% from 2020-2021 and reached 1.2 million children between September

[525] Potsdam Institute for Climate Impact Research (PIK) (2020), Climate risk profile: Mali - Agrica. Available here
[526] The World Bank (2019) Mali climate-smart agriculture investment plan. doi:10.1596/32741.
[527] Rahimi, J., Mutua, J.Y., Notenbaert, A.M.O. et al. (2020), Will dairy cattle production in West Africa be challenged by heat stress in the future?. Climatic Change 161, 665–685. Available here
[528] Douyon A, Worou ON, Diama A, Badolo F, Denou RK, Touré S, Sidibé A, Nebie B and Tabo R (2022) Impact of Crop Diversification on Household Food and Nutrition Security in Southern and Central Mali, Available here
[529] https://www.fao.org/giews/countrybrief/country.jsp?code=MLI&lang=ar
[530] Relief Web, (2022), Breaking the Spiral of the Food and Nutrition Crisis in Mali, Available here
[531] World Bank Group (2022), Africa's Pulse, No. 25, Available here
[532] Instat Mali (2023) Enquete modulaire et permanente aupres des ménages EMOP, Available here
[533] Household Economic Analysis by HEA Sahel (2022) was used by establishing the increase in the Survival Threshold in the 'Total Income' chart from 2020 to 2021. Available here
[534] Relief Web, (2022), Breaking the Spiral of the Food and Nutrition Crisis in Mali, Available here
[535] Relief Web, (2022), Breaking the Spiral of the Food and Nutrition Crisis in Mali, Available here

2021 and August 2022.[536] This is a significant increase and is attributed largely to the drought related production issues in 2021.

Vulnerabilities of specific livelihoods

At a national level, livelihood vulnerability and food insecurity are linked, due to the dependence on agriculture for formal employment, as well as food consumption. As agricultural production has been constrained, the impact has been felt across Mali.

Livelihood vulnerability, and the impact of climate change on those livelihoods is not uniform across Mali. Within Mali, there are 17 'livelihood zones', defined as a geographic space in which households meet their basic needs for survival, including food and income, in a similar way[537]. The livelihood zones are in part determined by the climate in the area. The livelihood zones offer a useful means of categorizing and analyzing the activities, assets and capabilities required for survival across the country, and to assess the vulnerability of the people living in these areas. Within the five regions in scope of this project (Gao, Koulikoro, Mopti, Segou, and Tombouctou), 11 of the 17 total livelihood zones are covered. Understanding the conditions in the specific livelihood zones is essential to understanding the complete picture of livelihood vulnerability in Mali.

Figure 1 below shows the location of the livelihood zones across Mali and for the 11 livelihood zones of the project, Table 1 outlines i) Climate and precipitation within the zone, ii) the primary livelihoods in the zone and iii) the main risks to the livelihoods.

Figure 122: Mali Livelihood Zone Map[538]

[536] Relief Web, (2022), Breaking the Spiral of the Food and Nutrition Crisis in Mali, Available here
[537] FEWS NET Livelihood Zones, Available here and here. Design by the National HEA Technical Committee and the Food Security Cluster, part of the Famine Early Warning Systems Network , in collaboration with the CSA (Food Security Commission), the technical services of the Government of Mali, the EWS (Early Warning System), Oxfam, Save the Children UK, and the NGOs of the Food Security Cluster.
[538] FEWS NET Livelihood Zones, Available here and here.

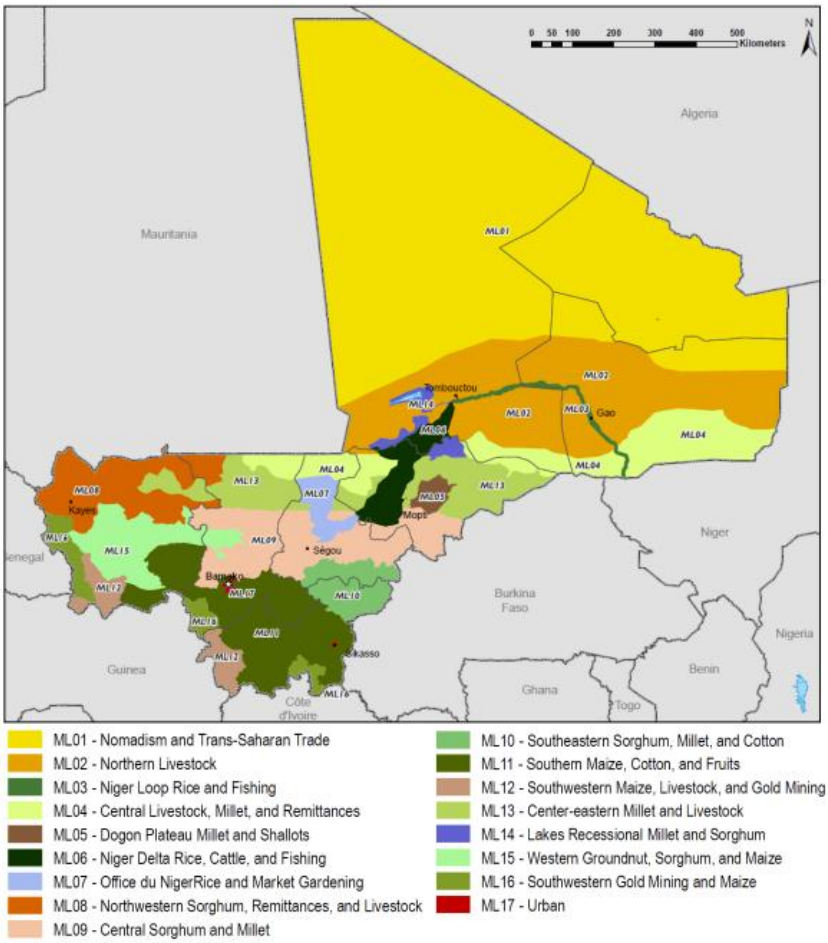


Table 6: Mali's livelihood zones and the barriers and risks facing in the IAAT Circles

Mali Livelihood Zone	IAAT circles within the livelihood zone[539]	Climate and precipitation[540] within the zone	Description of the primary livelihoods in the zone	Description of the main risks to the livelihoods and climate risks impacting agriculture in this zone
ML02 - Northern livestock	**Gao** -Gao Region, **Gourma-Rharous** - Tombouctou Region	Sahelian desert and semi-desert with low rainfall of 0-200mm annually.	Insufficient rainfall for most agriculture. Nomadic and transhumant pastoralism are dominant activities. During the dry season, many pastoralists move south in search of grazing grounds until the rainy season allows them to migrate back north into the Sahel (often across the border into Mauretania). Generally, better-off households engage in livestock trading (selling animals, milk, and other animal products) and poorer are labourers.	**Climate-related risks:** • The risk of climate change-induced droughts and extreme heat is rated as 'high'[541]. **Food insecurity:** • Food insecurity in the circles predicted to be in 'crisis' or in 'emergency in Menaka 2023[542]. • Dependent on grain supply from the rest of Mali/ imports which results in increasing vulnerability. 2023 price for millet was 64% higher than the five-year average in Gao and 100% higher in Menaka[543].
ML04 - Central livestock, Millet and Remittances	**Ansongo** - Gao Region	Sahelian desert and semi-desert with low rainfall of 250-350 mm annually.	Higher precipitation in Zone 4 than in the north of the country which allows for the cultivation of millet and cowpeas, but low and unreliable levels of rainfall mean that depending on agriculture alone is risky. Livestock rearing (cattle, goats, and sheep) is an important activity in this zone to mitigate against agricultural vulnerabilities. Significant migration through Niger[544] resulting in remittances. Generally, richer households engage in livestock trading and crop sales, with poorer households depending on labour e.g. fuel collection as a source of income.	**Climate-related risks:** • The risk of climate change-induced droughts and extreme heat and flooding is rated as 'high'[545] • Elevated risk of drought and erratic rainfalls results in insecurity both for rain-fed agriculture and for livestock rearing. **Food insecurity:** • Food insecurity is predicted to be in 'crisis' in 2023[546].
ML06 - Niger Delta Rice, Cattle and Fishing	**Tenenkou** - Mopti Region,	Rainfall of up to 500 mm annually.	The delta is a vast flood plain that is inundated for five months of the year. This creates a major resource in terms of pasture and allows households to cultivate rice and sorghum. Bozo fishermen depend on delta for survival. Generally, richer households engage in livestock trading and crop sales, and poorer households having more varied sources of income including agricultural labour, crop sales, livestock sales.	**Climate change** • Climate change impacts likely to alter flooding patterns in the Niger delta to prolong flooding seasons[547] which will have an impact on historic farming practices.

[539] https://data.humdata.org/dataset/wfp-geonode-ica-mali-most-predominant-livelihood-zones
[540] Precipitation taken at regional level https://climateknowledgeportal.worldbank.org/country/mali/climate-data-historical#:~:text=The%20Malian%20climate%20is%20characterized,Saharan%20wind%20called%20the%20harmattan.
[541] https://thinkhazard.org/en/report/1934-mali-tombouctou/DG
[542] https://www.ipcinfo.org/cadre-harmoniseb
[543] https://fews.net/sites/default/files/documents/reports/PB_ML_202302_EN.pdf
[544] https://data.unhcr.org/en/situations/sahelcrisis/location/8695
[545] https://thinkhazard.org/en/report/1927-mali-gao/FL

ML09 - Central Sorghum and Millet	**Bankass** and **Djenne** - Mopti Region, **Segou** - Segou Region	Rainfall of up to 650 mm annually.	Due to increased rainfall and more fertile land, there is a decreasing dependence on livestock in Zone 9 and an increasingly diverse range of food and cash crops that are being grown. With increasing agricultural potential, family size and population density increase. Due to the location of Zone 9 - the dividing point between north and south - means it dominates the north-south commercial axis of grain trade towards the deficit in the north, and the livestock trade and seasonal migration towards the south. Small-holder farming provides over 70% of the vegetables available on the market in the regions[548]. Generally, richer households engage in crop sales and livestock trading, with poorer households depending predominantly on agricultural labour as a source of income.	**Agricultural inputs and land access** • Limited availability of fertilizers at the beginning of the agricultural season also limited cereal production[549]. • ML09 has suffered significant reductions in agricultural areas. The circles most affected by significant decreases in terms of population are the circles of Bankass 20% in and Djenne 11% in the Mopti region[550]. **Food insecurity** • Food prices in Koulikoro, Mopti and Segou region generally more stable than the North of Mali with cattle and cowpea prices same as five year average in Mopti, and proportionately small increases in Segou and Koulikoro[551].
ML10 - South-eastern Sorghum, Millet and Cotton	**Bla** - Segou Region	Rainfall of up to 750 mm annually.	Sorghum, millet, and cotton farming are the dominant livelihoods in the zone. The typical model is small subsistence farmers who mix crop varieties to meet personal consumption needs and to sell in markets. Households generally meet consumption needs 11 months out of year[552]. Generally richer households engage in crop sales, with and poorer households depending predominantly on agricultural labour and crop sales as a source of income.	**Climate related risks:** • The risk of climate change-induced droughts, floods, and extreme heat is rated as 'high'[553]. **Agricultural inputs and pests** • Limited availability of fertilizers at the beginning of the agricultural season also limited cereal production[554]. • Mali's 2022 cotton production decreased ~31% compared to the previous year. This is due to the lack of mineral fertilizers and the heavy infestation of seedlings with cotton pests[555].

[546] https://www.ipcinfo.org/cadre-harmoniseb
[547] https://iwaponline.com/hr/article/52/4/958/82994/Impacts-of-climate-change-on-environmental-flows
[548] https://www.iaea.org/newscenter/news/malian-farmers-adapt-to-climate-change-improve-water-use-crop-yield-and-livelihood-using-nuclear-techniques
[549] Handicap International, (2022), Breaking the Spiral of the Food and Nutrition Crisis in Mali, Available here
[550] https://reliefweb.int/report/mali/summary-note-cropland-change-analysis-hard-access-areas-due-insecurity-2021-mali
[551] https://www.fao.org/3/cc5722en/cc5722en.pdf
[552] https://agra.org/wp-content/uploads/2020/12/AGRA-OM-Mali-Report_FINAL.pdf
[553] https://thinkhazard.org/en/report/1934-mali-tombouctou/DG
[554] https://www.hi.org/sn_uploads/document/Break-Spiralling-Food-and-Nutrition-Crisis-in-Mali-April-2022.pdf
[555] https://fscluster.org/sites/default/files/documents/mali_fiche_de_communication_mars2023_vf.pdf

ML11 - Southern Maize, Cotton and Fruits	**Dioila** - Koulikoro Region,	Rainfall of up to 750 mm annually.	Maize, cotton, and fruit farming are the dominant livelihoods. The typical model is small subsistence farmers who mix crop varieties to meet personal consumption needs and to sell in markets. Households generally meet consumption needs 11 months out of year[556].	**Climate related risks:** • The risk of climate change induced droughts and floods rated as medium or low, but extreme heat is rated as 'high'[557]. **Agricultural inputs and pests** • Limited availability of fertilizers at the beginning of the agricultural season also limited cereal production[558]. • Mali cut cotton output forecast an additional 29% for 2022/23[559] due in part to pests.
ML13 - Central Eastern Millet and Livestock	**Nara** - Koulikoro Region, **Douentza** and **Koro** - Mopti Region	Rainfall of up to 750 mm annually.	Households tend to practice both livestock rearing and crop production to mitigate crop production deficits. Livestock rearing is dominated by transhumant herds (cattle and small ruminants). The main income sources are livestock sales, migration, farm labour and crop sales.	**Climate related risks:** • The risk of climate change induced droughts, floods, and extreme heat is rated as 'high'[560]. **Income insecurity** • Migration made up ~25%, and donations a further 20% of annual income in 2022 in Koro, demonstrating the precarious nature of income security[561].

[556] https://agra.org/wp-content/uploads/2020/12/AGRA-OM-Mali-Report_FINAL.pdf
[557] https://thinkhazard.org/en/report/1934-mali-tombouctou/DG
[558] https://www.hi.org/sn_uploads/document/Break-Spiralling-Food-and-Nutrition-Crisis-in-Mali-April-2022.pdf
[559] https://www.reuters.com/world/africa/mali-cuts-cotton-output-forecast-an-additional-29-202223-2023-01-31/
[560] https://thinkhazard.org/en/report/1934-mali-tombouctou/DG
[561] https://hea-sahel.org/wp-content/uploads/2021/04/2021-HEA-Mali-FINALpdf.pdf

B: MARKET, TECHNOLOGY, AND AGRICULTURAL VALUE CHAINS ANALYSIS

INTRODUCTION

This section includes a detailed analysis of ten (10) high-potential value chains in Mali, providing (i) an overview of the key steps in Mali's agricultural value chains (inputs, production, processing, and marketing), (ii) an assessment of the extent of technology adoption, (iii) the role of private sector actors, (iv) and recommendations to make the value chains more economically and ecologically sustainable and resilient in the face of climate change.

The high potential value chains selected for analysis are diverse and include the following types of crops: cereals (rice, maize); tubers (sweet potatoes); bulb crops (onions, shallots); peas and beans (cowpea); legumes (peanuts); and fruit, legume, and shrub trees (mango, Gum Arabic and moringa).

The value chain analysis section has been divided into two parts. Part 1 covers the "inputs" step in the value chain for all crops, and Part 2 covers the remaining steps in the value chain (production, processing, and marketing).

The Rationale for the Selection of Priority Value Chains

The selection criteria for the value chains in this study were based on their strategic, economic, and ecological importance and the potential impact of adopting innovative efficient practices and technologies.

- **Rice** is a top priority, and its sustainability, availability, and affordability are a major preoccupation for the Government of Mali and its international partners. Whether its improving practices such as adopting System of Rice Intensification (SRI) techniques, better harnessing Mali's water resources so that farmers can have more control, or introducing more efficient and effective milling machines, the potential to grow more rice with less land and less water is crucial for achieving the Sustainable Development Goals.[562]
- Similarly, **maize** is vital for human nutrition and feeding livestock. The viability of the commercial poultry production sector relies heavily on the availability and affordability of maize, so investing in high-yielding hybrid varieties adapted to Mali's climate is crucial for meeting the caloric and nutritional needs of the country. It is also vital for farmers' food security, given that it is intercropped with cotton, a major source of export revenue for the country.[563]
- **Onions** and **shallots** are women's crops and key ingredients in Malian cuisine. Here too, investments in improved varieties, water-saving and distribution technologies, and processing equipment have major upsides for improving women's incomes and reducing the need to import onions from Morocco and the Netherlands to meet demand.[564]
- Crops such as **sweet potatoes**, **cowpea**, and **peanuts** are nutritious and well adapted to Mali's different agronomic climates and help improve soil health and quality by fixing nitrogen in the soil or, in the case of sweet potatoes, capable of growing even in nitrogen-depleted soils. They serve as ideal raw materials for downstream processing into ingredients, snacks, and their leaves are highly prized for human and animal nutrition.
- Given the economic importance of exporting crops to regional and international markets and their role in agroforestry, the **mango**, **shea,** and **Acacia Senegal (Gum Arabic)** value chains were included in this study. Their activities are dominated by women, from collection to

[562] Ministère de l'Agriculture, Stratégie Nationale de Développement de la Riziculture 2016-2025 (2016)
[563] World Bank Group, Creating Markets in Mali: Mobilizing the Private Sector for Economic Resilience and Recovery (2022)
[564] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)

transformation. From artisanal enterprises to large industrial scale processing facilities, investing in and supporting actors involved in valorising these three trees is vital in the face of a changing climate.[565] All three have very strong value addition the potential for both food and cosmetic applications and provide multiple avenues for adopting technology and innovative practices across all value chain segments.

- **Moringa Oleifera is an ancient plant that propagates naturally** and is also well adapted to commercial plantation. The leaves of **moringa oleifera** are highly prized for their nutraceutical properties and is increasingly coveted in international markets. As countries like Mali continue to develop and urbanize, plants like moringa which have been used in traditional medicine and culinary practices by rural communities for centuries, are well suited for innovative processing and marketing for consumers in Bamako or Paris to benefit from its virtues.[566]

Figure 1: Production by Crop and Region[567]

Crop	Region				
	Gao	Koulikoro	Mopti	Ségou	Timbuktu
Rice					
Maize					
Onion					
Shallot					
Cowpea					
Peanut					
Sweet Potato					
Shea					
Mango	*River zone only*		*River zone only*		*River zone only*
Acacia Senegal					
Moringa					

***Key**: Green indicates key production zone, Orange indicates potential production zone*

Technology Adoption

Overall, technology adoption in the value chains covered in this study is low. Smallholder farmers have limited access to modern technologies and practices that can increase productivity and profitability. According to a report by the National Directorate of Rural Engineering (DNGR) in 2020, out of the nearly 1.5 million farms in Mali, 702,357 (47.4%) are equipped with animal traction, while only 65,649 (4.4%) use motorized traction. The most common equipment farmers use include chisels, multi-cultivators, hoes, seeders, and carts, whilst only 7.2% of farms use mechanized sprayers, and 14.2% use mechanized tillers.[568] The following challenges have been identified as particularly pressing and represent potential areas of technological opportunity, including i) low adoption of certified and hybrid seeds due to high prices, ii) low yield attributed to low fertilizer use, and iii) the prohibitive cost of fertilizer and lack of subsidization for crops other than cotton and rice. Table 2 provides a breakdown of tilling methods used by region, obtained during the 2017 agricultural census. The table shows that farmers rely heavily on manual and animal traction to till their fields, indicating high potential for improvement.

[565] Ibid.
[566] Traoré et al., Promotion of *Moringa* products via an inclusive value chain for economic, social and environmental. impacts in Africa (2022)
[567] Ministère de Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[568] Ministère de l'Agriculture, de l'Élévage, et de la Pêche, Rapport Annuel de Mise en Œuvre des Activités de la DNGR-Periode Janvier 2020 à Decembre 2020 (2020)

Table 2: Type of Tilling (2017)[569]

Type of tilling	Kayes	Koulikoro	Sikasso	Ségou	Mopti	Timbuktu	Gao	Bamako
No tilling	7%	4%	3%	4%	8%	2%	0%	9%
Manual	43%	8%	11%	4%	28%	60%	20%	61%
Animal	24%	58%	71%	63%	33%	5%	13%	0%
Manual + Animal	23%	27%	10%	17%	28%	5%	65%	10%
Motorized	0%	0%	5%	10%	2%	1%	0%	9%
Manual + Motorized	1%	2%	0%	1%	0%	0%	1%	4%
Animal + Motorized	2%	1%	0%	1%	0%	1%	0%	0%
Other/don´t know	1%	1%	0%	1%	0%	26%	1%	7%

The continued dominance of manual and animal use suggests that there is high potential for increasing the adoption of a broad range of climate-smart agriculture (CSA) technologies. Some of the key CSA technologies identified as valuable in Mali are improved varieties, drip irrigation with solar-powered pumps, and weather monitoring systems, which can help farmers manage water resources more efficiently, reduce their carbon footprint, and increase resilience to climate change. Given the size of the country, drones can also play a key role in terms of mapping, crop monitoring, and pest management.[570]

Table 3 provides a snapshot of the latest projections conducted by the Ministry of Rural Development for the upcoming 2023 agricultural season. Rice and maize alone are projected to account for almost 2.4 million hectares of land under cultivation, providing over 7.1 million metric tonnes of grain.

Table 3: Estimates for Land Cultivation, Yield, and Production by Value Chain (2023)[571]

Crop	Area (ha)	Yield (MT/ha)	Projections for 2023 (MT)
Rice	898,222	3.4	3,048,802
Maize	1,499,829	2.8	4,128,891
Onion & Shallot	33,202	26	849,208
Cowpea	513,478	0.5	269,576
Peanut	493,174	1	468,028
Sweet Potato	37,136	15.7	582,812
Mango	46,138	16	736,639
Shea	na	0.06	215,759
Acacia Senegal (Gum Arabic)	75,000	0.18	13,626
Moringa	na	23	na

OVERVIEW OF OPPORTUNITIES BY VALUE CHAIN

A summary of the challenges and opportunities identified to support future growth is included for each key value chain below:

- **Rice** opportunities relate to i) access to certified seeds and affordable fertilizer, ii) enhanced mechanisation, and iii) more efficient and effective processing machines. Rice production in

[569] INSTAT, Enquete Agricole de Conjuncture 2017 (2019)
[570] Mali Climate-Smart Agriculture Profile
[571] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)

Mali is primarily concentrated in Ségou, Mopti, Tombouctou, and Sikasso. The types of production systems range from total irrigation control to rainfed rice but the limited production and distribution of certified seeds, along with the scarcity of subsidized fertilizer, hampers agricultural productivity. Currently, manual tools dominate rice production, highlighting the need for increased mechanization and post-harvest technology to enhance efficiency and yields.

- **Maize** opportunities relate to i) improved irrigation and ii) utilisation of hybrid seeds. Maize production in Mali is primarily rainfed, with the main growing season occurring from May/June to September/October. Access to controlled irrigation for a counter-season crop is currently limited to specific irrigated perimeters. Improved hybrid seeds offer potential yield increases of 20 to 30% but the adoption of hybrids remains low, accounting for less than 5% of total maize areas.
- **Sweet potato** production in Mali has been steadily increasing, with an average annual production ranging from 220,000 to 600,000 metric tonnes, although growth still lags other African countries. The crop is primarily cultivated by smallholder farmers and sold in local markets, offering opportunities for businesses to invest in production improvements and value-addition activities.
- **Market gardening and in particular onion and shallot** production in Mali is expanding rapidly, driven by factors such as increased involvement of women and youth supported by projects and NGOs, growing domestic and international markets, favourable climatic conditions, and increased investments in the sector. Opportunities for improvement are: i) weak sector organization, ii) reducing high seed costs, iii) enhancing availability of processing technologies, infrastructure for storage and packaging, and pest and disease management.[572]
- **Cowpea and peanut** are essential crops in Mali, providing food security and income for smallholder farmers, with women dominating both value chains from production to marketing (note cowpea is a protein source grown in drier areas, while peanuts are a cash crop). Future opportunities relate to i) improving limited credit access, and ii) access to improved processing technology and post-harvest handling practices.
- **Mango:** Mango cultivation covers over 46,000 hectares in Mali, making it the largest fruit crop. Mango plantations also contribute to ecological benefits, including soil erosion prevention and greenhouse gas sequestration. Opportunities relate to reducing post-harvest losses including through enhanced pest control and enhancing market access as currently only a small portion of the estimated 736,000 tonnes produced is sold.
- **Acacia Senega**l, known as the gum arabic tree, is a valuable resource with Mali being a major global supplier of Crude Gum Arabic (CGA) since the 19th century.[573] CGA is extracted from the sap of Acacia Senegal and finds wide application in the food, pharmaceutical, and printing industries. Natural factors and logistical challenges affect collection, and producers are typically low-income farmers and pastoralists.
- **Moringa oleifera,** has the potential to bring significant economic, social, and environmental benefits to Mali through extensive cultivation, processing, and commercialization. The versatile Moringa tree offers multiple revenue streams, including the processing of its nutrient-rich leaves into powder or supplements for the health market.[574] Enhancing the growth of this value chain is attracting private investment, with opportunities to vertically integrate the value chain by developing plantations and on-site processing capacity.

[572] Ministère de l'Agriculture, Plan de Campagne Agricole Consolidé et Harmonisé 2018/2019 (2018)
[573] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[574] Traoré et al., Promotion of *Moringa* Products Via an Inclusive Value Chain for Economic, Social and Environmental. Impacts in Africa (2022)

Definitions and Steps in the Value Chain

There are four major steps in agriculture and agroforestry value chains: inputs, production, processing, and marketing. Each step contributes to the success and sustainability of agriculture and agroforestry by optimizing productivity, adding value to products, and connecting producers with consumers. Farmers, agroforestry workers, and businesses can achieve improved yields, profitability, economic development, and environmental sustainability by understanding the importance of these elements and implementing appropriate practices and technologies. The definition of each of these value chain steps has been summarised below:

1. **Inputs** such as seeds/seedlings, fertilizers, herbicides, and pesticides, are the foundation of any agricultural or agroforestry venture. They provide the necessary resources and support for plant growth and development. Farmers can optimize yields, enhance crop quality, and improve productivity by using high-quality inputs and implementing appropriate agricultural practices. These inputs help address soil nutrient deficiencies, control pests and diseases, and promote healthy plant growth, ultimately ensuring a more sustainable and profitable agricultural system.
2. **Production** is the backbone of agriculture and agroforestry. It involves cultivating and managing crops or trees, ensuring they receive the necessary care and attention throughout their growth cycle. This includes land preparation, nurseries, planting, irrigation, and maintenance. Successful production practices lead to higher crop yields, increased quality, and improved farmer livelihoods. Cultivating trees alongside crops in agroforestry provides additional benefits such as soil conservation, biodiversity preservation, and climate resilience.
3. **Processing** is a critical step that adds value to agricultural and agroforestry products. It transforms raw materials into finished goods, making them more suitable for consumption or further downstream use. Processing can range from simple cleaning, sorting, and packaging to more complex procedures like milling, drying, or extraction. By processing agricultural and agroforestry products, their shelf life can be extended, quality can be improved, and marketability can be enhanced. Processed products also have the potential to fetch higher prices in the market, leading to increased income for farmers and businesses.
4. **Marketing** is essential for connecting producers with consumers and ensuring the efficient distribution of agricultural and agroforestry products. Effective marketing strategies help create awareness about the products, generate demand, and facilitate their sale. This involves branding, packaging, pricing, promotion, and distribution. A well-executed marketing plan enables farmers and agroforestry practitioners to reach their target markets, secure favourable market access, and generate income from their products. It also encourages sustainable consumption patterns and fosters economic growth in rural areas.

Mali's agricultural and agroforestry value chains encompass various private sector actors.

Private sector actors in the agricultural industry encompass a diverse range of stakeholders:

- **Input suppliers** form a vital component of the private sector, providing essential products and services such as seeds, fertilizers, and phytosanitary solutions to farmers.
- **Advisory service professionals** play a crucial role in providing expert guidance and technical assistance to farmers, aiding them in making informed decisions regarding their agricultural practices.
- **Financial institutions**, including banks and microfinance organizations, provide the necessary capital and financial services to support agricultural activities.
- Entrepreneurs within the private sector include **buyers/aggregators**, who collect and consolidate agricultural products from multiple farmers, **processors** who add value to agricultural commodities, **transporters** who ensure the efficient movement of goods, and exporters who facilitate the international trade of agricultural products.

These private sector actors contribute to the development and growth of the agricultural value chain by providing essential goods, services, expertise, and investment opportunities to enhance productivity and profitability in the sector.

Value Chain Analysis Part 1: Inputs

O V E R V I E W

The key agricultural inputs in Mali are seeds, fertilizers, and phytosanitary products. The private sector is key in producing, importing, and marketing these agricultural inputs but the Government of Mali (GoM), with support from international partners, plays a vital role as well. In particular, the government provides subsidies, training, capacity building, and to some extent the production of certified seeds. However, government agencies lack the necessary political, human, and financial resources to support the most vulnerable producers--namely rural female farmers.[575]

Challenges are present across the input system, as identified by the Ministry of Rural Development's 2022 report on the Agricultural Campaign for Input Subsidisation.[576] The most prominent difficulties highlighted were:

- Insufficient financial and material resources for monitoring,
- Shortage of supervisory staff,
- High fertilizer prices,
- Delays in subsidized input activities, limited allocations for subsidized fertilizers, and lack of support for distribution commissions,
- Premature water source depletion,
- Inadequate storage infrastructure for storing inputs,
- Infestation of cotton fields by jassids for the first time in Mali,
- Persistent insecurity in certain regions (primarily Gao, Mopti, and Timbuktu).

To address these challenges, the Ministry urged the government and its partners to implement the following solutions:

- Training farmers on compost production,
- Providing allowances for fertilizer distribution commission members,
- Allocating resources in a timely manner,
- Repairing infrastructure,
- Implementing pest management plans,
- Training farmers in improved techniques.

In the following sub-section, further analysis is conducted on the challenges faced across seeds, fertilizer and pest management with examples highlighted from key value chains.

S E E D S D E E P D I V E

Overview by Value Chain

- **Rice:** No genetically modified (GMO) rice varieties exist commercially however hybrids are very common. One of the most popular varieties in Mali, Kogoni-91 (Gambiaka) is a hybrid variety developed by Mali's *Institut de l'Economie Rurale* (IER) in 1970. More recently, researchers at AfricaRice have developed rain-fed varieties dubbed New Rice for Africa (NERICA). Production of certified rice seeds only covers 2,270 hectares, yielding an estimated 9,235 tonnes in 2022. This is far short of the country's needs, which are estimated

[575] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)

[576] Ministère de Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)

around 78,000 tonnes (87 kg of seeds per hectare).[577] Only 23% of farms use improved seeds, according to the 2017 Agricultural Census.[578]

- **Onion:** In Mali, onion seed demand is met through a combination of imports and local production in collaboration with the Coopérative de Producteurs de Semences (CooProSem), primarily for the Violet de Galmi variety. Other seed suppliers such as Mali Semences, Mali Protection des Cultures (MPC), and Bejo offer diverse varieties suitable for long-term storage and rainy season cultivation. The recommended seeding rate for onions is 5 kg per hectare. Prior to the season, seed requirements are assessed, and international orders are placed for maritime transportation to ensure timely availability. Onion cultivation in Mali benefits from direct seeding, eliminating the need for bulb propagation. The IER, in collaboration with partners like CIRAD, has successfully established basic onion seeds of the Violet de Galmi variety. These seeds are distributed to farmers through CooProSem based in Kayes.[579]
- **Shallot:** In contrast, shallot producers continue to rely on bulb propagation by producing their own seeds from bulbs. Notably, several shallot varieties are used in the Office du Niger area, including N'Galamakoro-djaba, B3-djaba, and Mamoutou-djaba. The adoption of research-developed seeds has been limited due to the unsuitability of available varieties for consumption.[580]
- **Cowpea:** Mali has a wide range of local cowpea varieties adapted to different agricultural production zones, in addition to many improved varieties such as Dounafana, Yerewolo, Sankaraka, Korobalen, TN88-63, Gorom-Gorom, and Wilibali, which have been popularized. Certified seeds are used in the major cowpea production areas with the estimated demand for certified cowpea seeds at 1,753 metric tonnes.[581]
- **Peanut:** The current varieties grown include: 28-206, 47-10, 55-437, GH119-20, JL24, and Fleur11.[582] However, the lack of certified seeds and the prevalence of aflatoxin are major problems. Aflatoxin is a toxic substance produced by a fungus that can contaminate crops. Seed requirements for peanut are 22,853 tonnes of seed (50 kg/ha) and the use of organic fertilizer such as manure can greatly enhance productivity.[583]
- **Sweet Potatoes:** In terms of seeds used for sweet potato production, farmers typically provide their own cuttings, while fertilizers and pesticides are rarely used. Sweet potatoes are primarily sold locally at the farm gate or in local markets, with prices varying depending on the season. The most common varieties produced are Dragon, Diakani, Fatokeni, Blagné, and Ganimapapa, all of which have white flesh and local names. Varieties with orange flesh, such as Chinoiwosson, Djewosson, or Wossonbleni, have better nutritional value due to their high vitamin A content.[584]
- **Mango:** mango seedlings stay in the nursery for 2.5 to 3 years before being transplanted. Once in production, a hectare of mango trees can yield a minimum of 5 metric tonnes of fruit. Nurseries are commonly established in public areas with an average size of 0.5 hectares. These nurseries can grow up to 60 plants per square meter and typically employ a staff of four to five people.[585] Some nurseries have undergone short training programs to improve their production practices and to produce certified plants. Programs such as PCDA, as well as

[577] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[578] INSTAT, L'Enquete Agricole de Conjuncture 2017 (2019)
[579] PACEPEP, *Analyse du marché et du développement de la filière fruits et légumes au Mali (20*18).
[580] Ibid.
[581] Ministere de l'Agriculture, Plan de campagne agricole consolidé et harmonisé 2018/2019 (2018).
[582] Ibid.
[583] Ibid.
[584] COLEACP, Fruits et légumes du Mali, hors saison de production de la mangue (2021)
[585] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)

organizations like FAO and the World Agroforestry Centre, offer such training opportunities to nurseries.[586]

As mentioned above, the GoM and international research organizations play a key role in the production of certified seeds by first developing new varieties and then selecting and training farmers and cooperatives to produce the improved seeds for distribution to fellow famers.[587] Table 5 recaps the data reported by the Ministry of Agriculture regarding the production of first generation and second generation certified seeds during the 2022 agricultural campaign.

Table 5: Production of Certified Seeds in 2022[588]

Crop	1st Generation Seeds (R1)		2nd Generation Seeds (R2)		Total	
	Production (MTs)	# of producers	Production (MTs)	# of producers	Production (MTs)	# of producers
Rice	3,830	678	1,408	432	5,238	1,110
Maize	1,746	484	525	240	2,271	724
Cowpea	319	234	120	117	439	351
Peanut	99	91	10	11	109	102
Vegetables	191	59	0	0	191	59
Total	**8,450**	**2,355**	**2,501**	**1,282**	**10,951**	**3,637**

Despite these efforts, the quantity of certified seeds produced is inadequate. For example, the quantity of seed required for rice is estimated at over 78,000 metric tonnes but the government reports production of 5,238 metric tonnes of certified rice seed by 1,110 producers. [589] At rate of 87 kg per hectare, the quantity of certified seed is sufficient to cover 60,200 hectares or less than 7% of the land where rice is cultivated. Table 6 displays the 2023 certified seeds production targets for the government's program. The quantity of certified seeds for rice is projected to increase to 7,616 MTs (45% increase) but still falls far short of needs. Production of certified maize seed is expected to increase from 2,271 in 2022[590] to 2,891 in 2023. While cowpea seeds are expected to remain steady, the government plans on doubling the production of certified peanut seeds. Onion and shallot seeds are projected at 1,025 and 100 metric tonnes respectively.

[586] FARA, Innovation Opportunities (2018)
[587] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[588] Ibid.
[589] Ibid.
[590] Ibid.

Table 6: Projected Production of Certified Seeds for 2023[591]

Crop	Area (ha)	Yield (MT/ha)	Total production (MT)
	R1+R2		R1+R2
Rice (Total Water Control)	1,017	4.6	4,710
Rice (Controlled Flooding)	626	2.7	1,707
Rice (Lowland)	171	2.7	462
Rice (Rainfed)	280	2.6	739
Rice (Total)	2,094		7,616
Maize	1,107	2.6	2,891
Cowpea	565	812	459
Peanut	195	1.1	215
Onion	25	40.6	1,025
Shallot	6	16.7	100

Private Sector case study for Seeds:

Faso Kaba is a leading agricultural seed company in Mali that specializes in producing and distributing a variety of high-quality agricultural seeds across Mali and neighbouring countries. The company offers a wide range of seeds, including cereals such as maize, sorghum, millet, rice, and niébé, as well as vegetables such as peanuts, eggplant, and tomato. In addition to seeds, Faso Kaba provides farming equipment and fertilizers, and offers services to both small and large-scale farmers. The company is the only national seed company in Mali that operates modern, quality-certified processing and packaging equipment. In 2017, Faso Kaba produced 770 metric tonnes of cereals and 630 metric tonnes of fertilizers, with over 90% of its products sold locally and the rest exported to neighbouring countries such as Côte d'Ivoire and Senegal. All seeds undergo government-mandated certification before being transported to the processing facility, where they are washed, sorted, treated with chemicals, and packaged into bags.[592]

FERTILIZER DEEP DIVE

Fertilizer Usage

Organic and mineral fertilizers play a crucial role during soil preparation for vegetable cultivation. Women dominate horticulture activities and rely on organic fertilization methods such as cow manure, poultry droppings, and household waste. The recommended application rate is 2 to 5 kg/m2 or 2,000 to 5,000 kg of manure per 0.10 ha. However, the women from the Danaya cooperative in Bla apply nearly double that amount, ranging from 4,000 to 10,000 kg.[593]

In terms of mineral fertilizers, the recommended option is 15N-15P-15K, with an application rate of 40 g/m2 or 100 kg per 0.25 ha. However, the cost of this fertilizer is relatively high, priced at 19,000 FCFA for a 25 kg bag, which may pose challenges for vegetable growers, particularly small-scale farmers. As an alternative, they often turn to more affordable options like cotton fertilizer (NPK), which costs 11,500 FCFA for a 50 kg bag. It's worth noting that the use of NPK among women in flooded areas is limited.[594] Given that most Malian households are agro-pastoral in nature, it follows that the use of organic fertilizer (*e.g.* manure, crop residue, and cereal byproducts), as well animals (*e.g.,* cattle and donkeys) for tilling and planting, is high in regions with high livestock production (*e.g.* Mopti and Ségou).[595]

[591] Ibid.
[592] Stakeholder interview with Faso Kaba (May 2023)
[593] Paul Onibon, Analyse du Marche et du Développement de la Filiere fruits et Legumes au Mali (2018)
[594] Ibid.
[595] World Bank Group, Creating Markets in Mali: Mobilizing the Private Sector for Economic Resilience and Recovery (2022)

Table 7: Input Usage by Gender and Type[596]

Region	Organic Fertilizer (Women)	Organic Fertilizer (Men)	Mineral Fertilizer (Women)	Mineral Fertilizer (Men)	Pesticides (Women)	Pesticides (Men)
Kayes	16%	35%	2%	9%	8%	22%
Koulikoro	11%	68%	18%	60%	7%	49%
Sikasso	6%	79%	33%	84%	38%	81%
Ségou	10%	98%	30%	98%	15%	93%
Mopti	30%	91%	6%	73%	13%	52%
Timbuktu	4%	63%	53%	97%	0%	63%
Gao	0%	73%	14%	51%	5%	7%
Mali	14%	75%	12%	67%	13%	56%

According to the 2017 Enquete Agricole de Conjuncture, inorganic fertilizer usage in the regions of Ségou (98%) and Timbuktu (97%) are almost universal amongst households headed by men but only 30% in Ségou and 53% in Timbuktu for households headed by women (Table 7). Surprisingly, in Sikasso—arguably Mali's breadbasket--only 84% of farms managed by men and 33% of farms managed by women use inorganic (mineral) fertilizer despite receiving a slice of the input subsidy. The main takeaway from the table above is that across the board and in all regions, men have access to and use more fertilizer and pesticides than women thus reinforcing the finding that only 7% of households headed by women receive loans for the purchase of inputs. In Gao and Timbuktu, respectively, 5% and 0% of female managed farms reported that they used pesticides. Therefore, it's critical to close the gender gap when it comes to access to finance as well as to high quality organic and eco-friendly fertilizer and pesticides.

Barriers to Fertilizer Usage

In sum, fertilizer is underused in Mali's agricultural value chains and has recently seen challenges related to increasing price despite government subsidies and the introduction of an electronic guaranteed system for distribution. Key barriers to fertilizer usage:

- **Utilization of fertilizer:** During the 2022 campaign, 332,615 farmers, including 27,426 women (8.2%), received subsidized fertilizers, amounting to 14 billion FCFA. The total quantities of subsidized mineral and organic fertilizers distributed for all crop production in 2022 (93,000 metric tonnes) needed to be increased to meet the requirements for intensifying rice production alone (218,000 metric tonnes).[597] The amount of fertilizer needed to intensify maize production is estimated at 264,000 metric tonnes in 2023. [598] Meanwhile the use of fertilizers in agroforestry value chains such as mango and moringa plantations in Mali is generally very limited, particularly amongst smallholder farmers with limited means and knowledge of appropriate fertilizers.[599]
- **Price of fertilizer:** The increase in global prices for fertilizer driven in large part by the invasion of Ukraine and subsequent sanctions imposed on Russia has consequences in Mali, where it has become very difficult to obtain fertilizer even at market prices (35,000-40,000 FCFA per bag instead of 11,000 FCFA for subsidized fertilizer). In this context, the government has decided to increase the fertilizer subsidy budget from 15 to 17 billion FCFA in 2023[600] and to encourage the use of local fertilizers, including organic fertilizers, which will be available at a price of 2,500 F CFA per bag.[601]

[596] INSTAT, Enquete Agricole de Conjuncture 2017 (2019)
[597] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[598] Ibid.
[599] Ibid.
[600] Ibid.
[601] https://www.commodafrica.com/14-04-2022-au-mali-le-president-de-la-transition-fixe-les-priorites-agricoles

- **Distribution of fertilizer:** An electronic guaranteed system (e-voucher) has been piloted since 2018 to improve transparency, target beneficiaries better, and reduce fraud risks. The system connects fertilizer suppliers with rice farmers via an electronic platform, with farmers receiving an SMS to collect a specific amount of fertilizer from a designated supplier. However, technical limitations, including incomplete databases of farmers and suppliers, lack of farmer access to mobile phones, and illiteracy, have hindered the widespread adoption of the system.[602]
- **Access to organic fertilizer:** the introduction of organic fertilisers by Eléphant Vert in 2016 showed promising results for vegetable growers but its cost prohibitive for most growers. This indicates the need for further development of more cost-effective alternatives without compromising the quality and productivity of vegetable crops.[603] The Ministry of Rural Development estimates the organic fertilizer requirements for intensive rice and maize production at 142,000 metric tonnes.

Table 8 below summarizes the results of the distribution of subsidized fertilizer during the 2022 campaign season highlighting the variation across regions. Overall, 93,000 metric tonnes were distributed to farmers with the Office du Niger (ON) zone receiving the most. In Mopti, just over 7,000 metric tonnes of organic fertilizer were distributed compared to only 872 in terms of mineral fertilizer. Gao received a mere 118.5 metric tonnes of organic fertilizer.

Table 8: Quantity (MT) of Subsidized Fertilizer Distributed[604]

Production zone	Urea	DAP	NPK	Total (Mineral Fertilizer)	Organic Fertilizer	Organic Soil Enhancers
Koulikoro	701	0	338	1,039	8,547	6.92
Sikasso	951	0	595	1,546	14,927	9.98
Ségou	725	0	0	725	3,166	0
Mopti	564	71	237	872	7,140	0
Gao	0	0	0	0	118.5	0
Tombouctou	1,663	51	326	2,040	480	0
Office de Périmètre Irrigué de Baguineda (OPIB)	400	0	92	492	38	0
Office de Moyen Bani (OMB)	388	0	140	528	15	0
Office Riz Mopti (ORM)	365	46	153	564	1,684.4	0
Office de la Haute Vallée du Niger (OHVN)	116	0	41	157	3 092	0
Office de Développement Rurale de Selingué (ODRS)	327	0	104	431	5 451	0
Office Riz Ségou (ORS)	1,134	0	100	1,234	1 153	0,63
Office du Niger (ON)	8 829	0	0	8,829	0	0
Total	**18,309**	**207**	**3,306**	**21,822**	**71,202**	**25.4**

[602] Ministère de l'Agriculture, Plan de Campagne Agricole Consolidé et Harmonisé 2018/2019 (2018).
[603] PACEPEP, *Analyse du marché et du développement de la filière fruits et légumes au Mali (2018).*
[604] Ministère de Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)

Private Sector Case Study for Organic Fertilizer:

Elephant Vert--a multinational company with operations in Europe, Morocco, Senegal, and Mali--transforms organic agricultural waste into fertilizers and pesticides at its plant in Ségou's industrial zone. With a production capacity of 50,000 metric tons per year, Elephant Vert Mali sources its raw material (mango pulp) as far as Yanfolila (Sikasso) where mango processor CEDIAM has its operations. For example, for its *Organova* product, the company recommends the application of 1.5 metric tonnes per hectare for cereals production and 3 tons per hectare for vegetable crops. Assuming the dosage is consistent for all its fertilizer products, Elephant Vert Mali's plant in Ségou can provide sufficient fertilizer to cover over 33,000 hectares of rice paddies.[605]

PHYTOSANITARY PRODUCTS AND SERVICES DEEP DIVE (PEST MANAGEMENT)

General Pest Management:

- The Office de Protection des Végétaux (OPV) is responsible for coordinating and monitoring efforts to mitigate damage by pests.
- Table 7 below provides a clear snapshot of the phytosanitary situation based on the type of pest. The Ministry of Rural Development fixed the objective of surveying 430,000 hectares but only managed to survey just under 270,000 hectares (62.65%). Of the area surveyed, 108,515 hectares (40%) was infested with pests ranging from the Fall Armyworm (68,667 hectares) to fruit flies (5,320 hectares). The Ministry had fixed an objective of treating 195,140 hectares but only managed to treat 78,304 hectares (40%) of areas infested with pests and diseases.

Table 9: Summary of Areas Surveyed, Infested, and Treated by Type of Pest[606]

Type of Pest	Surveyed Area (ha)	Infested Area (ha)	Area Treated (ha)
Tree Locusts	541	391	105
Grasshoppers	11,684	4,381	1,535
Beetles	6,577	3,597	1,897
Fall Armyworm	194,568	68,667	55,881
Caterpillars	10,088	4,358	2,012
Fruit Flies	9,077	5,320	1,736
Other Harmful Insects	22,372	15,439	12,259
Granivorous Birds	8,288	2,017	432
Rodents	1,346	1,154	1,013
Diseases	3,540	2,337	708
Weeds	1,481	855	728
Total 2022	269,562	108,515	78,304
2022 Objectives	430,270		195,140
Rate of Completion	62.65%		40.13%

- Application of pest management also varies by region: in the Office du Niger area and the flooded regions of Ségou and Mopti, there is minimal focus on control measures. The fight against parasitic attacks is almost non-existent in these areas, which impacts crop yields and quality.

Examples by value chain

- **Rice:** Phytosanitary products used in rice cultivation in Mali include herbicides, insecticides, fungicides, and rodenticides. These products are used to control weeds, pests, and diseases that

[605] Elephant Vert Mali, *Nos Offres. Retrieved from* http://en.elephant-vert.com/product/organova-1-1-1/
[606] Ministère de Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)

can negatively impact crop yields. However, using these products can also negatively impact human health and the environment if not used properly. As a result, there is increasing interest in promoting sustainable agriculture practices in Mali, such as integrated pest management and the use of biopesticides, as alternatives to chemical inputs.

- **Maize:** The cultivation of maize for example heavily depends on the use of various phytosanitary products including herbicides, insecticides, fungicides, and rodenticides to prevent the growth of weeds, control pests, and combat diseases that could damage crop yields. Nonetheless, the inappropriate application of these chemicals can have harmful effects on both human health and the environment. Hence, sustainable farming techniques, such as integrated pest management and biopesticide application, are becoming increasingly popular in Mali as substitutes for chemical inputs. These methods strive to safeguard crop yields while reducing the negative impact on human health and the environment.
- **Onion & Shallot:** When it comes to weed control, onion and shallot farmers in the Office du Niger region primarily rely on herbicides such as Roundup, Calache, and Béret Rouge for weed control. A single application is usually sufficient for weed management, with an average usage of 1 liter per 0.25 hectares of land (equivalent to 4 containers per hectare). However, in flooded areas, such as Bla and Bandiagara, women vegetable growers practice manual weeding, known as “sarclo-binage”, 2-3 times during the production cycle.
- **Mango:** In the mango value chain, fruit flies are a major pest, but farmers either lack the financial means to acquire biopesticides or are not well informed about alternative practices to fighting parasites. To mitigate infestation, plantations are treated by exporters and collectors who often receive financial support for this purpose from donor programs. Controlling fruit fly infestation is a significant challenge for the mango sector as it can reduce the quality of mangoes and result in shipments to international markets being seized and destroyed. In addition to standard practices such as pruning, weeding, and reducing the density of mango plots, local stakeholders are also adopting technology that is available locally to control the pests. This includes hot water treatment and the use of Spinosad, a biopesticide. In 2015, ECOWAS established a response plan to support the regional fruit fly management and control plan in West Africa. This plan aims to monitor the level of fly infestation and issue early warnings to producers and plant protection services of member states through Short Message Service (SMS). The alerts are accompanied by advice on how to take effective fruit fly preventive measures. As a result, between 2014 and 2018, the plan reduced the volume of fruit shipments damaged by fruit flies by 57% and increased mango exports from the ECOWAS area to Europe by 40%. Non-compliance with quality requirements due to fruit fly infestation has led to increased interception of infested fresh mangoes by the EU, with 31 containers in 2011, 60 containers in 2016, and 75 containers in 2017. However, initiatives such as the Projet d'Appui à la Compétitivité Agro-industrielle au Mali (PACAM), which treated 25,000 ha against this pest, have contributed to a decrease in intercepted containers to 11 in 2018.[607]

Private Sector Case Study for Phytosanitary Products

Mali Protection des Cultures (MPC) has been operating in Mali since 1998, offering crop protection and public hygiene solutions. As a part of the UPL group, a major player in the global agro-pharmaceutical industry, MPC leverages its expertise to support Malian agriculture with a comprehensive range of crop-specific solutions and personalized advisory services. The company provides both chemical and organic products.[608]

[607] Interprofession de la Filière Mangue - Mali (2017)

[608] https://www.upl-ltd.com/ml/mpc-presentation

LABOUR REQUIREMENTS

Labor plays a crucial role in the adoption and success of technology in Mali's agricultural value chains. Improved farming techniques, mechanization, and irrigation systems, have the potential to significantly enhance productivity, efficiency, and overall agricultural output. However, the effective utilization of these technologies relies heavily on the availability of skilled labour and their willingness to adapt and embrace new practices. Adequate qualified labour is necessary for tasks such as land preparation, planting, irrigation management, proper fertilizer application, effective pest and disease control, harvesting, and post-harvest activities and extension services can play a key role in transferring knowledge and skills. Table 10 shows the percentage of respondents receiving extension services by region.

Additionally, labour-intensive crops like rice and onions require substantial human involvement throughout the cultivation process. Therefore, investing in the training and capacity building of farmers and agricultural workers is essential to ensure they possess the necessary skills to effectively utilize and benefit from technological advancements. By strengthening the labour force's knowledge and capabilities, Mali's agricultural sector can optimize production, improve quality, reduce post-harvest losses, and ultimately contribute to food security and economic growth.

Table 10: Labour Requirements for Selected Crops[609]

Crop	Person/days per ha per year	Avg. Person/months per ha per month	Workers Required per ha
Irrigated rice (total control, broadcast, no additional hired labor)	293.1	9.77	2.44
Irrigated rice (total control, transplanted, no additional hired labor)	264	8.80	2.20
Irrigated rice (counterseason)	142	4.73	1.18
Irrigated rice (counterseason, no additional hired labor)	264	8.80	2.20
Irrigated maize (rainy season)	26	0.87	0.22
Irrigated maize (counterseason)	26	0.87	0.22
Shallot (gardens)	1012	33.73	8.43
Shallot (open fields)	325	10.83	2.71
Shallot (greenhouse)	509	16.97	4.24
Potatoes (greenhouse)	603.3	20.11	5.03
Cowpea (cover cropping)	20	0.67	0.17
Peanut	57	1.90	0.48

[609] Ministère du Développement Rurale, Étude de Faisabilité Économique et Financière pour le Développement d'Entreprises Agricoles dans la zone d'Alatona (2017)

Value Chain Specific Analysis Part 2: Production, Processing, and Marketing

R I C E

Overview

Mali's rice value chain presents opportunities for technological improvement and innovation. The potential cultivable areas for rice production are estimated to be around 2,200,000 hectares, including extensive lowland areas in the southern part of the country. However, less than 30% of the irrigable potential has been developed so far.[610] In 2022, rice production increased by 19% to an estimated 2,880,892 metric tonnes (96% of the target) compared to 2,420,245 metric tonnes in 2021.[611] Table 11 reports the projections for amount of land under cultivation, yields per hectare, and estimated production by type of irrigation system for the 2023 agricultural campaign. Yields per hectare range from 1.5 MT/ha in free flooding irrigation systems to 6.3 MT/ha in total control irrigation systems. In terms of types of irrigation systems, total control and lowland represent 56% of overall land devoted to rice cultivation but what is striking is that in terms of production output, producers with access to total irrigation control represent 54% of overall production.

Table 11: Area, Yield, and Production Estimates by Type of Irrigation System[612]

Irrigation System for Rice	Area (ha)	Yield (MT/ha)	Projection for 2023 (MT)	Percentage	
				Area	Production
Total Control	258,968	6.3	1,633,068	29%	54%
Controlled Flooding	130,458	2.8	362,517	15%	12%
Free Flooding	189,120	1.5	286,702	21%	9%
Lowland	244,002	2.4	581,925	27%	19%
Rainfed	75,674	2.4	184,590	8%	6%
Total	**898,222**	**3.4**	**3,048,802**	**100%**	**100%**

The major constraints to rice production in Mali include challenges in water management, low adoption of modern techniques and technological innovations, inadequate equipment, a shortage of agricultural labor, the persistence of waterborne diseases, high pest pressure, soil degradation, and the silting of the Niger River.[613]

The performance of rice cultivation in Mali in 2022 showed positive results in terms of sown areas, production, and average yield.[614] However, challenges such as flooding, drought, and insecurity affected the achievement of targets while the implementation of the System of Rice Intensification (SRI) in some areas contributed to increased yields. Here are some key points regarding the latest rice cultivation campaign:

- Rice cultivation covered **914,378** hectares, achieving 97.15% of the target set by the Ministère du Développement Rurale.
- Rice production reached **2,880,892 metric tonnes**, achieving 95.77% of the target.
- The average yield for rice was **3.151 MT/ha**, achieving 98.59% of the target.
- Challenges faced included losses of **45,430 hectares** due to flooding, **254.21 hectares** due to drought, and **27,339** hectares abandoned due to insecurity.

[610] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[611] Ibid.
[612] Ibid.
[613] Ibid.
[614] Ibid.

- The implementation of the System of Rice Intensification (SRI) resulted in increased yields, with **18.34** hectares sown and an average yield of **5.6 MT/ha**, producing **102.65 metric tonnes**.[615] The number of rice farmers practicing SRI in 2022 was **29,180**.[616]

By addressing challenges facing private sector actors, Mali can enhance its rice value chain, develop a more sustainable and resilient agriculture, increase productivity, and improve market competitiveness.

- **Production** opportunities include investments in equipment, the deployment of SRI, and enhanced irrigation:
    - **Mechanization and efficiency:** Investing in mechanized equipment significantly improves efficiency by reducing labour costs and increasing yields and quality.
    - **Sustainable production practices:** Encouraging sustainable practices such as System of Rice Intensification (SRI) can enhance the yield, marketability, and value of rice.
    - **Irrigation development:** Mali has vast untapped potential for irrigation. Developing irrigation systems, including drip irrigation, unlocks opportunities for increased yields, better water management, and reduced water usage.
- **Rice processing and quality:** Improving rice processing techniques, such as utilizing mini-rice mills with grading machines and blowers, can enhance the quality of finished products. In addition, contract farming agreements between processors and cooperatives create opportunities for quality control, standardized pricing, and fair-trade practices.
- **Market development:** Addressing trust issues and establishing formal contracts within the rice market can foster greater transparency and reliability. Promoting local rice through public tenders and disseminating price information creates opportunities to stimulate demand, increase market share, and support local rice producers.

Production

Mali has five main rice production systems: irrigated (total water control), lowland, rainfed, controlled flooding, and free flooding. Over 84% of rice production is concentrated in the regions of Mopti (27%), Ségou (26%), Sikasso (16%), and Tombouctou (15%).[617] Irrigated rice farming is mainly concentrated in the Office du Niger area and is characterized by high productivity due to the availability of water and the use of modern technologies. Rainfed lowland rice farming is practiced in the Southern regions of the country and relies on the rainfall pattern. Rainfed upland rice farming is mainly done in the central and northern regions and is characterized by low yields due to water and soil nutrient limitations. Inland valley rice (free flooding) farming is practiced in low-lying areas that are periodically flooded during the rainy season and is characterized by a combination of both irrigated and rain-fed farming techniques.

By capitalizing on opportunities and implementing innovative approaches, Mali can optimize its irrigation systems, enhance rice cultivation, and contribute to improved food security and agricultural sustainability. Key takeaways regarding opportunities in Mali's production and irrigation systems for rice cultivation are:

- **Untapped irrigation potential:** Mali has over 2.2 million hectares of areas suitable for irrigation, but less than 30% has been developed.[618] In particular, the following challenges are associated with the existing rainfed systems: decreasing rainfall and yield variations. These

[615] The FAO estimates Mali's average rice yield at 3.3 metric tonnes per hectare. However, they do not distinguish between the type of production system. Yields range from under 2 MT/ha in free flooding systems to 6 MT/ha under SRI and total irrigation control conditions.
[616] Ibid.
[617] Ibid.
[618] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)

challenges provide a need to develop resilient varieties and implement water-conservation techniques for more consistent yields.

- Expanding irrigation infrastructure presents an opportunity to increase rice production while improving water management. Options for improved irrigation are:
  - **Total water control:** Large irrigated areas and village irrigated areas have shown high yields and the potential for multiple harvests. Investing in water distribution systems, selected seeds, and proper fertilization can further enhance productivity.
  - **Partial water control:** Implementing controlled flooding techniques and improving water retention structures in lowland rice cultivation can boost yields. Encouraging the use of organic and mineral fertilizers can further optimize production.
  - **Free flooding adaptation:** As the oldest form of rice farming in Mali, free flooding rice cultivation faces risks due to climate change and uncertain flooding patterns. Developing robust varieties and exploring innovative irrigation methods can help mitigate risks and increase yields.

Case study: SRI[619]

The Office du Périmètre Irrigué de Baguineda (OPIB) in Mali faces significant challenges impacting rice cultivation, including poor land management, soil fertility issues, erosion, and land degradation. The OPIB perimeter is highly vulnerable to climatic hazards such as droughts and floods, and limited water resources during the off-season and canal invasion by aquatic plants further hinder irrigation and impact rice productivity.

To tackle these challenges, the GIZ introduced the System of Rice Intensification (SRI) within the OPIB perimeter in 2018. SRI practices focus on improving soil fertility, reducing water usage, and increasing rice yields, resulting in positive outcomes. Over the past three years, rice production in the OPIB perimeter has shown an upward trend, with increased yields and decreased water consumption. In 2021, the project achieved a production of 13,663 metric tonnes on 2,723 hectares, averaging 5.5 metric tonnes per hectare.

However, there are still pressing challenges to overcome such as recurring flooding during rainy and high-water periods, degradation of perimeter roads due to heavy truck traffic, and insufficient environmental control that need to be fully addressed.

Case study: Drip irrigation

A recent pilot project found that drip irrigation significantly increased rice yields, from 2 metric tonnes per hectare to 5-6 metric tonnes per hectare, while reducing water usage from 5,000 cubic meters to 1,500 cubic meters per ton of rice produced. In a partnership between Dexis (a US-based consultancy), Netafim (a global leader in drip irrigation technology), and SOPROTRILAD (a Mopti-based rice producer and processor), the pilot project explored the use of drip irrigation on rice cultivation and showed that the technology has the potential to reduce methane emissions associated with flood irrigation. A 10% adoption globally is equivalent to removing 40 million cars from the road in terms of emission reduction.[620]

Although drip irrigation offers promising benefits, the pilot study highlighted challenges in implementing these systems, including the need for technical expertise and substantial financial investment in infrastructure. However, farmers could potentially overcome these challenges by diversifying their crops and adding high-value crops like onions and shallots, which could generate additional income and help offset the initial cost of the irrigation system in as little as two years.[621]

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[619] http://magriculture.gouv.ml/index.php/ministere/organigramme/85-fil-d-actualites/126266-office-du-perimetre-irrigue-de-baguineda-le-riz-de-contre-saison-pour-entamer-sereinement-la-campagne

[620] https://dexisonline.com/insights/increasing-rice-yield-with-less-water-in-mali-results-from-a-dexis-pilot/

[621] Ibid.

Processing

In Mali, rice processing involves various actors, including farmers using manual methods and industrial rice mills with complex equipment. However, most of the processing is done by small, mobile units. These units produce low-quality rice with a high broken rate and impurities due to the obsolescence of the technology and the lack of sorting capabilities. In contrast, mini-rice mills utilize rubber rollers, grading machines, and blowers to extract bran, resulting in better quality rice. Industrial rice mills prioritize quantity over quality, purchasing large volumes at low prices without cultivation contracts.[622] In terms of quality and standards, local rice can be split into three main categories:

- **ELB:** Extra Long Grain White Rice, which is a superior quality rice, represents only 1 to 2% of the market.
- **RM25:** Malian rice containing 25% broken grains, which is a medium to high-quality rice, represents approximately 10% of the market.
- **RM40:** Malian rice containing 40% broken grains, which is a medium-quality rice. This rice quality represents 80-85% of the market.[623]

To improve processing quality, contract farming schemes have been introduced to establish agreements between Planète Distribution, a private company, and 128 farmer cooperatives (plus 7 unions) in the Mopti and Timbuktu regions. The contracts establish quantity, price, payment conditions, and quality specifications thus enabling advance payments and balance settlement, enhancing the quality of rice processing.[624]

Planète Distribution is responsible for managing the supply of inputs and equipment, conducting milling operations, and selling rice. The federation of cooperatives plays a vital role in coordinating production and mediating between Planète Distribution and individual cooperatives. The federation also facilitates the repayment of loans for inputs and equipment.[625]

Marketing and Commercialisation

The marketing and commercialisation of rice in Mali is characterized by mistrust between farmers and buyers especially when it comes to the quality and weight of rice being traded. Digital services like the Sénèkela platform created by Orange Mali is an attempt to introduce pricing transparency by providing producer, wholesale, and retail price information for rice and other crops.[626] Milled rice from their members and sell to wholesalers or establish service partnerships with processors. Aggregators/collectors purchase rice from farmers and in turn, sell it to wholesalers. Semi-wholesalers source supplies from wholesalers in order to distribute the rice to retailers in urban areas. Retailers sell rice to consumers and public buyers acquire rice through competitive bidding processes, often favouring imported rice.[627] While The Office des Produits Agricoles du Mali (OPAM) oversees national cereal procurement for the government, setting prices for local rice remains challenging. The Interprofession Riz (IPRIZ-M) advocates for the inclusion of local rice in government stocks and to purchase at prices favourable to farmers.[628]

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[622] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[623] Telephone exchange Faso Jigi/PACCEM in Ségou, a union of cooperatives in Ségou
[624] https://www.usaid.gov/sites/default/files/success/files/Rice_Producers_more_Resilient_Final.pdf
[625] Ibid.
[626] https://www.orangemali.com/fr/orange-vas/senekela.html
[627] Telephone exchange with Faso Jigi/PACCEM, a union of cooperatives in Ségou
[628] https://ifrizmali.org/les-op-de-riz-accedent-a-une-part-importante-des-marches-institutionnels-au-mali/

M A I Z E

Overview

Land under maize cultivation in 2022 covered 1,452,480 hectares, which represents 94% of the government's target of 1,548,793 hectares. Maize production increased by 4% from an estimated 3,732,505 metric tonnes compared to 3,603,000 metric tonnes in 2021. The average yield obtained per hectare is 2.57 MT, reaching 92.05% of the target yield of 2.8 MT/ha and showing improvement from the yield of 2.36 MT/ha in 2021.[629]

Mali can overcome challenges in maize production and processing by making targeted investments resulting in increased productivity, improved quality, reduced post-harvest losses, and enhanced market competitiveness. Some of the potential opportunities to pursue are the following:[630]

- **Enhancing post-harvest storage and conservation:** Investing in suitable warehouses and promoting improved storage techniques can reduce physical and qualitative losses, such as those caused by pests, fungi, and aflatoxin contamination.
- **Strengthening the post-harvest processing industry:** Supporting the development of efficient and quality-focused maize processing units, including small-scale rural mills, semi-industrial mills, and larger industrial units, can improve product consistency and enhance value-added processing.
- **Supporting investment and expansion of processing companies:** Providing funding and resources to established maize processing companies, such as COGETRAM, Karangana, and Moulins Moderne du Mali (M3), can help them expand their production capacities and meet growing market demands.
- **Encouraging diversification of maize-based products:** Promoting the development of small businesses engaged in the second transformation of maize, producing a variety of maize-based products, can increase value addition and create new market opportunities.
- **Exploring incorporation of maize flour in wheat flour formulations:** Investigating the use of maize flour in wheat flour formulations for bread production can stimulate demand for locally sourced maize and contribute to the utilization of maize in diverse food products.
- **Strengthening market linkages and information sharing:** Facilitating efficient connections between rural collectors, wholesalers, distributors, retailers, and end consumers can improve market efficiency and reduce transaction costs. Services like Sénèkela, which provide advisory services as well as agricultural price information, can enable better decision-making for market participants.

Production

Maize production in Mali largely depends on rainfall, with the primary growing season taking place from May/June to September/October. While some irrigated perimeters, such as the Office du Niger, Baguineda, and Selingué, have access to controlled irrigation for a counter-season crop, this remains limited and relies on water levels from rivers.[631]

In terms of technology and innovation, improved hybrid seeds, including around a dozen varieties developed by researchers, are increasingly available through seed farmers and agricultural input companies. These hybrids offer the potential for significant yield increases of 20 to 30% compared to traditional varieties.[632] However, despite their proven benefits, the adoption of hybrids in maize production remains relatively low, currently accounting for less than 5% of total maize cultivation in the

[629] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[630] Tambaroua Consultations, 2023
[631] Ibid.

[632] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)

country. To tap into the full potential of hybrid seeds and enhance maize productivity, there is an opportunity to promote their wider adoption and educate farmers about the advantages they offer in terms of higher yields and improved resilience.[633]

Processing

The maize flour milling industry in Mali is primarily composed of small-scale rural mills and semi-industrial mills. However, inconsistent product quality standards and challenges in sourcing good maize hinder the success of industrial mills. Small-scale mills operate as service providers, while semi-industrial mills face issues with irregular production and product quality.[634] Despite these challenges, there are notable companies involved in maize processing, and a growing number of small businesses are specializing in the second transformation of maize. The incorporation of maize flour in wheat flour formulations for bread production is being explored, and rural collectors play a crucial role in the marketing and commercialization of maize.[635]

There are 3 main types of maize processing units in Mali:[636]

- Small-scale rural mills operate as service providers, where customers bring their own maize for grinding. The output is a mixture of flour, bran, and germ that requires additional cleaning and sorting before consumption.
- Semi-industrial mills use mechanized equipment but struggle with inconsistent quality of maize and offering flexible payment terms, resulting in irregular production and inconsistent and sub-standard product.
- Industrial units historically supported by wheat mills face difficulties with the fragmented and variable quality of locally sourced maize.

There is a growing number of small businesses specializing in the second transformation of maize, producing various maize-based products such as biscuits, chips, breakfast cereals, infant flour, fortified flour/semolina, couscous, pasta, grits for breweries, and ingredients for poultry and dairy production. Some businesses rely on locally sourced maize flour, while others import flour due to quality limitations. The incorporation of maize flour in wheat flour formulations for bread production continues to be explored.[637] Some notable companies in maize processing in Mali areCOGETRAM, Karangana, and Moulins Moderne du Mali (M3).

Marketing and Commercialisation

Rural collectors serve as intermediaries, gathering surplus maize from smallholder farmers and selling it to wholesalers. However, there are alternative commercial channels where producers sell directly to wholesalers and semi-wholesalers, bypassing the need for collectors. Wholesalers and semi-wholesalers purchase large quantities of maize and store it temporarily in rented warehouses before reselling it locally to distributors and large traders.[638]

Retailers, who have limited working capital, primarily sell maize to end consumers and often diversify their offerings with other cereals and agricultural products. They can source maize from local or intermediary wholesalers, as well as directly from producers. Some retailers also double as rural collectors, procuring maize from production areas for their stores or roadside stalls.[639]

[633] Ibid.
[634] Ibid.
[635] Ibid
[636] Tambaroua Consultations, 2023
[637] Tambaroua Consultations, 2023
[638] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[639] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)

ONION AND SHALLOT

Overview

Market gardening and in particular onion and shallot production in Mali is expanding, driven by factors such as increased involvement of women and youth supported by projects and NGOs, growing domestic and international markets, favourable climatic conditions, and increased investments in the sector.[640] According to government statistics (see Table 12), land under onion cultivation in 2021 covered 8,593 hectares, which represents 81% of the government's target of 10,658 hectares. However, land under shallot cultivation is more than double that of onion cultivation with an estimated 18,386 hectares (87% of the target of 21,108 hectares). In 2020, land under onion and shallot cultivation was estimated at 9,606 and 18,257 hectares respectively. In terms of production, onion production decreased by 9.1% from 202,048 metric tonnes in 2020 to 183,604 metric tonnes in 2021. However, shallot production increased slightly (0.7%) from 493,031 metric tonnes in 2020 to 501,049 in 2021.The average yield obtained per hectare at the national level is 21 MT/ha for onion and 27 MT/ha.

However, the main challenges include weak sector organization, high seed costs, limited processing technologies, inadequate infrastructure for storage and packaging, and pest and disease management.[641] Other challenges facing actors in the value chain are:

- Small-scale female farmers are the primary producers of onions and shallots, with cultivation carried out using traditional methods.
- Domestic production falls short of meeting demand, leading to imports from the Netherlands, Spain, and Morocco.
- Farmers use manual watering or rudimentary motor pumps with tube wells for irrigation.[642]

Table 12: Onion and Shallot Production by Region (2021)[643]

Region	Onion		Shallot	
	Ha	MT	Ha	MT
Koulikoro	3,439	72,122	1,391	24,241
Sikasso	291	4,880	340	5,094
Ségou	325	6,055	10,079	312,766
Mopti	256	6,183	2,680	89,328
Timbuktu	2,705	60,700	1,051	20,238
Gao	552	11,428	124	1,568
Bamako	101	3,030	10	130
Mali 2021	**8,593**	**183,604**	**18,386**	**501,049**
Target 2021	10,658	243,134	21,108	590,595
% Completed	81%	76%	87%	85%
Mali 2020	**9,606**	**202,048**	**18,257**	**493,031**

Some of the opportunities for technology and innovation are:[644]

- Developing and disseminating improved **processing technologies** for onions and shallots to increase value-added products.
- **Investing in infrastructure for post-harvest storage and packaging**, including the development of more optimized storage facilities and warehouses.
- Introducing pest and disease management technologies to minimize crop losses.
- **Encouraging modern irrigation systems** with efficient water management characteristics such as drip irrigation

[640] Tambaroua Consultations, 2023
[641] Ministère de l'Agriculture, Plan de Campagne Agricole Consolidé et Harmonisé 2018/2019 (2018).
[642] PACEPEP, *Analyse du marché et du développement de la filière fruits et légumes au Mali (2018).*
[643] Ministère de l'Agriculture, *Bilan de Campagne Définitif 2021* (2022)
[644] PACEPEP, *Analyse du marché et du développement de la filière fruits et légumes au Mali (2018).*

- Strengthening sector organization and utilizing digital platforms for better coordination among stakeholders.
- **Implementing quality control technologies** to eliminate toxicity, ensure consistency and meet market demands.

Production

- Onions are mainly cultivated in the regions of Koulikoro, Mopti, Timbuktu, Ségou, Gao, and Sikasso while shallots are primarily grown in the regions of Ségou (Office du Niger) and Mopti (Plateau Dogon). The cultivation of onions and shallots takes place between the months of November and May. In the Dogon country, there are two harvests: a primary harvest in January/March and a primary harvest in October/December.[645]
- Production is almost exclusively carried out by small-scale farmers on plots ranging from 0.01 to 0.5 hectares. [646] In irrigated areas and peri-urban zones of major cities, plot sizes range from 0.25 to 1 hectare. The number of producers is estimated to be 70,000 small-scale farmers, predominantly women, with nearly 26,000 in the Office du Niger area and 15,000 in the Dogon plateau.[647] The cultivation methods remain traditional, although some commercial initiatives are starting to emerge.[648]
- The current level of onion production in Mali is not sufficient to meet domestic demand, although a portion is exported to neighbouring countries. Mali imports approximately 30,000 metric tonnes of onions from the Netherlands, Spain, and Morocco. The arrivals in the Bamako market are estimated at 30 trucks carrying 20 metric tonnes per week during the period from June to December.[649]
- Two types of irrigation are practiced in onion and shallot production based on the farmer's resources: manual irrigation with watering cans and irrigation using motor pumps with tube wells. Manual watering with watering cans is performed daily (morning or evening) until 15 days before harvest when the plants start to wilt. Gravity irrigation with motor pumps is done once a week from transplanting to bulb formation. From bulb formation onwards, watering is increased to twice a week until 15 days prior to harvest. These irrigation practices ensure proper moisture management and support the healthy growth of crops in market gardening operations.[650]

Processing

Currently, only one company is involved in the agro-industrial processing of onions and shallots, Entreprise Aminata Konaté, better known as Bara Musso. The company primarily sources fresh onions for its processing activities in order to manufacture onion powder as well as chopped anddried shallots.[651]

Marketing and Commercialisation

The three main production areas for onions/shallots--the Office du Niger area, the Dogon country, and the peri-urban region of Bamako (Kati, Koulikoro)--supply their harvests to the central market in Bamako, which subsequently serves the smaller markets in the Bamako region. Additionally, there are export channels to neighbouring countries such as Guinea, Senegal, Mauritania, Côte d'Ivoire, and Burkina Faso.[652] Shallot exports are facilitated from the major market in Bamako to Guinea, while exports from Sikasso cater to Côte d'Ivoire and Burkina Faso. In terms of imports, two main streams

645 Ministère de l'Agriculture, Plan de Campagne Agricole Consolidé et Harmonisé 2018/2019 (2018).
646 Ibid.
647 Ibid.
648 PACEPEP, Analyse du Marché et du Développement de la Filière Fruits et Légumes au Mali (2018).
649 Tambaroua Consultations, 2023
650 PACEPEP, Analyse du Marché et du Développement de la Filière Fruits et Légumes au Mali (2018)
651 Tambaroua Consultations, 2023
652 PACEPEP, Analyse du Marché et du Développement de la Filière Fruits et Légumes au Mali (2018)

exist: Dutch onions, which enter the major market in Bamako via Senegal (Dakar) and Côte d'Ivoire (Abidjan), and Galmi onions from Niger.[653]

COWPEA AND PEANUT

Overview

Cowpea and peanut are crucial crops in Mali. With cowpea serving as a staple commodity and peanuts as a cash crop, both contribute to food security and income for smallholder farmers. Women play a dominant role in the value chains of both crops, from production to marketing.[654] Mali has witnessed significant growth in cowpea production, while peanuts are mainly cultivated in specific regions. Both crops are vital because they also play a crucial in improving soil fertility especially in crop rotation systems while their leaves also serve as animal fodder. Both crops are also well suited for further value-addition through processing activities[655]

Table 13: Cowpea and Peanut Production by Region (2021)[656]

Region	Cowpea		Cowpea Leaves		Peanut	
	Ha	MT	Ha	MT	Ha	MT
Koulikoro	84,388	22,944	119	341	124,468	51,070
Sikasso	48,934	49,530	98	476	23,480	27,722
Ségou	225,802	99,832	49	394	52,153	27,120
Mopti	26,065	10,350	0	0	21,172	12,970
Tombouctou	9,194	2,251	28	118	476	112
Gao	0	0	0	0	0	0
Bamako	0	0	257	2,313	0	0
Total Mali 2021	**507,290**	**230,668**	**931**	**6,461**	**443,374**	**345,247**
Target	559,004	297,834	911	8,455	520,367	512,785
% Completed	91%	77%	102%	76%	85%	67%
Total Mali 2020	**559,004**	**297,834**	**636**	**4,531**	**484,139**	**464,538**

As reported in Table 13, with over 500,000 hectares dedicated to its cultivation in Mali, cowpea production is divided among four main regions: Ségou (99,832 metric tonnes), Koulikoro (84,388 metric tonnes), Sikasso (49,530 metric tonnes), and Mopti (10,350 metric tonnes) with an average yield of 0.45 MT/ha. Cowpea production in Mali has expanded significantly, with the country ranking 4th globally. It is grown in association with cereals and has cultural importance, fostering social cohesion.[657] Cowpea leaves also have economic value, being prized for their nutritional and sensory properties. They are typically used in sauces accompanying cereals like rice, maize, millet, and sorghum. The national estimates for land area under cultivation and metric tonnes produced are 931 hectares and 6,461 metric tonnes resulting in an average yield of approximately 7 MT/ha.[658]

During the 2021 production campaign, peanuts were cultivated on 443,374 hectares with the main production regions being Koulikoro (124,478 hectares), Ségou (52,153 hectares), Sikasso (23,480 hectares), and Mopti (21,172 hectares). Average national yields are estimated at 0.78 MT/ha with highest yields obtained by farmers in Sikasso (1.2 MT/ha).[659]

[653] PACEPEP, Analyse du Marché et du Développement de la Filière Fruits et Légumes au Mali (2018)
[654] Sissoko et al., Beyond the grain: the potential of cowpea in local markets in Mali (2021).
[655] Ibid.
[656] Ministère de l'Agriculture, *Bilan de Campagne Définitif 2021* (2022)
[657] Sissoko et al., Beyond the grain: the potential of cowpea in local markets in Mali (2021).
[658] Ministère de l'Agriculture, *Bilan de Campagne Définitif 2021* (2022)
[659] Ministère de l'Agriculture, *Bilan de Campagne Définitif 2021* (2022)

Cowpea Production

The cultivation of cowpea is practiced year-round in Mali, both during the rainy and dry seasons, either as intercrop with cereals such as sorghum, millet, and maize or as a sole crop with higher yields. Cowpea is grown across all production zones and in various production systems, including rainfed, lowland, and irrigated.[660]

Peanut Production

The main production basins for peanuts in Mali are the regions of Kayes, Koulikoro, Sikasso, Ségou, and Mopti. Peanuts are also grown in the lake areas of Tombouctou. The climatic and soil conditions in Mali offer significant potential for peanut cultivation. Peanuts are commonly used for human consumption (fresh peanuts, peanut butter/paste, and roasted peanuts) and for animal feed (peanut leaves).[661]

Processing

In Mali, cowpea and peanut processing are essential components of the local food system. While traditional methods of processing cowpeas and peanuts dominate, opportunities for technology and innovation exist to improve efficiency, product quality, and food safety.

Several challenges need to be addressed, including low processing rates, limited access to industrial units, aflatoxin contamination in peanut products, and the need for modern processing techniques. By leveraging technology and adopting innovative approaches, private sector actors can enhance its processing capabilities, increase value addition, and ensure the safety and quality of processed cowpeas and peanuts.

Processed cowpea products include couscous, fritters, pancakes, and cooked cowpeas, while peanuts are processed mainly into peanut butter. While the GoM supports projects and programs that provide technical assistance, equipment, seeds, fertilizer, and packaging to value chain actors, they still face challenges related to limited credit access, inadequate processing technology, and poor post-harvest handling. Addressing these challenges through improved farming practices, storage, processing technology, and access to finance can have a positive impact.

The following are the main challenges facing cowpea and peanut processors:[662]

- **Low processing rates:** A small percentage of cowpea production is currently processed for marketing purposes, limiting value addition and market opportunities.
- **Limited access to industrial units:** Mali lacks large-scale industrial units for processing peanut butter, relying mostly on small-scale operations managed by women.
- **Aflatoxin contamination:** Recent studies have highlighted the presence of aflatoxin in peanut butter and paste products in Malian markets, posing health risks to consumers.[663]
- **Traditional processing techniques:** The use of traditional processing methods, such as manual grinding, can limit efficiency and product consistency.

In terms of opportunities for technology and innovation, the following investments can strengthen the cowpea and peanut value chains:[664]

- **Modern processing techniques:** Introducing mechanized processing methods, such as mechanical grinders and roasters, can improve efficiency and product consistency.

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[660] Sissoko et al., Beyond the grain: the potential of cowpea in local markets in Mali (2021).
[661] Ministère de l'Agriculture, Plan de Campagne Agricole Consolidé et Harmonisé 2018/2019 (2018)
[662] Ministère de l'Agriculture, Plan de Campagne Agricole Consolidé et Harmonisé 2018/2019 (2018).
[663] https://www.jstm.org/a-kita-des-chercheurs-alertent-sur-la-presence-de-substances-cancerigenes-dans-les-pates-darachide/
[664] Tambaroua Consultations, 2023

- **Food safety measures:** Implementing sorting and screening techniques to remove aflatoxin-contaminated peanuts can ensure safer and higher-quality peanut products.
- **Industrial units for processing:** Investing in large-scale industrial units for peanut processing can enhance production capacity and meet the growing demand for peanut butter.
- **Value-added products:** Exploring the development of new cowpea and peanut products, such as snacks, sauces, and oils, can diversify the market and increase economic opportunities for farmers and processors.
- **Quality control and certification:** Establishing quality control measures and certification systems can assure consumers of the safety and quality of processed cowpeas and peanuts.
- **Research and development:** Conducting research to identify innovative processing techniques and improve post-harvest handling practices can contribute to the overall efficiency and sustainability of cowpea and peanut processing in Mali. Investment in storage technology such as PICS bags is a cost-effective way to reduce post-harvest losses.[665]

Peanuts are also a source of vegetable oil for cooking applications and while production numbers are unavailable, private companies are looking to supply consumers with locally sourced and produced oil. Bara Musso is a producer of spices and fast-moving consumer goods based in Bamako and operating in the sub-region. The company employs 200 workers to process shallots, onions, okra, and peppers into spices and sauces.666 In 2019, Bara Musso launched its own brand of cooking oil produced from peanuts grown in Mali. The oil is a prepared and extracted from peanuts using a hydraulic press at their production facility in Diago (Koulikoro).[667]

Marketing and Commercialisation

Women play a significant role in the processing and marketing of cowpea grains, while small-scale farmers and processors also play a key marketing role. Additionally, the cowpea and peanut fodder market presents opportunities for integration between agriculture and livestock farming. However, there are challenges in terms of organization, access to processing equipment, and limited market opportunities.[668] By leveraging technology and innovative approaches, Mali can address these challenges and unlock the potential of marketing and commercialization in these agricultural sectors.

The challenges facing the marketing and commercialisation:[669]

- **Limited organization:** The cowpea and peanut value chains lack formal organization, leading to fragmented activities and suboptimal coordination among actors.
- **Access to processing equipment:** Retailers and processors often rely on traditional processing methods and basic equipment, limiting efficiency and product quality.
- **Market opportunities:** The availability of cowpea and peanut products in local markets is influenced by the limited presence of wholesalers, collectors, and processors, particularly in rural areas.
- **Awareness of nutritional value:** Despite the nutritional benefits of cowpea leaves and fresh pods, there is a need to increase awareness and promote their consumption among consumers.

The opportunities for technology and innovation:[670]

[665] https://picsnetwork.org
[666] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[667] https://notrenation.com/BARA-MUSSO-L-huile-d-arachide-made-in-Mali-ideale-pour-la-sante-et-la-cuisson
[668] Sissoko et al., Beyond the grain: the potential of cowpea in local markets in Mali (2021).
[669] Sissoko et al., Beyond the grain: the potential of cowpea in local markets in Mali (2021).
[670] Tambaroua Consultations, 2023

- **Value chain coordination:** Introducing technology-driven platforms for cooperatives can enhance coordination among actors, facilitating better organization, information sharing, and market linkages.
- **Market infrastructure:** Developing storage facilities, marketplaces, and transportation networks can improve market access and facilitate the distribution of cowpea and peanut products.
- **Value-added products:** Exploring the development of new cowpea and peanut products, such as snacks, sauces, oils, and fodder formulations, can diversify the market and increase value addition.
- **Nutritional awareness campaigns:** Conducting educational campaigns to raise awareness about the nutritional benefits of cowpea leaves and fresh pods can stimulate demand and promote their consumption.
- **Livestock feed innovation:** Investing in research and development to create innovative and nutritious fodder formulations using cowpea and peanut by-products can support the integration of agriculture and livestock farming, enhancing income opportunities for farmers and retailers.

SWEET POTATO

Overview

Sweet potato production in Mali has been experiencing growth, providing opportunities for smallholder farmers and local markets. However, the sector faces challenges in terms of limited support from development projects, lack of involvement from NGOs and research institutions, and variations in demand and prices.[671] Additionally, the marketing sector is predominantly male-dominated, except in Ségou where women play a significant role.[672]

Table 14: Sweet Potato Production by Region (2021)[673]

Region	Sweet Potato		Sweet Potato Leaves	
	Ha	MT	Ha	MT
Koulikoro	2,067	32,770	184	490
Sikasso	25,916	395,308	120	800
Ségou	942	19,744	0	0
Mopti	60	1,250	0	0
Timbuktu	830	12,782	0	0
Gao	460	5,889	0	0
Bamako	0	0	26	177
Total 2021	33,563	519,788	851	3,933
Target 2021	45,751	731,449	586,5	3,529
% Completed 2021	73%	71%	145%	111%
Total 2020	39,104	573,184	574	3,014

According to government statistics (see Table 14), land under sweet potato cultivation in 2021 covered 33,563 hectares, which represents 73% of the government's target of 45,751 hectares. With an average yield of 15.5 MT/ha the national production for sweet potatoes was estimated at 519,788

[671] Ministère de l'Agriculture, Etude Diagnostique pour L'Élaboration de Strategies de Promotion et de Valorisation Des Filieres Pomme de Terre, Patate Douce, Manioc, Pois Sucre, Fonio et Sesame dans les Regions de Koulikoro, Sikasso Et Segou
[672] Institut d'Économie Rurale, Evaluation des Variétés Locales de Manioc et de la Patate Douce au Mali (2013).
[673] Ministère de l'Agriculture, *Bilan de Campagne Définitif 2021* (2022)

metric tonnes. Sweet potato leaves, which are used as a main ingredient in sauces for rice, was grown on 851 hectares of land with an average yield of 4.6 MT/ha.

The key challenges facing the sweet potato value chain are the following:[674]

- **Limited support and involvement:** The sweet potato sector in Mali lacks significant support from development projects, as well as involvement from NGOs and research institutions, hindering its growth and potential.
- **Fluctuating demand and prices:** Demand for sweet potatoes fluctuates throughout the year, leading to variations in prices. This can affect the profitability and income stability of farmers and other actors in the value chain.
- **Gender disparity:** The marketing sector is predominantly male-dominated, limiting opportunities for women's participation and empowerment.
- **Low popularity of orange-fleshed varieties:** Orange-fleshed sweet potato varieties, known for their nutritional value, have lower popularity due to perceived lower yields.

In terms of technological development, Mali lacks sweet potato processing facilities so investing in this segment of the value chain can generate significant impact. Areas where technology can enhance output and quality are the following:[675]

- **Improved production techniques:** Technology can enhance sweet potato production through the adoption of improved farming practices, such as precision agriculture, irrigation systems, and pest and disease management tools.
- **Value addition and processing:** Investing in technology and innovation to create value-added products, such as chips, flour, and snacks. This can increase market opportunities and add value to the crop.
- **Market information systems:** Developing technology-driven platforms and systems to provide market information, including prices, demand trends, and market linkages, can empower farmers and other actors in making informed decisions and facilitating transactions.
- **Gender inclusion initiatives:** Technology can play a vital role in promoting gender inclusion by providing training and access to resources for women in the sweet potato value chain. This can empower them economically and increase their participation in decision-making processes.
- **Research development:** Increased investment in research and development can lead to the development of new sweet potato varieties with improved characteristics, including higher yields, disease resistance, and enhanced nutritional value.
- **Regional and international market access:** Leveraging technology for market intelligence, logistics, and quality assurance can facilitate the export of sweet potatoes to neighbouring countries like Senegal and Mauritania, tapping into growing regional demand.
- **Public awareness and educational campaigns:** Creating awareness and promoting the benefits of more nutritional, orange-flesh varieties is crucial.

Production

The main season for production is during the rainy season (June to September).[676] Unlike the potato value chain, sweet potato production is not supported by development projects or programs. Indirect actors such as NGOs, research institutions, and technical services play a minimal role in technology

[674] Ministère de l'Agriculture, *Bilan de Campagne Définitif 2021* (2022)
[675] Ministère de l'Agriculture, Etude Diagnostique pour L'Élaboration de Strategies de Promotion et de Valorisation Des Filieres Pomme de Terre, Patate Douce, Manioc, Pois Sucre, Fonio et Sesame dans les Regions de Koulikoro, Sikasso Et Segou
[676] COLEACP, Fruits et légumes du Mali, hors saison de production de la mangue

development and support. Nonetheless, initiatives have been taken to improve varietal research through the West Africa Agricultural Productivity Program (WAAPP) under the guidance of the l'Institut de l'Économie Rurale (IER).[677]

Marketing and Commercialization

Sweet potatoes, in the form of fresh tubers are abundant in the market from October to December, but they are not available outside of this period. Most transactions in the sweet potato sector are based on informal agreements, and the distribution channels include producers, collectors, wholesalers, retailers, and consumers. The main markets for sweet potatoes are Bamako, the capital, and other major cities in the regions. However, there is an increasing demand for sweet potatoes in some neighbouring countries, especially Senegal and Mauritania, but unfortunately, there are no statistics available on the exported quantities.[678]

S H E A

Overview

Mali is a major player in the global shea industry, with abundant shea tree populations and significant production of shea nuts and butter. However, the sector is predominantly informal with formal, industrial processing and value addition technologies are nascent.[679]

The main production areas are in the cercles of Kita, Kéniéba, and Bafoulabé (Kayes region), Dioïla, Kangaba, and Kolokani (Koulikoro region), San, Bla, Baraouéli, Ségou, and Tominian (Ségou region), and all cercles in the Sikasso region. The country is one of the world's leading producers, with an estimated potential of 250,000 tons of shea nuts. An estimated 53,000 tons of almonds are exported.[680] In 2021, Sikasso led the way in the production of shea nuts with 53,554 metric tonnes followed by Koulikoro with 39,815 metric tonnes as shown in Table 15. Nationally, Malian producers collected 176,695 metric tonnes of shea nuts in 2021 compared to 167,967 in 2020.

Table 15: Shea Nut Production by Region (2021)[681]

Region	Shea Nuts (MT)
Koulikoro	39,815
Sikasso	53,554
Ségou	4,986
Mopti	241
Timbuktu	0
Gao	0
Bamako	0
Total Mali 2021	**176,695**
Target 2021	188,480
% Complete	94%
Total Mali 2020	**167,967**

[677] Institut d'Économie Rurale, Evaluation des Variétés Locales de Manioc et de la Patate Douce au Mali (2013).
[678] Ibid.
[679] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[680] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[681] Ministère de l'Agriculture, *Bilan de Campagne Définitif 2021* (2022)

The challenges facing the shea value chain can be broken down in three categories:[682]

- **Limited use of technology:** The shea industry in Mali has traditionally relied on manual labour, with little utilization of machinery for tasks such as nut collection. This poses challenges in terms of productivity, efficiency, and scalability.
- **Variability in extraction methods:** Different extraction methods, ranging from traditional to industrial, have varying impacts on the quality and yield of shea butter. Finding a balance between efficiency and maintaining the natural healing properties of shea butter is a challenge.
- **Informal market structure:** The dominance of informal actors in the shea industry hampers standardization, quality control, and traceability. Establishing formalized systems and supply chains is crucial for ensuring consistent quality and meeting market demands.

The challenges above can be addressed by investing in the following technologies and innovations:[683]

- **Logistics and mechanization:** Transportation solutions for nut collection, sorting, and processing can enhance productivity, reduce labour-intensive work, and increase overall efficiency.
- **Improved extraction techniques:** Advancements in extraction technology can help optimize the yield and quality of shea butter. Developing methods that maintain the natural properties of shea while increasing production rates can enhance profitability and market competitiveness.
- **Product diversification and value addition:** Technology enables the creation of new shea-based products and formulations. Investing in research and development for skincare, cosmetics, and other value-added products can expand market opportunities and increase the value of shea exports.
- **Partnerships and market linkages:** Collaboration between private sector actors, development partners, and local producers can foster innovation, access to finance, and market expansion. Establishing strong relationships and reliable supply chains can create opportunities for scaling up the shea industry in Mali.
- **Sustainability and traceability:** Technology can play a vital role in ensuring sustainable sourcing practices and improving traceability in the shea value chain. Implementing digital tools for data management, certification, and supply chain transparency can enhance market access and consumer trust.

Production

Shea butter production involves a series of steps, starting with the collection and drying of shea nuts, followed by sorting, cleaning, roasting, grinding, and separating the oil from the solids. The oil is then skimmed, cooled, and filtered to produce shea butter.[684] Technological factors affecting the shea value chain include traditional, semi-industrial, and industrial extraction methods, with varying extraction rates and quality:

- Shea butter production involves collecting and drying shea nuts, followed by sorting, cleaning, roasting, grinding, and separating the oil from the solids.
    - The **traditional method** involves grinding the nuts, mixing with water, heating, and separating the oil layer to obtain high-quality shea butter.
    - The **semi-industrial method** uses machines for grinding and pressing the nuts, resulting in faster production but potentially lower quality.

[682] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[683] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[684] WATH, The Shea Value Chain (2004)

- The **industrial method** utilizes fully mechanical and chemical processes to achieve high yields and uniform product, but it sacrifices the natural healing properties of shea butter.

Each method has its advantages and challenges in terms of time, quality, yield, and healing properties.[685]

Private Sector Case Study: Mali Shi

Mali Shi is a modern industrial unit for shea butter production located in Banankoroni, with a capacity to transform 30,000 to 32,000 tonnes of shea nuts into 14,000 tonnes of shea butter. [686] It was inaugurated in 2021, with its capital owned 58.5% by the Malian company Omnium Mali SA, 35% by ECODEV (560 million FCFA), the investment fund of the mining group Endeavour managed by the French company classM, and 6.5% by the Malian shea trader Société Abou Talla et Frère (SOATAF). OBJ[687]

Mali Shi operates throughout the value chain from the collection of nuts to their transformation into butter. The factory sources nuts from collectors organized in cooperatives in the regions of Sikasso, Ségou, Kayes, and Koulikoro, and buys nuts from wholesalers and exporters. At full capacity, it has the potential to impact over 100,000 women collectors. The estimated working capital requirement is between 4 and 5 billion FCFA.[688] A new industrial shea plant (Diogo Awa Kéita) is scheduled to launch by the end of 2023. Funded by the renowned Malian footballer Seydou Kéita in Sanankoroba (outskirts of Bamako), the complex will comprise seven production plants, including shea, cottonseed oil, palm oil, soap, and poultry feed. The investment is valued at over 9 billion FCFA.[689]

Processing, Marketing, and Commercialization

Most of the shea nuts destined for commercialization are processed by artisanal and semi-industrial units. Some of the most dynamic entities are supported by development partners such as COPRAKAZAN, COOPROKASI, Siyiriwa, ULPK, and Yiriwasso. In recent years, several enterprises led by young women from the middle and upper classes have specialized in producing soaps and skincare products for national and international niche markets. Provided that they sell finished products, they invest more in packaging, product development, and marketing. Some of the brands present in the market include Kocos, Soraya, Shea Butter Baby, and Karismétique.[690]

In contrast, Mali Shi targets the agro-industrial market, as the company sells its butter to refiners, mainly Bunge, which fractionates it to recover stearin, which is then sold as a vegetable butter for chocolate making, among other uses.[691] The International Finance Corporation via the Global Agricultural Food and Security Program has lent 1.7 billion FCFA to the company.[692]

The main shea butter exporters in Mali are SOATAF, ACO Industrie, ACOGEDI, Agro-Mali Sen, General Trading Mamadou Diakité (GTMD), Etablissement Soumaïla Daou, and Lawal International. These companies specialize in exporting shea butter to international markets and have established themselves as key players in the shea butter industry in Mali. They have developed strong relationships with local producers and cooperatives, ensuring a reliable supply chain of high-quality shea butter.

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[685] WATH, The Shea Value Chain (2004)

[686] https://www.agenceecofin.com/agro-industrie/1203-86109-au-mali-inauguration-de-mali-shi-premiere-usine-moderne-de-transformation-de-karite

[687] Ibid.

[688] http://www.commodafrica.com/12-07-2019-au-mali-la-sfi-investit-25-millions-dans-lusine-de-karite-de-mali-shi

[689] https://www.commodafrica.com/26-05-2023-le-footballeur-seydou-keita-investit-fcfa-9-mds-dans-lagroindustrie-au-mali

[690] Tambaroua Consultations, 2023

[691] https://europe.bungeloders.com/en/news/finding-common-ground-shea-crushers-mali

[692] https://www.ifc.org/en/types/stories/2020/shea-nut-mali

M A N G O

Overview

The mango tree, originating from India, spread to Senegal in 1824 and later to Mali, where the Amélie variety gained popularity. Mali became the first West African country to export mangoes to Europe in the late 1960s. Mango cultivation covers around 100,000 hectares in Mali, making it the largest fruit crop.[693]

The region of Sikasso, which shares borders with Burkina Faso and Ivory Coast, is the main mango production area in Mali. In 2019, Sikasso region accounted for 69% of the national production (58,000 tonnes), followed by Koulikoro with 19% (16,500 tonnes) and the Bamako district with 9% (8,300 tonnes). Mango is a highly perishable fruit and efforts are underway to reduce post-harvest losses and maintain quality: [694]

- Despite high production levels, post-harvest losses and limited market access result in a small portion of the mangoes being sold.
- The quantity of processed mango is increasing but remains secondary to fresh fruit production.
- Mango plantations provide ecological benefits such as preventing soil erosion and sequestering greenhouse gases.
- Storage facilities like the Périmètre Logistique Aménagé en Zone Aéroportuaire (PLAZA) and the Centre de Conditionnement pour la Mangue et la Pomme de Terre de Sikasso (CCMPS) support post-harvest processing
- The mango market in Mali is segmented among traders supplying different varieties, with Amélie being replaced by Kent and Keitt due to better shelf life and customer preferences.
- SCS International has invested in a cardboard factory in 2020 to support packaging and transportation.

Production

Producers of mango in Mali are mainly smallholder farmers who have diversified crops. Mango is an important source of income for them as it grows during the dry off-season. Traditional plantations, with an average size of 2 to 3 hectares and around 200 trees per hectare, are the most common method of production. These plantations are mostly rainfed. There are only a few commercial and professional plantations ranging from 20 to 100 hectares, with a high planting density of up to 400 trees per hectare, and drip irrigation in some cases.[695]

The development of industrial plantations and the promotion of sustainable farming practices can contribute to increased productivity and income for farmers, as well as meet the growing demand for mangoes in domestic and international markets. As such, there is potential for the mango industry in Mali to overcome challenges through the adoption of modern technologies, improved market access, and knowledge transfer to smallholder farmers.

Some of the challenges facing mango producers in Mali are the following:[696]

- **Reliance on rainfall:** Smallholder farmers rely on traditional rainfed plantations with limited access to modern techniques and technologies.
- **Significant post-harvest losses:** Limited market access and post-harvest losses result in a small portion of mangoes being sold.

[693] ECOWAS Mango Investment Guide (2020)
[694] ECOWAS Mango Investment Guide (2020)
[695] ECOWAS Mango Investment Guide (2020)
[696] Ibid.

- **Phytosanitary and quality concerns:** Quality standards for export are often not met by local mango varieties.
- **Capacity building gaps:** Lack of knowledge and training opportunities for farmers to improve production and adopt modern agricultural practices.

Opportunities in Mango Production in Mali:[697]

- **Plantation development:** The development of high-density industrial mango plantations, such as SCS International's plantation in Kamalé, offers opportunities for increased production yields and controlled supply.
- **Knowledge transfer:** Industrial plantations can serve as training and demonstration centers to educate farmers on modern techniques and best practices.
- **Varietal development:** Diversification of mango varieties and alignment with market preferences can enhance marketability.
- **Aligning interests and priorities:** Collaboration between private sector actors and smallholder farmers can lead to improved market access and higher income for farmers.
- **Leveraging irrigation technologies:** Adoption of drip irrigation systems and improved infrastructure can extend the mango production season and increase productivity.

Since 2008, SCS International has been developing a high-density industrial mango plantation that focuses on high-yield production. This activity is managed by SCS FF Production, a subsidiary of SCS International, and aims to maximize and control mango supply to meet the ever-increasing demand.[698]

The plantation is in Kamalé, a town 35 km from Bamako, and covers an area of 200 ha. Its mission is twofold: to improve production yields using targeted and modern techniques and professional guidance to achieve production levels of between 25 and 45 metric tonnes/ha (compared to 5 to 10 metric tonnes/ha in traditional plantations); and to serve as a modern training and demonstration center for producers on topics such as agribusiness and horticulture. The center aims to encourage young entrepreneurs to adopt the model in the mango industry and other commercial agricultural sectors, as well as to help farmers reconvert and rejuvenate their plantations to increase their yield and income.[699]

Processing

Efforts to address challenges in the mango value chain are ongoing and require continued investments, knowledge transfer, and collaboration across the value chain to improve efficiency, quality, and market access, benefitting both smallholder farmers and agribusinesses involved in mango production and processing.

The challenges in mango processing concern both cold storage and processing components under strict quality control mechanisms:[700]

- **Lack of storage:** Limited warehouse and storage facilities meeting international standards pose challenges for maintaining quality and extending shelf life.
- **Lack of access to quality fresh mangos:** Underutilization of processing plants during the mango season and inactivity throughout the year hinders production efficiency.
- **Competitive disadvantage with imports:** Local agro-processing companies face competition from imported brands with superior packaging and longer shelf life.

[697] Ibid.
[698] http://www.scsinternationalmali.com/cartonnerie.php
[699] Ibid.
[700] ECOWAS Mango Investment Guide (2020)

Opportunities for investing in technology that can improve the mango sector are the following:[701]

- **Continued investment in small and medium-scale cold storage:** Investment in infrastructure and modern storage facilities can reduce post-harvest losses and improve the quality of mangoes.
- **High value-added products:** Adoption of advanced processing technologies can enhance the production of fruit juices, pulp, and dried mango.
- **Improving coordination:** Collaboration between processing companies and farmers to improve agricultural practices and yield can boost productivity.
- **Packaging material:** Continued investments in corrugated cardboard and kraft paper contribute to the local economy and enhance the competitiveness of the mango industry.

For businesses involved in exporting mangoes grown in Mali, there are two types of warehouse and storage facilities that meet international standards. These facilities have a combined potential capacity of around 10,000 tonnes of fresh mango per campaign. The first one is the PLAZA located in Bamako, and the second is the CCMPS located in Sikasso. Important exporters like SCS International have their own packing and warehousing facilities.[702]

The agro-processing of mango into fruit juices, pulp, and dried mango has witnessed significant growth in recent years. Companies such as Comafruit and CEDIAM are involved in the production and export of mango puree and concentrate. In contrast, semi-artisanal companies like Nako, Mouna-Utrafle, Yango, and Zabbaan Holdings process mango and other fruits into juice to meet the local demand, competing with imported brands that benefit from superior packaging and longer shelf life.[703]

CEDIAM produces and exports mango concentrate from their FSSC ISO 22000 certified plant in Yanfolila (Sikasso), sourcing from 7,300 cooperative farmers. The processing plant is currently underutilized at 36% capacity during mango season and inactive throughout the year. To improve operations, CEDIAM is collaborating with producers to enhance practices and yield, while also establishing their own mango plantation with IFC backing.[704]

Marketing and Commercialisation

*A*n estimated 40% of mangoes collected from plantations in Mali never reaches a final consumer due to the lack of suitable transportation, logistic, and storage services. [705] To address these challenges, infrastructure investments like PLAZA and CCMPS have been made with the support of the Malian government and international partners. The market comprises various actors focused on supplying European, regional, and local markets. However, significant challenges exist in transportation, logistics, and storage, resulting in a large portion of mangoes going to waste. The market has also shifted from the Amélie variety to Kent and Keitt due to their better shelf life and customer preferences.[706]

The challenges facing the marketing and commercialisation of mangos are:[707]

- Approximately 40% of mangoes collected from plantations never reach consumers due to inadequate transportation, logistics, and storage services.
- The poor shelf life of the Amélie variety led to its replacement with Kent and Keitt, resulting in the need for grafting and replanting efforts.

[701] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[702] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[703] Ibid.
[704] Ibid.
[705] Ibid.
[706] Ibid.
[707] Ibid.

- European customers prefer mangoes with orange and yellow skin, creating a preference shift away from the green-skinned Amélie variety.

The main opportunities for technology adoption in the mango sector are:[708]

- Infrastructure investments like PLAZA and CCMPS provide improved conditioning, pre-cooling, cold storage, and loading facilities for mangoes, enabling better preservation and handling.
- Phytosanitary control officers at these centres ensure compliance with quality and safety standards, facilitating export opportunities.
- Air shipments of mangoes are handled at PLAZA, contributing to faster and more efficient transportation to international markets.

Both PLAZA and CCMPS are joint investments of the Malian government, the World Bank, and the Kingdom of Netherlands. They are managed by the Interprofession Mangue (IFM) and accessible to all members of the association.

SCS International Case Study

SCS has experienced significant growth, from exporting 22 metric tonnes in 2007 to 1,500 metric tonnes in 2016. Quality is a top priority for SCS, and mangoes harvested from selected plantations are tested for quality. Farmers are trained in maintaining their plantations to ensure the quality and consistency of their products. European auditors perform annual inspections to certify the plantations, ensuring their compliance with quality standards. Integrating new farmers into SCS's supplier base is a time-consuming process that requires significant resources, with only around 40 to 50 new farmers added each year.[709]

SCS International purchases mangoes from 850 smallholder farmers across the Sikasso, Bamako, and Koulikoro regions. These farmers' plantations are carefully selected based on well-defined criteria that prohibit the use of chemical fertilizers. The mangoes are then packaged and shipped in 20-ton containers to customers in Europe via Abidjan and Dakar using sea freight.[710] In 2020, SCS International invested 7 billion FCFA in the construction of a cardboard factory with a production capacity of 10,000 tonnes per year. SCS International aims to become the leading local producer of corrugated cardboard and kraft paper.[711]

ACACIA SENEGAL (GUM ARABIC)

Overview

The natural propagation of Acacia Senegal forests occurs in “Africa’s Gum Arabic Belt,” spanning from Somalia to Mauritania. The natural population of acacia gum trees in western Mali alone is estimated at 13,000 hectares. However, acacia trees are present across 604,000 km^2, extending from the centre to the north of Mali. Although most of Mali’s Crude Gum Arabic is produced in the Kayes region, there is production potential in the regions of Sikasso, Koulikoro, and the District of Bamako as well.[712]

Tapping acacia trees to create incisions of 40-60mm is the most efficient way to produce gum. Natural exudates average 250 grams per tree per year, while tapped nodules can yield up to 10 kilograms per

[708] ECOWAS Mango Investment Guide (2020)
[709] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[710] Ibid.
[711] http://www.scsinternationalmali.com/cartonnerie.php
[712] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)

tree annually. Optimal nodules require at least three weeks after tapping, and a single village can produce up to 12 tonnes per year.[713]

Mali is a significant global supplier of CGA obtained from the sap of Acacia Senegal, also known as the gum arabic tree.[714] According to the GoM, the country produced 11,827 metric tonnes in 2022.[715] The country's gum arabic value chain involves collectors, traders, and exporters who contribute to the production and commercialization of this valuable resource. While Mali has a long history in gum arabic production, challenges and opportunities exist in maximizing its potential.

Challenges:[716]

- **Collection challenges:** Natural factors and logistical obstacles impact the collection of gum arabic, affecting the overall supply and productivity.
- **Low-income producers:** Many gum arabic producers in Mali are low-income farmers and pastoralists, which can hinder their ability to invest in advanced production techniques and infrastructure.
- **Limited processing capacity:** Mali has a limited number of processing plants for CGA, and establishing higher value-added activities is complex and costly.
- **Competition and quality:** Malian traders face competition from Indian traders in the global market and ensuring the consistent supply of quality gum arabic nodules is crucial.

Opportunities:[717]

- **Untapped regions:** Exploring and expanding gum arabic production in regions such as Sikasso, Koulikoro, and the District of Bamako can unlock untapped potential in Mali.
- **Value-added processing:** Investing in equipment and developing processing capabilities within the country can add value to CGA, making it more attractive to specialized processing companies.
- **Growing global demand:** The increasing demand for natural and sustainably sourced ingredients presents a significant opportunity for Mali's gum arabic in the global market.
- **Sustainable and responsible sourcing:** Mali can capitalize on the trend towards responsible sourcing by promoting the ecological and sustainable aspects of its gum arabic production.

Production

Tree maturity is typically achieved after five years, with the output remaining stable until around age 15, and then becoming unproductive by age 20.[718] Natural factors like rainfall and temperature significantly impact output per tree, causing variation from year to year. Additionally, villagers face challenges collecting gum from trees far from villages, as scorching temperatures and a lack of logistics and transportation networks make it difficult.[719]

Processing

Processing CGA in Mali is currently limited to traders and exporters who are responsible for using manual labor or equipment such as sifters, hammer mills, and classifiers to clean, crush, and grade nodules. Foreign importers rely on sourcing CGA in Mali and other countries for further processing

[713] Radio France International (RFI), *Mali : Relancer la filière gomme arabique* (2016)
[714] Ibid.
[715] Ministère du Développement Rurale, Plan Triennale de Campagne Agricole Consolidé et Harmonisé (2023)
[716] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[717] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)
[718] Ibid.
[719] CrossBoundary, On the Functioning of Agricultural Markets in Mali: Strategies for Development (2018)

and exportation to industrial customers worldwide. Currently, Mali has two processing plants that use industrial machines to clean, crush, grade, and package nodules.[720]

One of them, Produits du Sud, was able to increase sales from US$ 17,000 in 2008 to over US$ 1 million in 2012, thanks to a stronger procurement network that allowed it to source from 2,000 farmers in 200 villages.[721] SOMIVAP has a similar model focused on supporting farmers in their collection efforts to export CGA. However, establishing higher value-added processing activities such as spray-dry powdered gum and instant soluble gum is complex and expensive. Therefore, Malian processors have positioned themselves as suppliers to processors that do further value addition.[722]

Marketing and Commercialization

Although pure gum arabic has some local uses in Mali, such as food, traditional medicine, and artisanal crafts, the potential market for selling it to specialized processing companies is much larger.[723] Mali currently imports less than 40 tonnes of processed gum arabic, mainly from China, for use in the beverage and baking industries.[724]

By investing in planting, tapping, and processing equipment, they can add value to the product and tap into the growing global market for natural and responsibly sourced ingredients. As consumers around the world increasingly prioritize natural and sustainably sourced ingredients in their food, beverage, pharmaceutical, and printing products, there is a growing demand for gum arabic. This presents a significant opportunity for Malian producers, traders, processors, and exporters to modernize and professionalize the sector.[725]

Several Malian companies are engaged in the trading and export of CGA. However, European buyers are selective and only purchase nodules that meet their quality standards**.** Competition from Indian traders has made it difficult for Malian traders, processors, and exporters to compete effectively. The availability of quality nodules is critical for success, which requires significant working capital.[726]

MORINGA OLEIFERA

Overview

Moringa oleifera, a versatile "superfood," is increasingly seen as a plant that can bring economic, social, and environmental benefits to countries like Mali. With its multiple revenue streams and health benefits, Moringa offers opportunities for extensive cultivation and commercialization in Mali. Companies are already taking the lead in harnessing the potential of Moringa, involving rural communities and promoting sustainable practices. By capitalizing on the global demand for natural and nutritious products, Mali can leverage Moringa to improve livelihoods and contribute to global health challenges.[727]

Official statistics on land area under cultivation, yield, and production for the moringa value chain in Mali are unfortunately lacking giving that the development of the value chain is still in its infancy. According to studies conducted in the neighbouring Niger, one hectare for moringa trees can produce on average 23 MT/ha under irrigated conditions.[728]

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[720] Ibid.
[721] Foote Willy, Mali Entrepreneurs Offer Path to Peace, Forbes (2013)
[722] Ibid.
[723] Tambaroua Consultation, 2023
[724]Ibid.
[725] https://unctad.org/news/gum-arabic-growing-demand-means-new-opportunities-african-producers
[726] Ibid.
[727] Traoré et al., Promotion of *Moringa* products via an inclusive value chain for economic, social and environmental. impacts in Africa (2022).
[728] https://duddal.org/files/original/6175a372d26145442862c782d1fa8898a3b77df3.pdf

Challenges:[729]

- **Awareness and education:** Promoting awareness about the health benefits and commercial potential of Moringa among farmers, communities, and consumers is crucial for its successful cultivation and market development.
- **Access to quality seeds:** Ensuring the availability of high-quality Moringa seeds for farmers to establish productive plantations can be a challenge, requiring effective seed distribution systems.
- **Processing and value addition:** Developing efficient processing methods and value-added products from Moringa leaves, seeds, and oil requires investments in equipment, infrastructure, and technical expertise.
- **Market expansion:** Expanding market reach, both locally and internationally, and establishing market linkages for Moringa products to reach a wider consumer base can be a challenge.
- **Lack of data on information:** Mapping the location, quantity, and availability of moringa trees and its various products (leaves, fruits/seeds) requires collaboration by private sector, government, and non-governmental actors to properly evaluate the potential of the value chain.

Opportunities:[730]

- **Diverse revenue streams:** Moringa offers multiple revenue streams, including leaf powder for the health market, oil for the cosmetic industry, culinary applications, and biodiesel production, providing opportunities for farmers and entrepreneurs.
- **Health and wellness trends:** The growing global demand for natural, nutrient-rich, and functional foods presents an opportunity for Moringa products, given its recognized health benefits and nutritional value.
- **Rural development and job creation:** Moringa cultivation and processing can contribute to rural development by creating employment opportunities, particularly for women and young farmers in rural areas.
- **Sustainable agriculture:** Moringa's ability to thrive in challenging environments and its ecological benefits, such as soil improvement and erosion control, align with sustainable agriculture practices, providing an opportunity to promote environmentally friendly farming methods.

Production[731]

Moringa seeds possess natural propagation abilities, allowing them to reproduce without human intervention, contributing to the expansion and proliferation of Moringa in suitable environments. However, for businesses seeking controlled cultivation and consistent production, selected seeds and specific cultivation techniques are preferred to ensure optimal growth and quality.

The challenges for Moringa cultivation are the following:

- Ensuring optimal germination conditions and seedling care.
- Addressing pests, diseases, and soil-related issues.
- Maintaining consistent watering and nutrient supply.

[729] Ibid.
[730] Ibid.
[731] Ibid.

Potential technological solutions for improving moringa cultivation are the following:

- **Adoption of advanced agricultural technologies** for germination and seedling care, such as controlled environment systems, automated irrigation, and nutrient management systems.
- **Integration of precision agriculture techniques, including drone and satellite imagery**, to assess plant health, identify pest and disease outbreaks, and optimize resource allocation.
- **Implementation of smart farming solutions** for data-driven decision-making, including real-time monitoring of soil moisture, temperature, and nutrient levels.
- **Utilization of digital platforms and e-commerce** for market access, connecting Moringa producers with local and international buyers.

Processing

The components of the Moringa tree offer diverse processing opportunities, resulting in a wide range of products. Moringa leaves are commonly dried and ground into a fine powder, serving as a dietary supplement, food additive, or infusion ingredient. The seeds yield high-quality oil through cold-pressing, widely used in cosmetics for its nourishing and moisturizing properties. The remaining seed cake can be transformed into protein-rich powder, suitable for protein bars, shakes, or animal feed.[732]

Moreover, the medicinal properties of Moringa roots and bark make them ideal for extracting valuable compounds used in extracts, tinctures, and herbal remedies. These versatile processing methods unlock the full potential of the Moringa tree, enabling the creation of a diverse range of products catering to the dietary, cosmetic, and healthcare industries.[733]

Marketing and Commercialization

The private sector plays a significant role in the marketing and commercialization of moringa-based products, with a focus on vertical integration. One notable example is Mamali Moringa, a woman-led company located in the Koulikoro region near Bamako. They specialize in cultivating and processing moringa into a diverse range of cosmetic and food products, including moringa powder for nutritional supplementation and haircare, soaps, and body lotions.[734]

Another woman-led company, Herou Alliance, follows a similar approach, engaging rural farmers, women, and young people throughout the value chain. They cater to both local and international markets in Africa, Europe, the Caribbean, and the Americas, while creating local jobs and improving livelihoods through training, capacity building, and sustainable practices.[735] Additionally, Fulbe & Khem, established in 2015, focuses on transforming indigenous medicinal plants, including moringa, into food supplements and cosmetic products. Founded by a Franco-Malian with a background in international level athletics, the company distributes nutraceutical products through various retail channels, contributing to the promotion of moringa and its benefits.[736]

Summary of Interviews with Farmers, Households, and Key Organizations

This summary provides an overview of the interviews conducted with farmers, households, and organizations in the regions of Gao, Koulikoro, Mopti, Ségou, and Timbuktu in April and May of 2023. The information gathered through surveys conducted with 125 farmers and 219 households offers valuable insights into their demographics, farming practices, production quantities, marketing, education levels, and resource management.

Additionally, the survey focused on the involvement of women and youth in decision-making processes and their access to resources. Understanding these profiles is crucial for designing policies

[732] Ibid.
[733] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5697473/
[734] https://mamalimoringa.ml/a-propos/
[735] https://heroualliance.com
[736] https://fulbeandkhem.fr

and solutions that leverage technology and private sector actors in the fight against climate change and its adverse impacts.

STAKEHOLDER PROFILES

The demographic profile of the farmers and households surveyed reveal that most respondents were male (79%), while 21% were female. The average age of farmers was 44 years old, and those under 30 made up 27% of the respondents. Educational levels varied, with 38% having informal education, 12% completing only primary education, and 10% having no formal education.

Regarding farming practices, most farmers (67%) engaged in mixed farming, combining subsistence and commercial practices. Mechanization was limited, with only 13% utilizing mechanized methods, while 70% relied on manual labour and animal traction. On average, farmers had 2.8 parcels of land available for cultivation, with an average size of 5.7 hectares. In terms of production and sales, farmers reported significant quantities of cereals, horticultural products, and agroforestry items harvested and marketed. The total sales over the past two years amounted to 110,584,200 F CFA (€168,584) in 2021 and 144,243,000 F CFA (€219,800) in 2022.

Regarding the involvement of women and youth, over half of the respondents (57%) reported that women and young people had access to land and participated in decision-making processes. In terms of household profiles, male-headed households accounted for 59% of the surveyed households, while female-headed households represented 41%. The average age of household members was 41 years old, and youth made up 16% of the respondents. Resource management varied, with men identified as the main manager in 52% of cases, women in 29%, and both genders in 20%.

MITIGATION MEASURES FOR CLIMATE CHANGE EFFECTS

- To mitigate the effects of climate change in cereal, agroforestry, and horticultural production, various measures and practices have been implemented by different stakeholders. Cooperative and union initiatives have focused on implementing irrigation systems (60%), using improved seeds (40%), applying organic fertilizers (40%), reforesting parcels (60%), protecting forests (60%), and adopting agroforestry practices (40%) as strategies to adapt to climate change.
- Farmers have also taken action to mitigate the effects of climate change, with a strong emphasis on environmental protection and sustainable forest management (91%). They have engaged in activities such as planting trees and establishing new forests to restore degraded areas and increase forest cover.
- Measures to prevent illegal logging, encroachment, and unsustainable resource extraction in forested areas have been implemented. Furthermore, the integration of trees with crops (agroforestry) has been promoted to enhance biodiversity, soil fertility, and climate resilience. However, the data reveals that women are underrepresented in certain categories, such as the implementation of coexistence rules between breeders and farmers (15%) and the conservation of biotope/biocenosis (19%). This highlights the importance of targeted interventions to ensure gender equality and inclusivity in climate change adaptation efforts.
- Organizations involved in the agricultural sector have demonstrated a high level of commitment to protecting the environment and sustainably managing forests, with 96% of surveyed organizations stating that efforts are underway. These efforts include the implementation of improved soil conservation techniques and crop protection (96%) and the enforcement of rules governing coexistence between pastoralists and farmers (72%). However, there is a significant regional discrepancy in the application and enforcement of these rules. Regions such as Mopti (100%) and Segou (89%) are highlighted as areas where the relationships between pastoralists and farmers can occasionally be violent.
- Small and medium-sized enterprises (SMEs) have also contributed to climate change mitigation by focusing on training, capacity building, and facilitating access to modern equipment that meets environmental standards. Increasing financial support for agricultural producers who comply with environmental measures, discontinuing excessive logging practices, and promoting the use of solar power are among the actions taken.

CHALLENGES AND CONSTRAINTS

The findings from the surveys highlight various constraints and obstacles in the agricultural sector. Buyer-aggregators face marketing challenges, farmers encounter resource conservation and waste/water management constraints, women and youth struggle with limited resources and equipment, and organizations seek support for teaching climate-friendly techniques and access to environmentally friendly technologies.

- **Buyer-Aggregator:** Marketing cereal products encounters challenges such as market saturation, customer instability, transportation and logistics difficulties, limited financing options, storage challenges, export restrictions, insufficient financial resources, and security concerns. Meanwhile, marketing horticultural products faces challenges related to climate change impacts, insecurity, product drying and packaging challenges, premature drying of crops, and significant crop loss during floods.
- **Farmers:** Constraints to implementing agricultural practices include the conservation of resources (91%) and a lack of waste and water management (62%). While women (96%) and youth (95%) exhibit awareness of the importance of resource conservation, there is room for improvement in waste and water management (50%). Higher percentages of constraints are

observed in Gao (100%) and Tombouctou (100%), indicating areas that require targeted interventions.

- **Households:** Obstacles faced by women and youth in cereal growing, agroforestry, and horticulture include the need for more arable land (25%), equipment (22%), and financial resources (19%). Respondents in all regions emphasize the lack of financial resources, with households in Koulikoro, Ségou, and Timbuktu also highlighting challenges related to equipment and availability of arable land.
- **Organizations:** The top three constraints identified by surveyed organizations are the need to teach climate-friendly techniques to growers (87%), the lack of financial support for beekeeping, aquaculture, and poultry farming (79%), and the lack of access to technology and materials with a lower environmental impact (77%).

RECOMMENDATIONS AND SOLUTIONS

Gender and youth considerations play a crucial role in climate change adaptation and agricultural practices. Targeted interventions, capacity building, access to financing, and policy support are essential to enhance the participation and empowerment of women and youth.

The findings emphasize the importance of capacity building and technical assistance (64%) to provide training and enhance skills among women and youth**.** Policy interventions (32%) that promote the involvement of women and young people are also recommended. Access to financing (31%) is significant to enable women and youth to invest in agricultural activities and realize their potential.

Creating an inclusive environment involves outreach efforts, such as appointing dedicated youth/women ambassadors, and engaging women and youth in decision-making processes through specific programs and initiatives designed to empower them. Additionally, addressing gender and generational inequalities and ensuring equal access to resources are crucial steps toward fostering the participation and empowerment of women and youth in agricultural practices and climate change adaptation efforts. The stakeholders surveyed also provided recommendations and solutions to strengthen agriculture and agroforestry and to mitigate the effects of climate change. Below is a summary of the results:

- **Cooperative/Union:** Recommendations from cooperatives and unions include strengthening the capacities of their members and aligning with Mali's agricultural policy (60%). Exploring alternative irrigation systems (20%), securing agricultural areas, and implementing reservoirs (20%) are also suggested. Active involvement in youth organizations (20%), facilitating access to land and financing (20%), and providing comprehensive training and assistance are crucial for long-term success (20%).
- **Farmers:** According to 39% of farmers, reforestation is a recommended solution to mitigate the effects of climate change. Capacity building and technical assistance (55%), access to financing (30%), and better access to agricultural inputs (24%) are essential for improving cereal growing, agroforestry, and horticulture. Engaging women and youth in decision-making processes and ensuring their access to resources and opportunities are considered essential by 32% of respondents.
- **Households:** To enhance agriculture, households recommend better access to agricultural inputs (21%), financing (18%), and capacity building (17%). Outreach and inclusivity efforts (12%) targeting women and youth are crucial for their active involvement in cereal growing, agroforestry, and horticulture.
- **Input Suppliers:** It is important for input suppliers to raise awareness about the consequences of climate change and adhere to national environmental protection norms and policies (100%). Creating balanced and environmentally friendly collaborations among farmers, livestock keepers, and agroforestry (57%) is viewed as an effective strategy to

address climate challenges. Other recommendations include increasing the production of organic fertilizers, promoting reforestation, conservation, and processing climate-adapted products, and providing climate-adapted seeds.

- **Organizations:** Organizations emphasize the enforcement of forestry and agroforestry legislation (100%), provision of environmentally friendly inputs and equipment (96%), training in forest protection and soil conservation (94%), and increasing awareness of climate change consequences (91%). Financial support (49%), better infrastructure access (47%), and capacity building (40%) are considered crucial for developing agriculture and agroforestry production.
- **Small and Medium-sized Enterprises (SMEs):** To mitigate climate change effects, SMEs recommend access to modern equipment (40%), financial support for environmental compliance (40%), discouraging excessive logging (40%), promoting effective tree planting (40%), and the commitment of public and private partners (20%).