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CLIMATE-SMART AGRICULTURE INVESTMENT PLAN

COTE D´IVORE

WORLD BANK GROUP

INITIATIVE AAA
ADAPTATION OF AFRICAN AGRICULTURE

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

CGIAR

RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security

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Foreword

Climate change threatens to bring substantial impacts to Côte d'Ivoire's agriculture sector, which is central to the country's economic productivity and food security. Climate change, of course, poses challenges not only for Côte d'Ivoire but also for countries across Africa. This was recognized at the United Nations Framework Convention on Climate Change (UNFCCC) 22nd Conference of Parties (COP22; 2016) in Marrakech, Morocco, where the Moroccan government launched the Adaptation of African Agriculture (AAA) Initiative. This Initiative highlighted the investments needed to help African countries cope with the risks that climate change poses to agriculture, and best position themselves for a future of higher temperatures and uncertain precipitation. The AAA Initiative also builds on the Comprehensive African Agriculture Development Programme (CAADP), first launched in 2003 through the African Union.

Côte d'Ivoire is a signatory to the UNFCCC Paris Agreement and has submitted its nationally determined contributions (NDC), committing to take action both on adaptation to climate change and on reducing greenhouse emissions. Côte d'Ivoire is by far a minor emitter of greenhouse gases. However, interventions in agriculture and associated land use change (e.g., deforestation) that increase productivity and resilience to climate change can also contribute to reduce greenhouse gas emissions. The NDC provides targets that Côte d'Ivoire is aiming to meet. However, it is not intended to provide the specifics regarding what investments are necessary or how these investments should be implemented.

This document provides an investment plan for climate-smart agriculture (CSA) in Côte d'Ivoire, developped with support of the AAA Initiative and the World Bank, and technical assistance of the CGIAR Research Program on Climatre Change Agriculture and Food Security (CCAFS). It identifies specific interventions that define on-the-ground actions that are consistent with Côte d'Ivoire's NDC and National Agricultural Investment Plan II (2017-2025), which can be funded by public- and private-sector partners. CSA interventions are designed to increase agricultural productivity; help farmers, livestock keepers and fisher-people adapt and build resilience to climate risks; and, where appropriate, reduce greenhouse gas emissions that cause climate change. CSA interventions can include on-farm technologies such as stress-tolerant crop varieties and livestock breeds, agricultural management activities (involving water, soil, fertilizers, pests, etc.) and agricultural services such as insurance, credit and weather advisories.

This plan includes a set of 12 key CSA investments for Côte d'Ivoire that were developed with strong stakeholder engagement, expert input and scientific evidence. This plan is not intended to be comprehensive, but prioritizes these investments, and can further include additional investments when more funds are available. The plan presents a situation analysis of Côte d'Ivoire's national policies, plans and programs that form the context for the 12 key prioritized interventions. Designed project concepts are developed for each of these key investments, including the main project objectives, components and implementation arrangements. These provide a tangible set of project concepts for potential investors and donors to consider for funding. Finally, a general framing for developing a monitoring and evaluation (M&E) framework for the CSA investment plan is provided, showing how CSA outcomes relate to other M&E frameworks and to other monitoring activities for national-level development priorities.

Because it is a member of the AAA Initiative and is also committed to delivering on its NDC commitments, Côte d'Ivoire now has an investment plan that includes a set of specific climate-smart projects that improve productivity, build resilience to climate change and, as appropriate, reduce greenhouse gas emissions in the agriculture sector. The CSA Investment Plan provides the context and evidence for the importance of these projects, and explains how they can be economically beneficial to the people of Côte d'Ivoire. The plan can help spur investment and funding for CSA to help Côte d'Ivoire deliver on its NDC and other national targets.

Abbreviations

AAA	Adaption of African Agriculture
AAW	Agribusiness Africa Window
ACE-WR	Agricultural Commodity Exchange Warehouse Receipt Scheme
AfSIS	Africa Soil Information Service
AGRA	Alliance for a Green Revolution in Africa
ANADER	National Rural Development Agency
AR	Adoption rate
ASAP	Adaption for Smallholder Agriculture Program
BAU	Business as usual
BN	Bayesian networks
CAADP	Comprehensive Africa Agriculture Development Program
CC	Climate change
CCAFS	Climate Change, Agriculture, and Food Security (part of CGIAR)
CIAT	International Center for Tropical Agriculture
CIS	Climate information services
ClimDev-Africa	Climate for Development in Africa Initiative
CNRA	National Center for Agricultural Research
COP22	22nd Conference of Parties of UNFCCC
CPF	Country Partnership Framework
CSA	Climate-Smart Agriculture
CSAIP	Climate-Smart Agriculture Investment Plan
ECOWAP	ECOWAS Regional Agricultural Policy of West Africa
ECOWAS	Economic Community of West African States
ENACTS	Enhancing National Climate Services
ESM	Earth system model
FAO	Food and Agriculture Organization
FSP	Full-sized project
GCF	Green Climate Fund
GCM	General circulation model
GDP	Gross domestic product
GE	Government effectiveness
GHG	Greenhouse gas
GMIA	Digital Global Map of Irrigation Areas
GOCI	Government of Côte d'Ivoire
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
LULUCF	Land use, land use change, and forestry
MINEFI	Ministry of Economy and Finance
MINADER	Ministry of Agriculture and Rural Development
MINAGRI	Ministry of Agriculture
MINSEDD	Ministry of Environment and Sustainable Development
MIRAH	Ministry of Animal Production and Fisheries Resources
MIREF	Ministry of Water and Forest
MSP	Medium-sized project

NAIP2	Second National Agricultural Investmenent Plan, 2017-2025
NDC	Nationally determined contributions
NDP	National Development program Plan
No-CC	No climate change scenario
NPCC	National Program on Climate Change
NPV	Net present value
NRDS	National Rice Development Strategy
NSDRM	National Strategy for Disaster Risk Management
ODA	SCCF grants
PDO	Proposed development outcome/objective
PES	Payment for Environmental Services
PICSA	Participatory Integrated Climate Services for Agriculture
PNCC	National Program for Greenhouse Gas Mitigation and Adaptation to Climate Change
PSAV	Political stability and absence of violence
PSDEPA	Strategic National Plan for the Development of Livestock, Fisheries & Aquaculture
PSRDF	Strategic Plan for the Rehabilitation and Development of Forests
RCP	Representative concentration pathway
REDD+	Reducing Emissions from Deforestration and Forest Degradation Program
ROI	Return on investment
RIMA	Resilience Index Measurement and Analysis
SCCF	Special Climate Change Fund
SDG	Sustainable development goal
SME	Small and médium enterprise
SMN	Service Météorologique National
SNAIC	National climate-smart agriculture strategy
SODEXAM	The Institution for Aeronautical and Meteorological Development
SSP	Shared socioeconomic pathway
STAR	Specific Resource Allocation Framework
UNFCCC	United National Nations Framework Convention on Climate Change
UNISDR	United Nation's Office for Disaster Risk Reduction
WAAPP	West African Agricultural Productivity Program

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ES

Executive Summary

Agriculture is Côte d'Ivoire's largest economic sector and is the foundation of its economy. Agriculture contributes over 21% of the country's gross domestic product (GDP), employs over half of the working population and provides over 75% of export earnings. In rural areas, where just under half of the population lives, over 75% of people are engaged in agriculture. Despite strong recent GDP growth in other sectors, agriculture will remain vital to Côte d'Ivoire's economy far into the future.

Agricultural sector productivity and high rural poverty are closely linked. Yields for most crops are declining, and yields for all major crops except cocoa are below the West African average. Rural poverty has increased with time, and the income disparities between urban (36% poor) and rural areas (57% poor) are increasing. Rural poverty is higher in north Côte d'Ivoire, where subsistence agriculture is predominant. Given high population growth, low agricultural productivity, high prevalence of malnutrition in some areas, and increasingly erratic weather caused by climate change, insuring Côte d'Ivoire's food security is a priority.

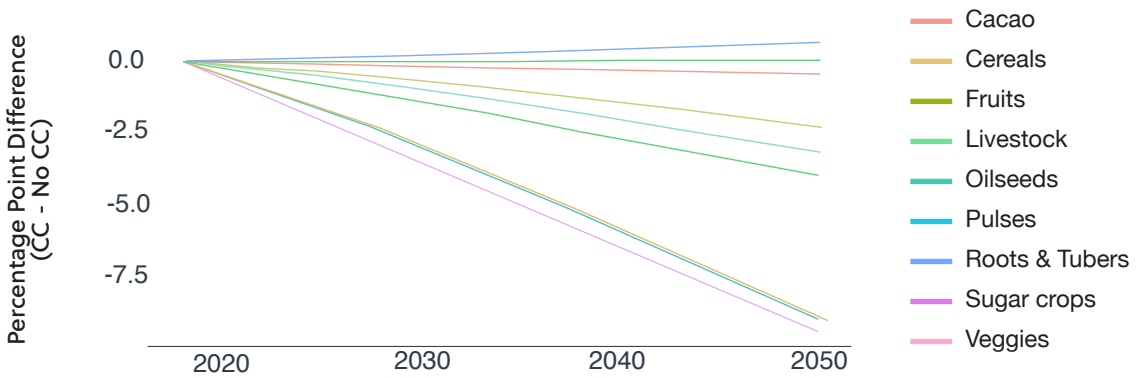
Climate change is already affecting agricultural production and will adversely affect most crops in the future. Climate change has already led to warmer temperatures, greater weather variability, changed rainfall patterns and more extreme weather events. For closely monitored crops, such as cocoa and rice, climate change has already lowered yields. These impacts directly affect food security for poor rural farmers, and they also affect the entire agricultural sector.

Côte d'Ivoire is involved in a multicountry effort coordinated by the World Bank to develop a national climate-smart agriculture investment plan (CSAIP). Climate-smart agriculture (CSA) *increases productivity* in an environmentally and socially sustainable way, *strengthens farmers' resilience to climate change*, and *reduces agriculture's contribution to climate change* by reducing greenhouse gas emissions and increasing carbon storage in farmland. CSA focuses on agriculture, but is multi-sectoral, and also includes commitments to enhancing livelihood benefits, insuring food security and promoting sustainability. This CSAIP uses an established framework and process, and builds on Ivorian programs, policies and strategic plans (e.g., Côte d'Ivoire's NDC) and the work of numerous local, national, regional and international institutions.

Côte d'Ivoire's national CSAIP prioritized a set of 12 investments and actions needed to boost crop resilience and enhance yields for more than 2.2 million beneficiaries and their families[1], helping them adapt to climate change. The CSA investments were identified based on a situation analysis of Ivorian plans and policies, the current context of agriculture, and analysis and scenario development of climate change impacts on different crops and livestock under a variety of warming scenarios for different time frames stretching out to 2050. The CSAIP relied on analysis and prioritization of investments by Ivorian stakeholders. This CSAIP also includes elements of program design and implementation, with economic analysis, priority setting and an analysis of barriers and opportunities. The process used to develop this plan also supports engagement and capacity strengthening.

Climate modeling shows that the shifting economic landscape from climate change could exacerbate biophysical damages for some crops, especially cereals, vegetables, pulses and sugar crops, as shown in figure ES-1 below. Some of these commodities warrant protective action because of their importance for food security, nutrition or the national economy. CSA practices supporting resilience are essential to anticipating climate impacts and stopping yields from declining.

Figure ES.1 **Percentage point difference between percentage change in yield (aggregate rainfed and irrigated) over 2020 with and without climate change, high emissions (RCP 8.5), high population growth scenario with low to moderate GDP growth (SSP3), major commodity groups.**



Climate modeling scenarios for other crops show that some are climate resilient, so CSA should emphasize practices that maintain this resilience. For example, cocoa yield and area cultivated are projected to have minimal future declines. Therefore, a higher investment commitment supporting resilience and yield-enhancing technologies for these crops could expand and increase yields and production. Other crops with some resilience include cassava, mango, yam and rice. Some climate modeling scenarios that assume continued population growth and climate change show that Côte d'Ivoire will not produce sufficient food to meet its needs. Demand will drive a substantial dependence on increasing imports, which would expose Côte d'Ivoire to fluctuations in the global markets.

The CSAIP emphasizes strengthening agriculture across Côte d'Ivoire, with four national-level investments and eight commodity-specific investments in all major agrozones. The geographic reach matters from an equity perspective, given the high levels of poverty and regional inequality in agriculture, and also offers a way to introduce CSA practices across the country.

[1] assuming all 12 investments are made and with no beneficiary overlap

The four national-scale initiatives that are foundational to an adaptive and climate-smart agricultural sector are: agrometeorology, finance services, soil fertility and agricultural extension. These investments are vital to integrating CSA nationally by providing both the real-time information needed for decisions (e.g., agroclimatic information and soil fertility monitoring) and the guidance, knowledge and financial support necessary for improving yield and productivity (e.g., finance services, soil fertility and agricultural extension). For example, integrating CSA practices into the national extension system helps farmers directly while also creating a mechanism for transferring the information from the three national technology-based investments to farmers and other users. The proposed development outcomes (PDOs) and the beneficiary estimates (which also often extend to households) for the four-national scale investments are:

- **Soil fertility:** To increase agricultural producers' ability to practice CSA by providing producers and extension agents with location-tailored information on soil characteristics and best management practice recommendations, as well as the tools, products, partnerships and policy environment to implement recommendations, benefitting **87,000** agricultural workers.

- **Agricultural financial services:** Sustainably increase productivity by improving agricultural producers' access and ability to successfully leverage financial products and services, and increase their ability to manage climate-related risks, benefitting **980,000** agricultural workers

- **Agrometeorological system:** Increase farm productivity and mitigate climate-related risks by providing timely, accurate agrometeorological information to producers, extension agents and agribusiness, benefitting **312,000** agricultural workers.

- **Agricultural extension services: I**mproving the quality and quantity of CSA-informed recommendations that farm advisors give producers will increase farm productivity and minimize climate-related risks, benefitting **235,800** agricultural workers.

Eight climate-smart crop and livestock investments were prioritized to support adaptation of agricultural production systems by introducing a variety of climate-smart practices into the different investments. The eight CSA investments, and their PDOs and beneficiary estimates (which also often extend to households), are:

- **Cassava: I**ncrease the cassava sector's capacity to practice CSA by providing producers, processor and extension agents with technical assistance and increased access to improved varieties and up-to-date research, benefitting **90,000** producers.

- **Abidjan food system: I**mprove economic and nutritional self-sufficiency through CSA practices in the regions supplying Abidjan, benefitting **66,000** peri-urban agricultural workers.

- **Cocoa:** Increase cocoa farm climate resilience to increase productivity and generate new income opportunities, particularly for women and youth, benefitting **88,000** rural agricultural workers.

- **Livestock:** Increase the productivity and climate resilience of the livestock sector through CSA practices, infrastructure development and scientific research, benefitting **80,100** smallholders.

- **Mango:** Increase incomes in the Ivorian mango sector via (i) greater productivity through CSA practices and (ii) reduced post-production losses through value-added processing, benefitting **5,000+** mango producers.

- **Maize:** Increase farm productivity and minimize climate risks by increasing the capacity of producers, cooperatives, extension agents and researchers in CSA maize research, production, processing and marketing, benefitting **138,000** female farmers.

- **Rice: I**ncrease rice productivity and stabilize producer revenues by scaling CSA practices applicable to the African context in order to achieve national rice self-sufficiency, benefitting **68,640** rainfed rice producers.

- **Yam:** Increase farm productivity and minimize climate risks by increasing CSA yam production and strengthening yam markets for improved economic and nutritional resilience, benefitting **70,000** rural agricultural workers.

The CSAIP focuses on insuring resilience for some commodities, growth for others, and a dual emphasis of resilience and growth where appropriate. Bringing together the results of the situation analysis, the climate modeling impacts on commodities, beneficiaries and Côte d'Ivoire's objectives from national plans and programs provides insights on what the eight crop and livestock investments hope to achieve. Table ES-1 below demonstrates the value of the commodities within the Ivorian economy and society, the response to climate change, likely trends without interventions and the intended emphasis of the response.

Table ES.1 Rationale for all crop and livestock investment

CSA Investment	On-farm importance	Ivorian importance	Projected response to climate change	What could happen in the future without CSA investment	Response: investment for improving resilience, expanding growth or both
Cassava	Food security	35% of daily calories (with yams) & grown by 85% of smallholders	Relatively resilient	Yield stable, little growth to meet higher demand	Growth
Abidjan food system (vegetables)	High economic value	Address growing demands of rapid urbanization	Bad	High demand, so increased imports	Resilience and growth: reducing import need
Cocoa	High economic value	Employs 15% of Ivorians	Small decline	Lower yields, expansion to forests, lower export revenue	Resilience and growth: expanding exports
Livestock	High nutritional value & food security	Produced by 58% of rural population, including 800,000 pastoralists	Moderate decline	Environmental degradation, conflict, reduced productivity	Growth
Mango	High-value nutrition	Largest exporter in West Africa; 50% consumed domestically	Small decline	Lower yield and small production	Growth: expanding yield and value added
Maize	Food security	21% of daily cereal consumption & 36% of all cereal grown now	Very bad	Serious declines	Resilience and growth: toward self-sufficiency
Rice	Food security	61% of daily cereal consumption &45% of all cereal grown now	Small decline	Slight decline in production	Resilience and growth: toward self-sufficiency
Yam	High-value nutrition	35% of daily calories (with cassava) – largest crop area	Small increase	Slight increase in yield but not enough to meet higher demand	Resilience and growth: expanding yield and value added

Moving from the CSA investment plans to implementation requires a strong operational framework, with solid economic analysis to identify opportunities, constraints and financing opportunities with stakeholders. The economic analysis, as well as an assessment of productivity, resilience, risks and greenhouse gas mitigation, is necessary to move from proposed investment and project design to implementation. The CSAIP identified a preliminary set of barriers to and opportunities for the proposed investments that form a baseline for design considerations.

Stakeholders identified four investments as high priority, and detailed economic modeling analyzes the potential economic performance of these investments, subject to expected costs, project and climate risks, and potential outcomes. Stakeholders targeted three national-scale programs—soil fertility, agrometeorological systems and financial services—and one production system, cassava. Stakeholders viewed the national investments as foundational to expanding CSA at national scales and supporting specific commodity investments. The four investments are predicted to provide significant benefits to smallholder farmers in Côte d'Ivoire, with return on investment (ROI) with CSA management compared to business as usual ranging from 41%–2071%, as shown in table ES-2. These substantial gains are a result of conservative estimates of both potential beneficiaries and rates of adoption, excluding risks.

Côte d'Ivoire has made significant progress in bolstering the business climate and improving financial management, but barriers remain that could affect CSAIP implementation. Many barriers are related to national politics or policies (e.g., policy disincentives, potential political crises, farmer–pastoralist conflict), while others are either contextual (e.g., gender discrimination, low information access) or direct agricultural sector risks (e.g., erratic weather, pest and disease outbreaks). Specific investments face specific risks, as the preliminary analysis in table ES-3 shows.

Table ES.2 Performance of the four priority investments

Project	Number of beneficiaries	Impact Ben^{-1} (% ± st dev)	Cost (m $)	Cost Ben ($)	NPV* (m $)	Prob. Of + NPV* (%)	ROI (%)
National soils	87,000	46 ± 44	31.0	356.3	40.4	80	130
Agrometeorological	312,500	10 ± 15	20.9	66.9	46.7	93	329
Financial services	980,000	46 ± 121	38.4	39.2	794.7	83	2,071
Cassava	90,000	15 ± 57	25.1	212.6	10.4	56	41

*NPV and ROI using baseline scenario without including major risks and using conservative adoption estimates.

Table ES.3 Barriers to adoption of proposed CSA investments in Côte d'Ivoire

NATIONAL INVESTMENTS		RISKS
Agricultural finance services	🔴	Diverse producer need segments and geographic dispersion limit economy of scale opportunities
	🟡	Low-literacy users unable to access many ICT-based services
Agricultural extension system	🔴	Systematic exclusion of women limits potential innovations in woman-produced crops
	🟢	Lack of subsidies to encourage fallowing
Soil fertility	🟢	Risks are not well understood pending further investments in farmer capacity
Agrometeorological System	🟢	Risks are not well understood pending further investments in farmer capacity
REGIONAL INVESTMENTS		**RISKS**
Irrigated and rain-fed rice	🟡	Technical and financial capacity of enterprises in infrastructure sector
	🔴	Tenure and rent issues within irrigated perimeters; community conflict
Irrigated and rain-fed rice	🔴	Inconsistent or absent value chain infrastructure, (e.g., tranportation, cold chain, storage facilities)
	🟢	Incorrect or excessive use of inputs such as fertilizer
Sustainable cocoa production	🟡	Farmer-pastoralist conflict
	🟢	Limited feed availability for livestock
Yam production and processing	🟢	High market volatility due to labor intensivity and product quality variability
	🟡	High crop nutrient demands exhausts soil and encourages slash and burn
Maize development	🟢	High market volatility due to product quality variability
	🟢	Extremely susceptible to environmental variability
Cassava production and processing	🟡	High market volatility due to labor intensivity and product quality variability
Abidjan market vegetable & livestock	🟡	Lack of boreholes, pumps, and other infrastructure to facilitate water access
Livestock sector in northern Cote d'Ivoire	🟢	Environmental degradation exacerbates competition for land and water

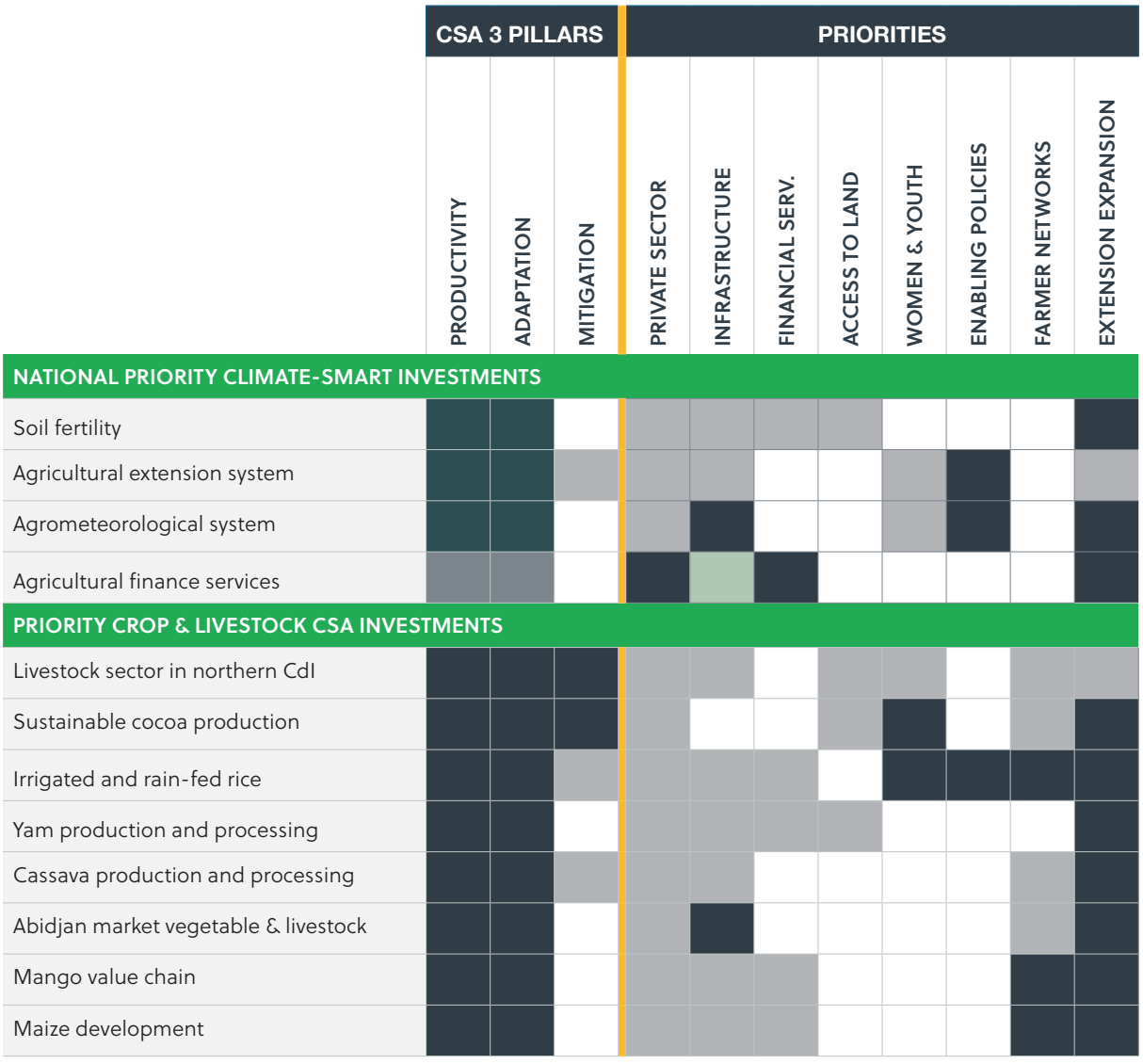
🟢 Low barriers to adoption 🟡 Medium barriers to adoption 🔴 High barriers to adoption

CSAIP project design and implementation can maximize project outcomes, build on existing capacities and opportunities, and leverage CSA investment to support national policies. There is strong correspondence of Ivorian national policy and the CSAIP. For example, the Ivorian NDC aims to foster linkages between agriculture, agribusiness and industry to support the overall national economic development. The CSAIP both contributes to and benefits from Côte d'Ivoire's strong economic growth and private sector expansion. Similarly, it contributes to and benefits from Côte d'Ivoire's strong capacity in agricultural sciences. Other opportunities and improvements supporting CSA expansion include: increasing numbers of producer organizations; improved financial transaction systems (including mobile phones); improved smallholder access to inputs and services; good and improving road infrastructure; and post-harvest storage improvements. Project design and implementation can draw on these to overcome barriers and support policy objectives. Figure ES-2 identifies how each of the investments relates to CSA pillars and to selected Ivorian policy priorities,

showing that the four national-scale investments provide the basic supportive infrastructure for good agricultural decision-making at all scales, while the eight crop and livestock investments strongly support increasing agricultural productivity, increasing adaptation, private sector growth and expanding extension services and infrastructure.

Monitoring and evaluation (M&E) is an essential component of the CSAIP implementation; it lays out the assumptions of how change will occur (theory of change) and provides the evidence and information to implement results-based management (results framework, indicators and M&E systems). Monitoring and evaluation of the CSAIP will deliver reliable and real-time information, allowing the Government of Côte d'Ivoire, development partners and implementing agencies to track progress on activities, outputs, outcomes and impact against targets, and also to raise flags when adaptive actions may be necessary. M&E activities create a mechanism for learning lessons and increase accountability. The CSAIP M&E system will align with other programs and policies such as the NDP, NAIP2 and NDC. In this way, investments in a CSAIP M&E system will build the institutional and human capacity for collecting and using data for decisions, ultimately helping the Government of Côte d'Ivoire show in a robust and evidence-based way how the implementation of the CSAIP results in on-the-ground impact and contributes to the NDC and other key targets and goals.

Figure ES.2 Links between CSA investments and national priorities



Section 1

Justification for a climate-smart agricultural investment in Côte d'Ivoire

Climate change is already evident in Côte d'Ivoire, it is adversely affecting agricultural production, and it will adversely affect most crops. Climate change will affect many different sectors of Côte d'Ivoire's economy and population, but it will especially increase challenges facing Côte d'Ivoire's most poor and vulnerable by reducing agricultural production and food security. Changing precipitation patterns across the country and increased temperatures are stressing crop and livestock production both directly (e.g., less rainfall for crops) and indirectly (e.g., crop pests reproduce more quickly). To address these current and future climate change impacts, a robust and broad-scale package of rural development initiatives is needed to help Côte d'Ivoire's agricultural sector meet future food demand. This document outlines a portfolio of investments to support the rural sector in addressing climate change through climate-smart agriculture.

CSA increases productivity in an environmentally and socially sustainable way, strengthens farmers' resilience to climate change, and, where appropriate, reduces agriculture's contribution to climate change by reducing greenhouse gas emissions and increasing carbon storage in farmland (see figure 1). CSA recognizes that economic investments that account for climate change can increase agricultural productivity and sustainability while having direct climate benefits to agriculture that build resilience and reduce emissions. CSA focuses on agriculture, but is multi-sectoral and also includes commitments to enhancing livelihood benefits, insuring food security and promoting sustainability. While CSA aims to create triple-wins across productivity, resilience and adaptation, it also recognizes tradeoffs among the three pillars depending on the biophysical, agricultural and socioeconomic context.

CSA is not a specific agricultural practice; instead, it identifies solutions for programs, policies and investments that are place-based and time-specific. For example, in one place, stakeholders may give higher priority to mitigation, while in another adaption or sustainable productivity are the priority. Defining the appropriate priorities is part of the process of developing a climate-smart agricultural investment plan (CSAIP).

This CSAIP for Côte d'Ivoire emphasizes productivity and adaptation, given the challenges the country will face in meeting food security goals under a changing climate and its relatively minor contributions to global greenhouse gas emissions. Mitigation is a co-benefit of investments in agricultural development including productivity and resilience. The plan places a focus on lowering greenhouse gas emissions per unit of food produced—known as lowering greenhouse gas intensity—in which food production increases at a greater rate than greenhouse gas emissions. Thus, this CSAIP address all three pillars of CSA, by focusing on increasing productivity and building resilience while reducing greenhouse gas emissions, where appropriate

Figure 1 Climate-smart agriculture: The triple win of sustainability, resilience and lower emissions[5]

1.1 The Climate Smart Agricultural Investment planning framework

Côte d'Ivoire has planned investments for climate-smart agriculture based on four components of CSA planning and implementation: (i) situation analysis; (ii) prioritizing interventions; (iii) program design; and (iv) monitoring, evaluation and learning[3]. All four of these components depend on strong engagement with key decision-makers and experts, and capacity strengthening of key people and institutions involved. This framework (figure 2 and in detail in annex A) guided the development of the Côte d'Ivoire CSAIP and organization of this document. This CSAIP is focused on the first two components: the situation analysis and prioritizing interventions, even though elements of program design & implementation and monitoring and evaluation are discussed. The process used to develop this plan also supports engagement and capacity strengthening, other components of the CSA planning framework.

Côte d'Ivoire is involved in a multicountry, coordinated effort to develop this national CSAIP (see annex B). The World Bank coordinated this plan though the Adaptation of African Agriculture (AAA) Initiative, which was launched at the United Nations Framework Convention on Climate Change (UNFCCC) 22nd Conference of Parties (COP22; Marrakech, Morocco). This plan is directly in support of the Côte d'Ivoire nationally determined contributions (NDC) commitment to the UNFCCC, National Agricultural Investment Plan (NAIP2, 2017–2025) and other national and regional (such as Economic Community of West African States, or ECOWAS) plans, programs and policies.

[2] FAO 2012

[3] Girvetz et al. 2017

Figure 2 Components of a CSA planning framework used for Côte d'Ivoire[4]

[4] Girvetz et al. 2017

The NDC[5] of Côte d'Ivoire provides the guiding targets for mobilizing support to achieve climate goals while enhancing sustainable development. Côte d'Ivoire's NDC determines its formal COP21 engagements, setting targets to lower emissions by 28% by 2030 compared to the baseline scenario (business as usual, or BAU)—agriculture and land use change comprise 26% of total emissions in the country[6]. The NDC identifies agricultural sector adaptation and mitigation actions through (i) improving water resources management; (ii) strengthening agricultural and animal production systems; and (iii) fighting against deforestation and land degradation.

Côte d'Ivoire's national CSAIP builds on the NDC initiatives and priorities, as well as the work of numerous local, national, regional and International institutions. There is a solid foundation of programs, policies and strategic plans to support scaling-up of CSA in Côte d'Ivoire. These include the National Program on Climate Change (2012), the recently developed Second National Agricultural Investment Plan (NAIP2, 2017–2025); the Strategic National Plan for the Development of Livestock, Fisheries and Aquaculture (PSDEPA); the Strategic Plan for the Rehabilitation and Development of Forests (PSRDF); and the National Strategy for Disaster Risk Management (NSDRM; Government of Côte d'Ivoire, 2011). A CSA profile was developed (FAO; ICRISAT; CIAT, 2018), and a REDD+ capacity-building strategy has been elaborated, which this CSAIP builds on.

[5] The NDC embodies a country's efforts to reduce national emissions and adapt to the impacts of climate change. The Paris Agreement (Article 4, paragraph 2) requires each Party to prepare and communicate and nationally determined contributions (NDCs) that it intends to achieve through domestic mitigation measures.

[6] FAO, 2018

Section

2

Situation analysis of livelihoods, agriculture and climate change

2.1 Côte d'Ivoire's agricultural sector in Brief

Côte d'Ivoire is a lower-middle-income country, with high poverty and a high dependence on agriculture for food security, livelihoods, employment and foreign exchange. Rural households are the poorest in the country. Both smallholders and the central bank rely substantially on agricultural, especially commodity-based exports of cocoa, rubber, palm oil, cotton and cashew. Yet these crops are affected by volatile weather, yields and international market prices. While Côte d'Ivoire has had high economic growth (7%–8%) in recent years, agricultural prosperity and poverty reduction remain elusive for most smallholders. High regional and rural-urban inequality exists, and agricultural households are both poorer and more likely than urban residents to face challenges related to food insecurity, illiteracy and limited access to productive resources.

Figure 3

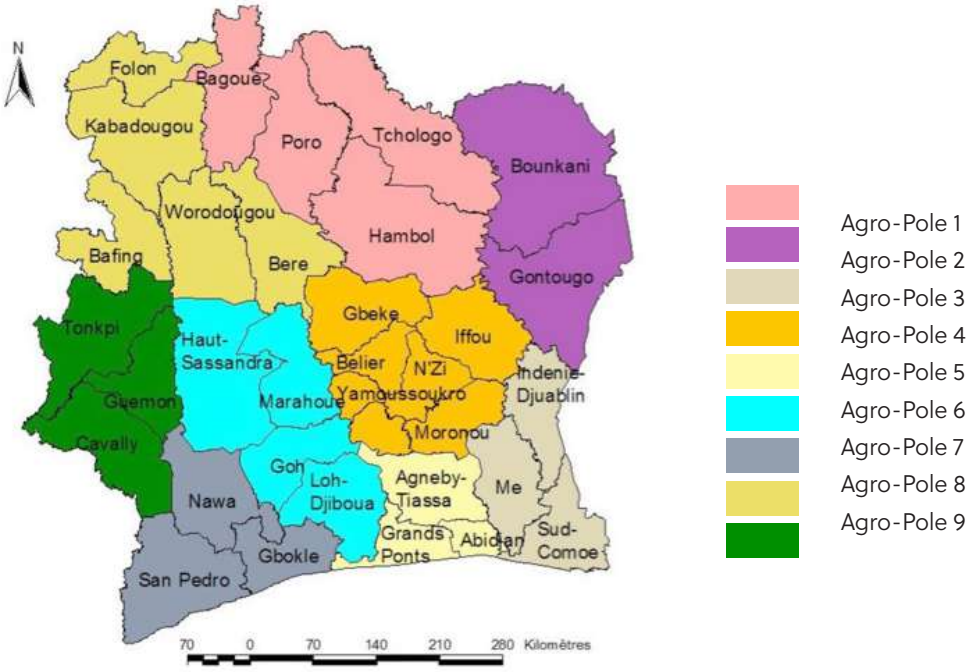


Table 1 Agroclimatic zones in Côte d'Ivoire, as they relate to the agropoles

ZONES	AGROPOLES	AGROCLIMATIC PRODUCTION ZONE CHARACTERISTICS
Northern savannah	1,2,8	Northern area with rainfed crop systems of maize, millet, groundnuts and cotton, as well as transhumance herding
Central	4,6,9	Semi-mountainous area
Southern forests	3,5,7	Larger farms with fewer farmers, mostly cocoa, coffee, rubber and cashew nuts, as well as forested lands

Agriculture production (what is grown, who grows it and how it is grown) varies across Côte d'Ivoire's main agro-ecological regions. The country is classified into four broad agroclimatic zones (figure 3a) that can be subdivided into eight smaller zones based on biophysical and socioeconomic characteristics (figure 3b). The savannah zones are in the north region, while the semi-mountainous forest is a transition zone in the central part of the country[8] (see table 1). Cocoa and coffee (accounting for almost two thirds of the cultivated land) are predominantly grown in the fertile forest zone of the south (including in many legally protected areas). Farm sizes for these crops in this zone are often larger than average (e.g., 10–13 ha) and, while less than 10% of farmers live in this zone, they receive greater support and production incentives than smallholders elsewhere. The north savannah region is characterized by rainfed crop systems of maize, millet, groundnuts and cotton and transhumance herding, while in the south cocoa, coffee, rubber and cashew nuts are produced. Yams are produced countrywide and occupy the largest cultivated area. These zones served as a key input to this CSAIP (see annex 2).

[7] NAIP2

[8] The 4 agroclimatic zones are: Sudan savannah (900-1400mm) Guinea savannah (1000-1500mm), Western semi -mountainous forest zone (1200 to more than 1600mm) and the forest zone (1200mm to more than 1600mm) based on biophysical and socioeconomic characteristics.

Agriculture is Côte d'Ivoire's largest economic sector, contributing over 21% of the country's GDP, employing over half of the working population and providing over 75% of export earnings. Small-scale agriculture predominates, yet Côte d'Ivoire is also among the world's biggest producers (as of 2014) of cocoa (32.2%), kola nuts (21%), cashew nuts (14.3%) and yams (8.5%)[9]. Cocoa, coffee and cashew are major crops farmers grow for income, whereas important food crops include maize, rice, plantain and cassava. Integration of livestock, especially poultry, is becoming common. About 63% of small-scale farmers own chickens (broilers), while another 33% own sheep and goats, respectively. Manure from chickens is becoming an important component in cocoa production.

Subsistence agriculture with minimal inputs is the predominant management approach, with small-scale farmers relying on rain, family labor and traditional, manual, land-extensive practices[10]. Shifting cultivation (slash-and-burn) is a common practice in the country (and is one of the factors contributing to the high deforestation rates). Due to population growth, fallow periods have significantly reduced, and as a result the soils are more degraded. Much of the agricultural growth has resulted from extensification and unsustainable natural-resource exploitation, largely at the expense of forests. Farmers growing mostly food crops are more vulnerable than those growing both food and cash crops[11]. Poverty levels are highest and greater malnutrition exists in the northern (60%) and western (54%) regions, where most production is for subsistence[12]. While less than 10% of the country's farmers are in these zones, they receive more production support and incentives than small-scale farmers elsewhere. Yet even considering the additional support for cash crops, most farmers countrywide live on less than US$2 a day.

Cocoa is vitally important to Côte d'Ivoire, providing over 50% of the agricultural export value annually, and about 32.2% of total global output. The crop is grown by between 800,000 and 1,200,000 smallholder farmers on farms averaging about 4.87 ha. A survey of cocoa farmers done in 2013–2014 showed that 96% of the farmers are men, and that cocoa farmers are among the oldest in the country[13]. The growing areas extend throughout the forest area that stretches from east to west in the southern region. Yields are highest in the southwestern region and lowest in the west. Low yields may be attributed to bad weather, low fertilizer use, pests, diseases and aging cocoa plants (yields start declining when the plant is more than 16 years old; the average age of cocoa plants in Côte d'Ivoire is 24 years[14]). Lack of capital is the biggest reason for the low use of inputs (such as chemical and organic fertilizers). The export value for cocoa shows a general increase, with occasional declines attributed to production shocks due to harsh weather and volatility in international cocoa prices. Over 6 million people depend on cocoa production, and its share of agricultural exports and livelihoods is likely to continue increasing, making investments in production, research and policies essential, especially for reducing poverty[15]. From 2012–2016, the export value for cocoa was on average US$ 2.86 billion[16].

[9] USAID, 2016f

[10] Achterbosch, T.J. van Berkum and Meijerink 2014.

[11] Mali has registered high (4.4%) urbanization rate

[12] Balineau et. al 2016 and OECD; FAO; UNCDF, 2016

[13] Balineau et. al 2016

[14] Balineau et. al 2016

[15] See Katayama et al. 2017

[16] This is based on FAOSTAT data (2018)

Agricultural sector productivity as a share of total GDP has been declining. The share of GDP attributable to agriculture has been steadily declining, from about 45% in 1960 to about 20% in 2017. While this decline results from a significant increase in GDP from the industrial and service sectors, there has not been a corresponding improvement in the well-being of Ivorians. Most measures of poverty and inequality (such as the Gini coefficient) have worsened over time. Total factor productivity has been declining[17], and the yields for all major crops except cocoa are below the West African average. Low agricultural sector productivity can be blamed on time-lagged impacts from the political and military crisis, low investment in agriculture, and high impact to the sector from weather events (including droughts and intense rainfall).

Use of inputs and irrigation for agriculture is very low, but farmer interest in their use is high. The use of fertilizer has been targeted to boost cocoa production, but virtually all fertilizer is imported and its quality is low[18]. Virtually all of agriculture (98%) is rainfed, with only industrial/cash crops under irrigation. Out of the total irrigation potential of 475,000 ha, only 73,000 ha (15%) have irrigation systems installed, and only 45% of that land is actually irrigated[19]. Yet a 2016 survey showed that smallholders are willing to make investments for the future, with a high willingness to save money to purchase pesticides (92%), seeds (91%) and fertilizers (90%), and also to use irrigation (68%) in the subsequent season[20].

Lack of access to banking systems, credit and extension services, combined with marginalization, is limiting investment by smallholder farmers. The bank account penetration rate has remained low (13.4%) in the last three years[21]. Even with savings, farmer access to purchase inputs would remain challenging. Fifty-four percent of smallholder farmers lack savings or access to financial resources, increasingly their vulnerability; only 30% of these farmers have bank accounts. The major reason smallholder farmers lack bank accounts is that they don't have any money to put in one. Financing for cocoa production (and the agricultural sector generally) is nonexistent. Some of the contributing factors to marginalization include low literacy levels (only 15% of the small-scale farmers have an education of secondary school or above).

Côte d'Ivoire is highly vulnerable to food insecurity, ranking 38th out of 188 (20th percentile) for food vulnerability by the ND-GAIN Index for 2016[22]. The low ranking is also driven by high child malnutrition (77th percentile) and low agricultural capacity (72nd percentile), above-average food import dependency (65th percentile) and high rural population (55th percentile). This means that insuring agricultural productivity given climate change is essential for well-being.

Globally, Côte d'Ivoire is a low emitter (0.06% in 2014) of greenhouse gases, with agriculture emitting only about 12% of the country's GHGs (26% when land use change is included), and the energy sector contributing the most emissions. Most agricultural emissions (63%) come from

[17] AGRA 2016.

[18] See AfricaFertilizer.org; Ingram et al. 2017.

[19] Siebert et. al 2013

[20] Riquet et al 2017.

[21] ADB 2017.

[22] Notre Dame Gain, 2017.

burning of savannah contribute 5%, 6% and 17%, respectively, of the emissions from agriculture, while livestock manure left on pastures and enteric fermentation contribute about 27% and 31%, respectively, of agriculture-sector emissions. Land use change, mainly converting forests to either croplands or settlements, is also an important emitter (14% of total emissions), with clearing for cocoa increasing. Given the population growth rate, and people migrating from the north to the south to be employed in cocoa production, pressure for increased cocoa production and forest clearing will intensify. However, coalitions of international chocolate buyers, development groups and others are working to insure cocoa production is sustainable and does not increase forest loss[23]. Investing in technologies that increase the per unit productivity of Côte d'Ivoire's important crops, and integrating practices such as agroforestry, present opportunities for adaptation and mitigation.

2.2 Climate Change in Côte d'Ivoire

Climate change can already be detected in Côte d'Ivoire, which has experienced warmer temperatures, greater weather variability and more extreme weather events. Since 1961 the national average temperature has increased between 0.5 and 1.0°C[24]. Temperatures are projected to increase, although the amount of gain will vary in different growing areas (see figure 4). Projections show increased temperatures of about 1.3°C in 2030, 1.8°C in 2050, and 2.1°C in 2070. The north, east and central regions of the country are likely to experience relatively more warming than the southern and western regions of the country[25].

Rainfall patterns in Côte d'Ivoire have already changed and will continue to change, and inter-annual rainfall has fluctuated significantly. So far, the volume of rainfall has declined by 20% in some parts of the country compared to historical times, with shorter rainy seasons and longer and more frequent dry spells[26]. Between 1940 and 2010, rainfall declined by 28.9% in Abidjan and 23.5% in Soubré[27], while decreasing less in the forest zones of Gagnoa and Abengourou. Climate change also means that rains start and end earlier, and growing seasons end sooner than historic norms. Intense rainfall causes flooding, which can lead to crop destruction, soil erosion, infrastructure destruction and loss of lives. Aggregate statistics may not reflect these changes because, for example, timing of rains may change while total rainfall remains about the same—large amounts of rain may fall in a short time period instead of over a period of months, which can be disastrous for crops. Climate models show little change in precipitation in the future, with gains of 0.4%, 0.3% and 1.2% by 2030, 2050 and 2070, respectively (see figure 5), although the north and western parts of the country are projected to increase slightly more, whereas the southeast is projected to slightly decrease in precipitation.[28]

Climate change will bring spatial variations to these changing rainfall patterns. As shown in figure 5, the north and west are likely to experience increased precipitation of about 1.5% and 1.4%, respectively, while the central, east and south of the country are likely to experience decreases of about 0.1%, 0.2% and 0.7%, respectively.

[23] Kroeger et al. 2017.

[24] see Yao et al., 2013

[25] Ramirez and Jarvis, 2008; Collins et al., 2013; Ramirez and Jarvis, 2015.

[26] FAO; ICRISAT; CIAT 2018

[27] FAO; ICRISAT; CIAT 2018

[28] ibid.

Figure 4 Projected changes in temperature in Côte d'Ivoire by 2050 [29, 30, 31]

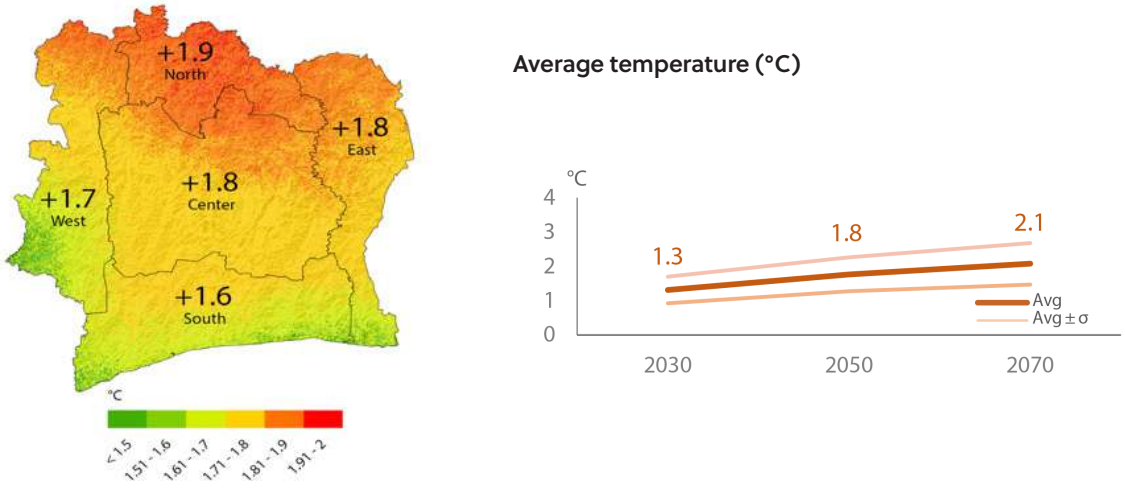
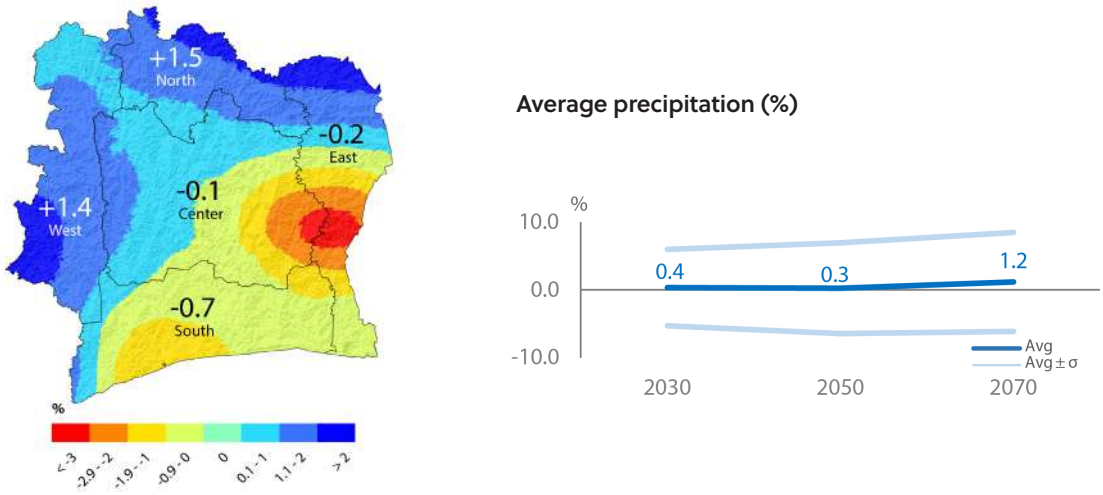


Figure 5 Projected changes in precipitation in Côte d'Ivoire by region by 2050 [29, 30, 31]



Climate change and year-to-year variability has already impacted agricultural productivity in Côte d'Ivoire. Trends for cocoa, the most closely monitored crop, show that years with less rain have lower yields. Rice yields are also lower when there is less rain, with a 27% yield drop over the 2016/2017 planting season due to poor rains. The 2015/2016 post-harvest assessment revealed that 60% of farmers in the north and northeast had lower yields due to poor rainfall and lack of resources to purchase inputs. Another 2016 survey of rural households showed that 72% of the households consumed fewer meals. The fishing sector has declined since the 1990s, with fish die-offs as temperature have increased and lack of rain shrinks lake size and adversely affects water quality[29].

Suitability of crops and areas where they are grown will change because of these new temperature and precipitation patterns. Changes in temperature and rainfall mean that many crops will be more prone to failure or will have to be shifted from current production zones, increasing food insecurity.

[29] http://www.wamis.org/agm/meetings/etdret09/WOS2-CoulilDKbaly.pdf

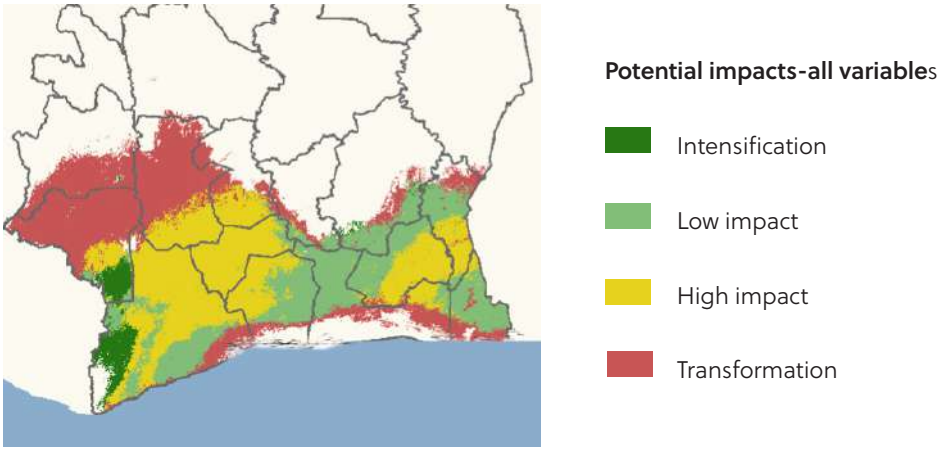
[30] Laderach et al., 2013

[31] Bunn et al. 2018

Climate change will have pronounced negative effects on agriculture in the south, the region with the highest population concentration and where most cocoa is produced. For instance, the suitability for growing cocoa in many of the current growing areas will decrease (see figure 6) as higher temperatures cause more evapotranspiration, and increase in drought risk is likely by 2050 (even in areas that might see rises in annual precipitation)[30]. A combination of the temperature increase and reduction in precipitation will greatly affect crop suitability in the southern zone. These projected changes demonstrate the importance of ensuring that CSA investments are made to diversify crops and maintain yields amid declining suitability, while reducing environmental degradation and deforestation.

Côte d'Ivoire faces declining agricultural yields from climate change, potentially decreasing its main agricultural exports (and the world's chocolate supply), while also increasing vulnerability and food insecurity. Additionally, climate change will bring floods and increased droughts, land degradation, sea-level rise, coastal erosion, endemic health vulnerability (from meningitis, malaria, etc.) and air pollution[32]. However, the next chapter shows that investments made now can support adaptation and resilience to future climate impacts.

Figure 6 **Suitability change for cocoa growing regions to 2050. Dark green areas are opportunity areas; light green areas are adjustment or incremental adaptation areas; yellow areas are designated systemic adaptation zones; and red areas will transition to other crops without substantial changes in production systemS[31]**



2.3 Climate change impacts on Côte d'Ivoire's agricultural economy

Climate change will impact the production of key agricultural products in countries globally, which will, in turn, impact each country's economic activity. Climate change will drastically alter what crops are suitable for a given place, reducing suitability across large areas (e.g., countries) but also creating pockets of increased suitability. At a global scale, these shifts will be significant in determining what countries can grow what crops, affecting international trade. At the same time, demographic changes in countries will impact demand and consumption. Taken together, these demographic shifts and climate change impacts will result in a global rebalancing of comparative advantages in agricultural production.

[32] Dje, 2014

Modeling conducted with the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT)[33] suggests that the landscape of economic incentives will change, offsetting suitability loss for some crops while exacerbating it for others. To understand the impact of climate change on global agricultural production and trade, IMPACT simulates a climate change scenario from the present to 2050. The climate change (CC) scenario is an average of five IMPACT model runs, each run incorporating a distinct global climate model. An IMPACT "no climate change" (No-CC) scenario holds climate constant at its current levels to establish a baseline point of comparison. Both the CC and No-CC scenarios were modeled under different assumptions regarding population growth, growth in GDP, greenhouse gas emissions and general investment in agricultural R&D. Scenarios for changes in population and GDP were determined by the Shared Socioeconomic Pathways (see table 4 in section 2-6 and annex D), and variations in GHG emissions scenarios were determined by the representative concentration pathways (known as RCPs). Percentage point differences due to climate change (compared with no climate change) for crop yield and for area cultivated are presented for rainfed and irrigated commodities in tables 2 and 3, respectively. Higher levels of greenhouse gas emissions (RCP8.5) generally result in greater changes in yield and area of production. For detailed information on the model and scenarios, including an explanation of percentage point difference as opposed to percentage difference, see appendix D.

Table 2 Percentage point difference in yield and area of production with different levels of climate change for rainfed crops in Côte d'Ivoire (shown as percentage point differences over the baseline No-CC)

	Difference in yield (SSP3)				Difference in area of production (SSP3)			
	RCP 4.5		RCP 8.0		RCP 4.5		RCP 8.5	
Rainfed crops	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Banana	-1.7	-4.5	-1.0	-2.7	0.3	1.0	0.9	2.8
Cassava	-1.2	-3.3	-1.2	-3.2	0.1	0.5	0.1	0.7
Cotton	-2.5	-7.7	-2.7	-7.2	-0.8	-2.1	-0.3	-0.8
Cowpeas	-1.6	-5.5	-1.7	-5.6	0.1	0.4	0.5	1.4
Groundnut	-3.4	-9.3	-4.6	-12.4	1 .2	3.6	2.0	6.1
Maize	-5.9	-17.2	-7.6	-21.7	-0.1	-0.5	0.2	-0.3
Millet	-1.7	-6.5	-2.4	-9.2	0.1	0.2	0.4	1.1
Potato	-1.5	-4.7	-1.0	-3.7	1.1	1.1	2.2	2.8
Rice	-1.7	-5.9	-2.3	-7.6	0.4	0.9	0.8	1.9
Sorghum	-1.4	-5.4	-2.3	-9.0	0.4	1.2	0.3	0.8
Soybean	-2.3	-5.1	-3.7	-7.8	0.0	-0.1	-0.2	-0.4
Tea	-2	-5.5	-1.3	-3.6	-0.1	-0.1	0.4	1.3
Tropical fruit	-2.7	-7.1	-2.8	-7.0	-0.3	-0.8	0.0	0.0
Yams	-0.9	-2.3	-1.0	-2.4	0.2	0.5	0.1	0.4

[33] IMPACT is a model of the global agricultural sector that takes account of climate change as well as economic agency. See Robinson et al. (2015) for model documentation.

Table 3 Percentage point difference in yield and area of production with different levels of climate change for irrigated crops in Côte d'Ivoire (shown as percentage point differences over the baseline No-CC)

	Difference in yield (SSP3)				Difference in area of production (SSP3)			
	RCP 4.5		RCP 8.0		RCP 4.5		RCP 8.5	
Irrigated crops	2030	2050	2030	2050	2030	2050	2030	2050
Cowpeas	-1.9	-7.9	-1.9	-8.2	0.7	2.4	1.1	3.7
Groundnut	-3.6	-11.5	-4.5	-14.2	1.6	7.9	2.7	13.3
Maize	-6.3	-21.2	-8.0	-26.7	0.0	-1.0	0.4	-0.6
MIllet	-1.4	-5.3	-2.2	-8.2	0.7	2.1	0.9	2.9
Rice	-1.7	-6.0	-2.2	-8.1	1.0	3.2	1.4	4.8
Sorghum	-1.3	-5.0	-2.2	-8.3	1.0	3.4	0.6	1.9
Sugarcane	-2.8	-7.3	-3.6	-9.5	1.7	4.3	2.5	5.9
Sweet Potato	-1.3	-3.7	-1.5	-4.3	-0.1	0.1	-0.2	0.0
Vegetables	-2.9	-11.3	-3.7	-14.2	-1.4	-5.3	-1.8	-6.8
Wheat	-2.6	-6.9	-4.4	-11.3	-2.8	-6.7	-4.3	-9.3

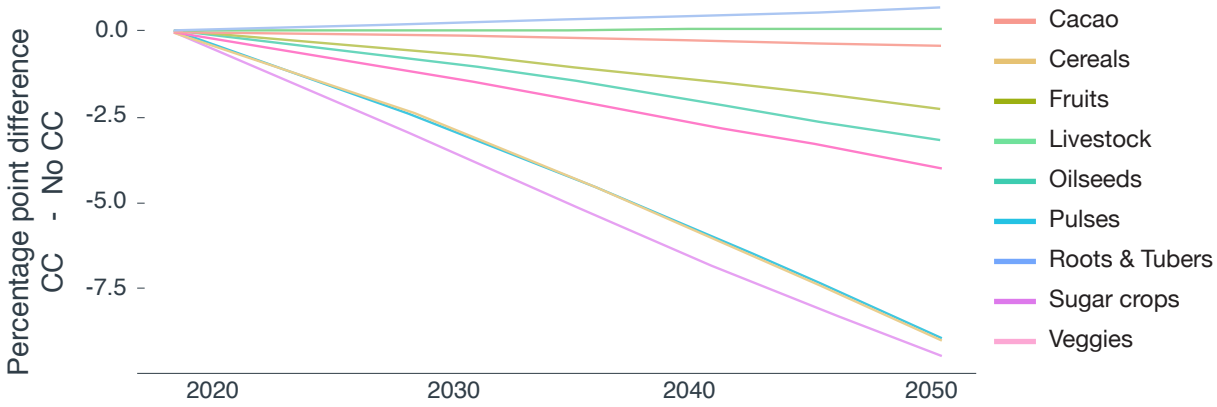
2.4 Climate change impacts potentially aggravated by shifting economic incentives

In Côte d'Ivoire, modeling shows that the shifting economic landscape induced by climate change could exacerbate biophysical damages for cereals, vegetables, pulses and sugar crops (figure 7). Some of these commodities warrant protective action because of their importance for food security, as discussed in the following sections. For example, in a scenario of high emissions, high population growth and low to moderate GDP growth (RCP 8.5, SSP3), yields of rainfed and irrigated vegetables—a critical source of nutrients—exhibit aggravated vulnerability to climate change when international market incentives are taken into account, falling 3.8 pp and 5.7 pp beneath their No-CC baselines, respectively (tables 2 and 3). Areas under rainfed and irrigated vegetable cultivation, meanwhile, are also projected to fall 1.2 pp and 4.4 pp below their No-CC baselines (tables 2 and 3, respectively). Relying on imports to meet domestic vegetable consumption is projected to increase at an alarming rate out to 2050.

Cereal yields generally exhibit high vulnerability to climate change and are of particular relevance in Côte d'Ivoire, where they constitute 35% of all daily caloric intake and 12% of cultivated area. There are, however, important variations for different cereals (figure 8). Maize and rice are the predominant cereals on farms and plates in Côte d'Ivoire, accounting for about 21% and 61% of all daily cereal derived caloric intake, and 36% and 46% of all cereal cultivation, respectively. Maize yield is projected to fall by well over 10 pp below its No-CC baseline trajectory across a wide range of climate change scenarios, while rice yield exhibits relative resilience, falling no more than 2.6 pp below its No-CC baseline in any scenario (tables 2 and 3). The area under maize cultivation is projected to hold close to its No-CC baseline across all scenarios, whereas the areas under rainfed and irrigated rice cultivation are projected to rise by as much as 6 pp above its No-CC baseline (tables 2 and 3). Currently, about half of all rice calories and all wheat calories (accounting for 14.7% of cereal caloric

intake) consumed in the country must be imported. However, rice could serve as a rallying point for cereal adaptation strategies because of its potential as a relatively resilient cereal crop.

Figure 7 **Percentage point difference between percentage change in yield (aggregate rainfed and irrigated) over 2020 with and without climate change, high emissions (RCP 8.5), high population growth scenario with low to moderate GDP growth (SSP3), major commodity groups**



2.5 Climate change impacts potentially offset through shifting market incentives

Shifting economic incentives resulting from climate change could play out favorably for Côte d'Ivoire in some key commodities. From a commercial standpoint, international trade and the modest levels of investment in yield-enhancing technology research assumed in IMPACT could substantially offset the anticipated steep decline in biophysical suitability for cocoa. Cocoa yield and area cultivated are projected to diverge from their No-CC baselines by less than a percentage point across a wide range of climate change scenarios (table 2). Therefore, a higher investment commitment[34] in yield-enhancing technologies could achieve much more.

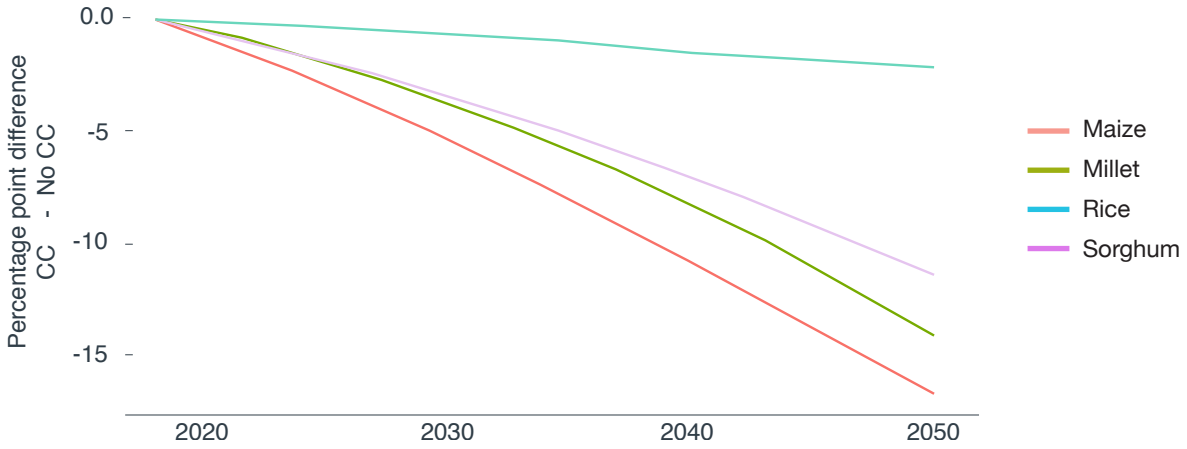
Roots and tubers, such as yams and cassava, also exhibit resilient yield trajectories out to 2050, diverging from their No-CC baselines by less than a percentage point across all climate change scenarios (table 2). This is good news considering the critical role that these crops play on farms and plates in Côte d'Ivoire, accounting for 35% of all daily caloric intake and 14% of cultivated area. Yams and cassava are especially vital to food security in the country, accounting for 63% and 29% of all daily caloric intake from roots and tubers, and 63% and 36% of all root and tuber cultivation, respectively. Projections show a slight rise in area under yam and cassava cultivation relative to the No-CC trajectory (table 2), and also show that cassava may even have budding commercial potential by 2050, with export quantities that are 29% greater than they would be without climate change (figure 9)[35].

Tropical fruit and plantain yields exhibit resilience in future climate change scenarios that take account of shifting international market incentives. Projections show plantain yield holding close to its No-CC baseline trajectory, and in some scenarios rising above it by as much as 2 pp (table 2). The area under plantain cultivation, meanwhile, is projected to rise above its No-CC trajectory between about 1-6 pp in 2050, depending on the scenario (table 2). Plantain exports in 2050 under climate change are projected at levels that are 38% higher than they would be without climate change. This

[34] Such as this CSAIP's Sustainable Cocoa Production investment

[35] Such as this CSAIP's proposed investments for Climate smart Cassava Production and Processing, and Yams

Figure 8 Percentage point difference between percentage change in yield (aggregate rainfed and irrigated) over 2020 with and without climate change, high emissions (RCP 8.5), high population growth scenario with low to moderate GDP growth (SSP3), cereal crops



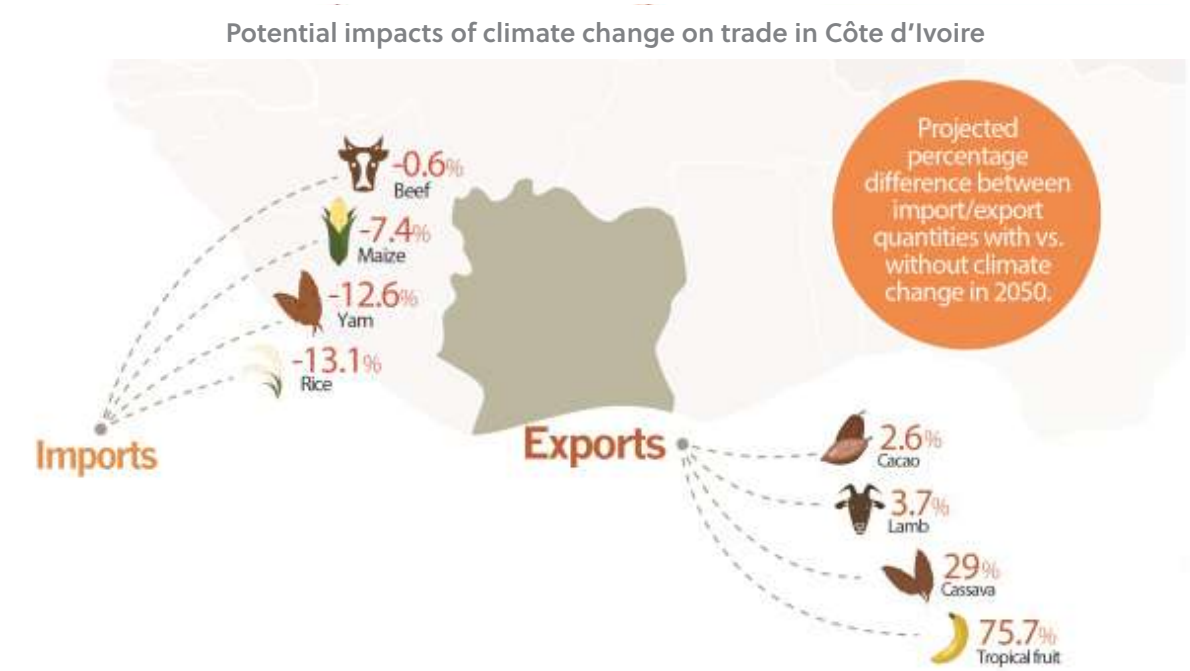
suggests that, with investments, Côte d'Ivoire has the potential to emerge from climate change impacts with a strong comparative advantage in plantain. While tropical fruits account for a small portion of domestic caloric intake, they provide critical nutrients. Tropical fruit yield is projected to diverge from its No-CC trajectory by less than 1 pp across all climate change scenarios, with slight increases in area cultivated relative to the No-CC baseline (table 2). In both climate change and no-climate change scenarios, Côte d'Ivoire's small export quantities of tropical fruits are projected to hold steady until about 2035, and then to begin declining out to 2050—but in 2050 this projected decline is buffered by climate change, declining 76% less with climate change than without (figure 9). Again, a higher investment commitment could greatly enhance this point of resilience[36].

Livestock productivity also exhibits resilience to climate change with investment support[37], diverging from its No-CC trajectory by less than a percentage point. While lamb shows budding export potential, domestic beef demand, requiring imports, is projected to increase at an alarming rate out to 2050. This is concerning because beef and small-ruminant meat account for 28% of all livestock-derived calories in Côte d'Ivoire. This highlights the importance of interventions targeting beef or the need for consumption to switch to other proteins.

[36] For example, this CSAIP's proposed investment for climate-smart mango production. Figures in this paragraph are based on an RCP 8.5, SSP3 scenario.

[37] For example, this CSAIP's proposed investment for livestock development (focusing on cattle and small ruminants).

Figure 9 Percentage difference between imports and exports in 2050 with and without climate change (RCP 8.5, SSP3).



Note that percentage differences are with respect to the No-CC value for the same year (2050), and thus do not necessarily indicate a positive or negative change over the 2020 baseline year (details of calculation in appendix D-6).

2.7 Climate adaptation has the potential to reduce import dependency

CSA investments in economic incentives offset biophysical climate change impacts for some crops, as shown by the IMPACT assessment. Low levels of investments, such as those assumed by the IMPACT assessment above, are insufficient to counteract negative trends. The higher levels of commitment envisioned in the present proposal could achieve substantially more. This underscores the importance of maintaining a commitment to adaptive technologies and practices, and suggests that effective strategies must skilfully balance efforts across areas of both vulnerability and potential resilience.

Modeling of shared socioeconomic pathways (SSPs; table 4) of the future shows that adaptation approaches can improve Côte d'Ivoire's trade balance. Under SSP 5, where Côte d'Ivoire agriculture grows and benefits from economically led and adaptation-friendly development, the growth in exports is about two-times greater than the growth in imports (figure 10). However, under SSP 3 and SSP 4, where adaptation challenges are high, import and export growth are very similar and net trade balance does not change much. As such, economically led and adaptation-friendly agricultural development would help improve the trade balance.

Demand for domestic production is much higher under SSP3 and SSP4 (compared to SSP5), because projected population growth results in a substantial dependence on increasing imports, potentially exposing Côte d'Ivoire to fluctuations in the global market as a function of climate change or other related perturbations. Like many countries, Côte d'Ivoire does not benefit substantially in the short term from mitigation-related activities, though in the long term it could see benefits from a more favorable global market.

Table 4 Description of select shared socioeconomic pathways (SSPs) modeled using IMPACT.

Shared Scosioeconomic Pathways	DESCRIPTION
SSP 3	Highly fractured, countries pushing apart, high problems both with mitigation and adaptation
SSP 4	High inequality, low challenges to mitigation, high challenges to adaptation
SSP 5	Competitive markets, fossil fuel led, high challenge to mitigation, low challenges to adaptation

Note that SSP 3 and SSP 4 both have high challenges with adaption, whereas SSP 5 has low challenges. See annex D for a complete description of all scenarios.

Côte d'Ivoire has the potential to realize agricultural-led economic development under a variety of climate conditions. While Côte d'Ivoire's agriculture has the potential to grow and benefit from economically-led development scenarios (e.g., SSP5), this necessitates a great deal of adaptation within the country. For the agricultural economy to thrive under SSP5-style economic growth and good adaptation trajectories, GDP will need to generally grow, population growth will need to rapidly level off and slow over time, and high levels of urbanization would be expected. The foresight scenarios suggest that if these conditions hold, Côte d'Ivoire will have adequate surplus within its agricultural system to participate in global markets, fueling economic growth and lowering import dependency. Investments that enhance productivity in key crops, anticipate crop and land use transitions, and facilitate sustained adaptation over the long term have the potential for substantial payoffs.

Figure 10 IMPACT model results showing changes in total imports and total exports over time.

Note that SSP 5 (blue line), with low adaptation challenges, has lower increases in imports and greater increases in exports, showing the positive benefits adaptation can bring to the trade balance.

Section 3

Prioritizing interventions for Climate-Smart Agriculture in Côte d'Ivoire

3.1 Process to develop the Climate-Smart Agriculture Investment Plan

Climate-smart agriculture aims to achieve productivity, resilience and mitigation outcomes, but it requires understanding what is climate-smart in different locations and designing projects to fit the varied contexts. What is climate-smart for one group of farmers or agro-ecological context may not be appropriate for another. There may also be trade-offs among the three pillars, so what is good for one pillar, such as resilience, may not be good for another, such as productivity. Projects are designed to meet the three of CSA pillars—increasing productivity, resilience, and mitigation—although priority may be given based on the context, such as emphasizing productivity and resilience rather than mitigation. The process described below generally follows the CSA Prioritization Framework (see annex A).

The first step in developing the CSA investment portfolio process was a technical review by CSA specialists of Ivorian national documents (policies, strategies, plans) related to agriculture and climate change, in order to identify potential CSA practices within these documents. Côte d'Ivoire has engaged in many analyses that provide input to the situation analysis (detailed in prior sections) that serve as a basis for planning and identifying CSA investments, setting targets, identifying climate risk and enabling conditions, including: National Program on Climate Change (2012); the Second National Investment Plan for Agriculture (NAIP2, 2017–2025)[38]; the Strategic National Plan for the Development of Livestock, Fisheries and Aquaculture (PSDEPA); the Strategic Plan for the Rehabilitation and Development of Forests (PSRDF); the National Strategy for Disaster Risk Management (NSDRM; Government of Côte d'Ivoire. 2011); the National Development Plan (NDP, 2016–2020; Government of Côte d'Ivoire, 2016); and the Country Partnership Framework for

[38] Part of the AU-NEPAD Comprehensive African Agricultural Development Program (CAADP)

Côte d'Ivoire (World Bank, 2015). The different plans, programs and policies relevant to the CSAIP are detailed in annex B. Also, a CSA profile was developed with support of FAO and including the CGIAR research program on Climate Change Agriculture and Food Security (CCAFS) partners (FAO; ICRISAT; CIAT, 2018). A REDD+ national capacity-building strategy also was developed. The investment plan proposed in this document builds on these initiatives and priorities and the work of various local institutions, including CGIAR research program on CCAFS and its partners. The long list of potential investments identified through the literature review and key stakeholder discussions were organized into "groups of interventions" in four categories: agricultural system, fishery and livestock system, forests and sustainable management of water and soils, and CSA services.

The second step was a prioritizing workshop to identify a final short list of 12 proposed investments from the original long list and select four of these investments for more detailed ex ante assessment of productivity, resilience and mitigation impacts. This occurred with local experts from Ivorian national organizations supported by CGIAR and national stakeholder expertise at a meeting in Côte d'Ivoire from May 29–June 1, 2018. The long list of 29 potential investments (annex C-1) supporting CSA that were directly relevant to national needs were assessed against their potential impact on: a) climate smartness (productivity, adaptation, mitigation); b) co-benefit outcomes (employment, GDP, contribution to other national commitments and strategies); c) likelihood of success (farmer adoption likelihood, scaling out potential, sustainability after project ends); d) alignment with AAA pillars and priorities; and e) likelihood of mobilizing funds from specific sources. The investments also were assessed for their distribution by zone (see annex C-2), beneficiaries, value for money and trade-offs. Participants had the ability to make this prioritization since many represented likely implementing agencies.

The final CSAIP portfolio of 12 proposed CSA investments were then developed into project concepts. Technical experts who participated in the workshop and other external experts were consulted in the development of the project concepts (annex F). Assuming all investments target different beneficiaries and all investments were made, these 12 project concepts aim to reach over 2.2 million beneficiaries, and often their families as well. As shown in table 5 below, in additional to national coverage by four investments, there is a good balance in strengthening agriculture in all parts of country. This is important both from an equity perspective and because it introduces climate-smart agricultural practices across the country. The project concepts are highlighted and summarized below, and more detailed economic and social analyses were developed for the four selected investments in chapter 4. Note that the order of these investments listed are not based on priority, but rather all investments presented in this plan are considered a priority.

Table 5 CSAIP investments by zone

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

3.2 National-scale Climate-Smart Agriculture service investment summaries

The four national-scale initiatives represent the fundamental components of an adaptive and climate-smart agricultural sector that are viewed as necessary at the national scale: agrometeorology, finance services, soil fertility and agricultural extension. These initiatives are foundational in supporting programs that are vital to insuring that the agricultural sector becomes climate smart, by providing both the real-time information farmers need to make decisions (e.g., agroclimatic information and soil fertility monitoring) and the guidance, knowledge and financial support for needed investments in the sector (e.g., finance services, soil fertility and agricultural extension). For example, integrating CSA practices into the national extension system not only helps farms directly but helps insure that there is a mechanism for transferring the information from the three national technology-based investments to farmers and other users. These four national-scale investments, the beneficiaries, and the proposed development outcomes (PDOs) are shown in table 6 and described below.

The National Soil Fertility Program aims to increase agricultural producers' ability to practice CSA by providing producers and extension agents with location-tailored information and recommendations, and the tools, products, partnerships and policy environment to implement those recommendations. Healthy soils regulate nutrient and water cycles, increasing the soil fertility while contributing to carbon sequestration, agricultural productivity and the buffering of climate change and variability. Ivorian soils present considerable agricultural management challenges, including low fertility, erosion susceptibility, irreversible hardpanning, high acidity and aluminum toxicity. The government of Côte d'Ivoire (GOCI) has prioritized addressing soil quality and fertility issues as part of sustaining the national agricultural sector and food security. This high-priority project will support producer's soil management decisions via development and implementation of a national soil information system. It could directly benefit 87,000 producers and their households in Agropole 2, and indirectly benefit smallholders throughout the country through increased awareness of the benefits of soil CSA practices and improved nutritional and economic outcomes.

Table 6 National-scale investments in climate-smart services

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

The National Agrometeorological System Project aims to increase farm productivity and mitigate climate-related risks by providing producers, extension agents and agribusiness with timely, accurate agrometeorological information and surveillance systems. Effective climate information

services reduce the uncertainty surrounding erratic climatic patterns, allowing producers and agribusiness to anticipate and manage adverse weather conditions, take advantage of favorable ones and adapt to change. They also support climate-informed policy, planning and extension agent recommendations. The GOCI has identified climate information service implementation as a high-priority investment because it is a key component of sustainably managing environmental resources and climate resiliences, as well as strengthening institutional frameworks and business governance. This project will strengthen public-sector systems, technical capacity to produce, monitor and convey climate information, and producer technical ability to access and leverage the information, by addressing physical infrastructure; data aggregation, synthesis and dissemination; and national capacity for maintaining and leveraging the information system. It could directly benefit 312,000 agricultural workers and their households and indirectly benefit producers across the country via improved extension, agribusiness and policy outcomes by improving access to timely, accurate climate information.

The Climate-Smart Agricultural Finance Services and Products project aims to increase agricultural producers' ability to manage climate-related risks and sustainably increase productivity by improving their access to and ability to leverage financial products and services. Good access to financial products and services enables agricultural producers and agribusinesses to leverage collateral, decrease transaction costs and reduce risk, thus improving economic outcomes. Improving rural populations' access to existing financial services is a high priority for the GOCI because it will improve consumer protection, foster more business-friendly environs and expand risk-reducing (e.g., insurance) and credit instruments to marginalized populations. This project will strengthen the foundations for a national CSA financial services system to provide savings, credit and insurance products for agricultural producers seeking to adopt CSA practices and manage climate-related risks. This priority-ranked project could directly benefit 980,000 producers and indirectly benefit agricultural workers across the country by fostering entrepreneurship, economic activity, strategic risk-taking and innovation.

The National Climate-Smart Agricultural Extension System project aims to increase farm productivity and minimize climate-related risks by improving the quality and quantity of CSA-informed recommendations made to producers by farm advisors. Farm advisors play a crucial role in translating scientific information into practical recommendations, promoting CSA by supporting technology development, strengthening farmers' capacity, facilitating conversations between producers and other stakeholders (e.g., researchers, processors, cooperatives) and advocating for pro-CSA policy. Increasing the production and dissemination of high-quality agricultural technologies through the research and extension systems is a key investment priority for the GOCI. This project will increase the extension system's capacity to provide recommendations to producers that are informed by and promote CSA practices. It could directly benefit 235,800 agricultural producers and their households in Agropole 4, and indirectly benefit producers throughout Agropoles 4 and 8 through improved nutritional and economic outcomes.

3-3 Climate-Smart Crop and Livestock Investments

There are eight climate-smart crop and livestock investments identified to support adaptation of agricultural production systems for important crops that will be harmed by climate change, while also supporting the expansion and development of climate-resilient crops and livestock. This dual perspective of including both adaptation of climate-sensitive crops and expansion of resilient crops provides a way for Ivorian farmers to adapt to climate change. The proposed crop and livestock investments all introduce climate-smart practices into the different investments. All of these site-

specific investments are well supported by the four national-scale foundational investments. These eight crop and livestock specific investments, the beneficiaries, and the proposed development outcomes are shown in table 7, and described below and in appendix F.

The proposed Climate-Smart Cassava Production and Processing Program project aims to increase the cassava sector's capacity to practice CSA by providing producers, processors and extension agents with technical assistance and increased access to improved varieties and up-to-date research outputs. Climate-smart agricultural practices can significantly improve cassava climate resilience and yields. Cassava, a priority crop for the GOCI, is crucial to food security, has good nutritive value, and is primarily produced by 89% of smallholder farmers for consumption (Riquet, et al. 2017). This project will increase producer capacity to integrate CSA practices by training extension agents, developing and distributing improved varieties, bolstering value-added processing organizations (with potential to engage women and youth), and building national capacity on cassava. It could directly benefit up to 90,000 producers (and their households) in Agropoles 3-5, 7 and 9 via improved nutritional security and value chains, while also developing the sector's capacity to continue to support cassava production into the future. This was deemed a priority project.

The proposed Development of a Climate-Smart Livestock Sector in northern Côte d'Ivoire project aims to increase the productivity and climate resilience of the livestock sector through climate-smart practices, infrastructure development and scientific research. Climate-smart practices can significantly improve livestock climate resilience, longevity and productivity, and reduce impact on natural resources. Sedentary and nomadic herds are crucial to nutritional and economic security. The GOCI has prioritized doubling domestic meat supplies in order to reduce dependence on expensive imports. This project will build producer capacity for climate-smart livestock production by strengthening research and development, training extension agents, and developing sector infrastructure. It could directly benefit approximately 80,100 smallholders and their households in the Hambol region of Agropole 1 and indirectly benefits the entirety of Agropole 1 through improved nutritional security, climate resiliency, productivity and natural resource health.

The proposed Sustainable Cocoa Production project aims to increase cocoa farm climate resilience in order to augment productivity and generate new income opportunities, particularly for women and youth. Climate-smart agricultural practices can significantly improve cocoa climate resilience and yields. Cocoa, Côte d'Ivoire's largest export crop, employs nearly 15% of Ivorians and, as international demand continues to rise, represents a significant national economic opportunity. This project will increase cocoa producers' capacity to leverage CSA practices to achieve improved economic outcomes and adapt to climate change by training extension agents, strengthening research and development, and promoting enabling policy. It could directly benefit 88,000 rural agricultural workers and their households in the Moronou region of Agropole 4, and indirectly benefit cocoa farmers throughout Agropoles 3 and 4 via increased productivity and new income opportunities, particularly for women and youth.

The proposed Irrigated and Rainfed Rice Development project aims to increase rice productivity and stabilize producer revenues by scaling climate-smart practices in order to achieve national rice self-sufficiency. Climate-smart agricultural practices can significantly improve rice climate resilience, reduce production costs and bolster yields. Rice is a staple food and economic crop, yet international imports dominate the market due to lower production costs. The GOCI has prioritized becoming rice self-sufficient. This project will increase producer capacity to leverage CSA practices developed for African rice production by strengthening research and development, training extension agents and developing sector infrastructure. It could directly benefit 68,640 rainfed rice producers and

their households in the Cavally region of Agropole 7, and indirectly benefit rice producers throughout Agropole 7 by scaling climate-smart practices to increase rice productivity, reduce costs and stabilize producer revenues.

Table 7 Crop and livestock climate-smart investments

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

The proposed Development of Climate-Smart Production and Processing of Yam project aims to increase farm productivity and minimize climate-related risks by increasing capacity for climate-smart yam production and strengthen yam markets for improved economic and nutritional resilience. Climate-smart agricultural practices can significantly improve yield and quality, as well as reduce labor, input costs and sensitivity to abiotic stressors. Yam is a staple food crop and a cornerstone of the Ivorian culture and economy. Strong, reliable demand creates significant opportunity to improve productivity and expand value-added processing. This project will build capacity for climate-smart yam production and optimized processing by strengthening research and development, training extension agents and supporting market development in terms of propagation, production and processing. It could directly benefit 70,000 producers and their households in the Gbeke region of Agropole 4, and indirectly benefit producers throughout Agropole 4 through improved nutritional security and greater economic opportunity.

The proposed Climate-Smart High-Value Vegetable and Livestock for Abidjan Market project aims to improve Ivorian economic and nutritional self-sufficiency through climate-smart agricultural practices in the regions supplying the Abidjan market. Côte d'Ivoire is a net importer of many foodstuffs, and Abidjan is at the heart of that demand. Climate-smart agriculture offers the opportunity to promote economic and nutritional self-sufficiency in the region through improved agricultural productivity. It also minimizes environmental impact, fosters the resilience of food

systems and supports the economic viability of rural populations. This project will expand year-round production of vegetables, poultry and pork products in order to meet the growing food demand of the Abidjan metropolis and foster economic opportunity (especially among women and youth) and climate resilience. It could directly benefit 66,000 peri-urban agricultural workers and their households in Grand Ponts region of Agropole 5 and indirectly benefit the population of the La Me region of Agropole 3 via greater economic opportunity and nutritional security.

The proposed Climate-Smart Development of the Mango Value Chain project aims to increase incomes in the Ivorian mango sector via greater productivity through CSA practices and reduced post-production losses through value-added processing. Climate-smart agricultural practices can significantly improve the climate resilience and productivity of mango plantations, and value-added processing can leverage products that do not meet fresh fruit quality standards to diversify and strengthen economic outputs. Mango is a strategic export crop for Côte d'Ivoire and a primary source of vitamins for the domestic population. The potential for post-production value addition is largely untapped and offers significant economic opportunity, particularly for women and youth. This project will bolster productivity and postharvest processing by training extension agents, strengthening research and development programs, supporting postharvest value-added organization, offering producer technical assistance, and making climate information services available. It could directly benefit 5,000 mango producers and their households in the Poro region of Agropole 1, and an additional 245,000 employees of value-add, transport and other post-harvest processes, through improved nutritional and economic outcomes.

The proposed Climate-Smart Maize project aims to increase farm productivity and minimize climate-related risks by increasing the capacity of producers, cooperatives, extension agents and researchers in climate-smart maize research, production, processing and marketing. Climate-smart agricultural practices, particularly agroforestry, can significantly improve maize yields and climate resilience, and reduce yield variability. Maize is a staple food crop primarily produced by smallholders for consumption; maize self-sufficiency is a priority for the GOCI. This project will increase producers' capacity for CSA in maize and their access to relevant inputs by strengthening research, development, and distribution of climate-smart maize technologies, increasing the capacity of extension agents, supporting cooperative and professional organization capacity, augmenting public awareness of the benefits of CSA practices, and improving access to financial services. It could directly benefit 138,000 female agriculturalists and their households in the Poro region of Agropole 1, and indirectly benefit producers throughout Agropoles 1, 6, and 7 through improved nutritional security and economic opportunity.

Section

4

Guiding CSA investments in Côte d'Ivoire from concepts to programs

4.1 What Côte d'Ivoire gains from CSAIP: an overview

Climate-smart agriculture (CSA) is based on the idea that what works for one farmer in one location may not work for another, thus actions within investments are tailored to the setting. Thorough context-specific innovation is necessary to maximize benefits. This approach makes CSA extremely effective. Although scalability through simple replication is not possible, the process for building CSA within a country is well known, and it requires ensuring that enabling conditions are right and that strong capacity-building and stakeholder involvement mechanisms are clearly identified. The CSAIP has been based on a great deal of situational analysis and prioritization, as described in prior chapters. There has also been a strong review of the national context to insure that CSA design and implementation wholly builds on and becomes integrated into policies, programmes and projects. These are all of the early steps in moving from concepts to concrete actions.

An operational framework to guide CSA programming into practice is thus crucial to project success. Effective frameworks support planning and implementation by producing concrete information through situational analysis (e.g., enabling conditions, goals, constraints), targeting and prioritizing (e.g., of high-interest options such as capacity building), design and implementation (e.g., field testing, scale-out planning), and monitoring and evaluating to facilitate iterative learning. This chapter details an operational framework and the elements needed for project design and implementation to the priority investments in order to identify opportunities, constraints and financing opportunities. See annex A for more information on CSA planning and implementation frameworks.

Table 8 Gains from CSA Implementation: Rationale for Investments

CSA Investment	On-Farm importance	Ivorian importance	Projected response to climate change	What could happen in the future without CSA investment	Response: investment for improving resilience, expanding growth, or both
Cassava	Food security	35% of daily calories (with yams) & grown by 85% of smallholders	Relatively resilient	Yield stable, little growth to meet higher demand	Growth
Abidjan food system (vegetables)	High economic value	Address growing demands of rapid urbanization	Bad	High demand, so increased imports	Resilience and growth, reducing import need
Cocoa	High economic value	Employs 15% of Ivorians	Small decline	Lower yields, expansion to forests, lower export revenue	Resilience and growth, expanding exports
Livestock	High nutritional value & food security	Produced by 58% of rural population, including 800,000 pastoralists	Moderate decline	Environmental degradation, conflict, reduced productivity	Growth
Mango	High nutritional value	Largest exporter in West Africa; 50% consumed domestically	Small decline	Lower yield and small production	Growth, expanding yield and value added
Maize	Food security	21% of daily cereal consumption & 36% of all cereal grown now	Very bad	Serious declines without intervention	Resilience and growth toward self-sufficiency
Rice	Food security	61% of daily cereal consumption & 45% of all cereal grown now	Small decline	Slight decline in production	Resilience and growth toward self-sufficiency
Yam	High nutritional value	35% of daily calories (with cassava); largest cultivated area of any crop	Small increase	Slight increase in yield but not enough to meet higher demand	Resilience and growth, expanding yield and value added

Promoting CSA in Côte d'Ivoire should be understood not as a collection of agricultural practices in different parts of the country but rather as a methodology for integrating and evaluating climate change scenario planning, economic analysis, priority setting of regional areas, and potential barriers and opportunities. Decision-makers at all levels, from national ministries to farmers making planting decisions, must understand the purpose of CSA and the bottom lines. Table 8 demonstrates, for each of the crop and livestock investments, why that commodity was selected, what climate change impacts will be for the commodity, and what the objective is of the CSA investments.

The next section (4-2) describes economic analysis for four priority investments. One of those, cassava, shows a relatively lower rate of return after the five-year project compared to the other investments. It should not be dismissed, however, because of two critical points: it is grown by 85% of smallholders, and it has the potential, with appropriate investments, to respond well to the future conditions of a warming climate. It is a great investment for future expansion in the sector, for which this project lays the groundwork.

4-2 Climate-Smart Analysis for Four Select Investments

Four investments were selected to be of high priority to increase productivity, strengthen resilience and mitigate climate change. Stakeholders targeted three national-scale programmes—soil fertility, agrometeorological systems and financial services—and one production-system-specific program focused on cassava (see synopses above and detailed concept notes in the appendix).

Detailed modeling was conducted to predict the potential economic performance of these investments, subject to expected costs, project and climate risks, and potential outcomes. The model uses a probabilistic approach (Bayesian Networks, or BN) to estimate the net present value (NPV) and return on investment (ROI) for the four investments[39]. A BN model was used for two reasons. First, providing accurate estimates for project costs, returns and adoption is a main challenge in project evaluation. The parameter uncertainty of all of these variables can be explicitly modelled in the BN and is taken into account. That is, instead of assigning a single value for the targeted number of beneficiaries or their income, it relies on a probability distribution that represents the degree of confidence in the estimate. Probability distributions are used for all variables in the model. Second, different risk scenarios, climate and non-climate, can be factored into the modeling. The model takes the likelihood (frequency) and impact (severity) of risk factors into account when modeling project performance. Full description of the model and sources of parameter values can be found in annex E, along with additional results.

Productivity

Estimates of changes in income for farmers implementing CSA are the core of the modeling, and this analysis relied on the most comprehensive and state-of-the-art dataset available, the CSA Compendium. The CSA Compendium is a dataset, compiled from more than 1,500 peer-reviewed articles, contains more than 150,000 data points that compare 45 different outcomes of productivity, resilience and mitigation for 100 different farm practices in Africa[40]. This includes data on the changes in yield and economic returns, as well as other factors, following adoption of CSA (table 9).

Table 9 Estimates of changes in yield and income with the adoption of CSA. The CSA Compendium for Africa provides an estimate of productivity benefits (changes in yield and income) with adoption of priority investment projects. Details on the methodology used are provided in Annex E and Rosenstock et al. (2015)

Climate-Smart Agricultural practices	Investment				No. of studies[b]	Change in yield[b] (% ± sd)	Change in income[b] (% ± sd)	Change in costs [b] (% ± SD)
	CSC[a]	SFP	FSP	AMS				
Improved crop varieties	✓		✓	✓	21	36 ± 85		
Crop rotation	✓	✓			38	52 ± 68		
Intercropping	✓	✓			33	-2 ± 62	-18 ± 52	-40 ± 44
Mulch	✓	✓			57	46 ± 81		
Inorganic fertilizer	✓	✓	✓		165	68 ± 68	51 ± 37	-55 ± 33
Organic fertilizer	✓	✓			56	73 ± 101	42 ± 10	-48 ± 83
Green manure	✓	✓			32	42 ± 82	113 ± 88	-63 ± 89
Agroforestry alley cropping	✓	✓	✓		22	15 ± 97		
Agroforestry tree pruning	✓	✓			48	44 ± 68	67 ± 57	-30 ± 25
Reduced tillage	✓	✓			49	-8 ± 75	-19 ± 10	8 ± 15
Terracing, ridging, bunds	✓	✓	✓		29	44 ± 92	30 ± 14	-2 ± 3

[39] Yet et al. 2016.

[40]. Rosenstock TS, Lamanna C et al. 2015.b Crop data shown for cereal crops (maize, millet, sorghum and rice) in West Africa; livestock data is for all livestock (cattle, goats, sheep, chickens) in West Africa.

[41]. Sadler M, Milan A, et al. 2016. Washington DC

a. Checkmarks indicated which technologies were included under which investment projects, according to their concept notes. CSC = Climate-smart Cassava, SFP = National Soil Fertility Program, FSP = Financial Services Program, and AMS = Agrometeorological Services.
b. Crop data shown are for cereal crops (maize, millet, sorghum and rice) in West Africa for comparison across projects; however, input data for the cassava project used corresponding data for cassava only.

This one-of-a-kind resource provides first evidence of the performance and productivity of improved technologies and management practices identified in the priority concept notes of the CSAIP.

The four investments are predicted to provide significant benefits to smallholders farmers in Côte d'Ivoire (table 10). Net present value (NPV) ranges from $10.4 million with the cassava program to nearly $800 million with the program focused on financial services. Return on investment with CSA management compared to business as usual ranged from 41%–2071%. These substantial gains are a result of conservative analysis estimates of both potential and rates of adoption (see annex E for methodology). These values do not assume any risks (social or natural) to project implementation, so they serve as an upper limit to potential value. Though the model accounts for the uncertainty in each of these factors, actual implementation may deviate significantly from data and assumptions underlying this modeling approach. Thus, this analysis can best be thought of as a first appraisal. The results provide an indication of relative benefits among the investments, whereas subsequent analysis can increase precision on estimates by bringing in additional informed opinions.

Investments in financial services are among the best bets for increasing incomes in Côte d'Ivoire. The use of financial services can have transformative impacts on wealth and reduce risks over very short time periods. The substantial potential gains predicted in this analysis result from a combination of high numbers of potential beneficiaries (~1 million) and significant impact for each beneficiary, with increases in income averaging nearly 50%. However, there is significant uncertainty regarding what investments farmers will make with access to credit. Farmers often make investments that add value to production systems and the long-term health of their land (e.g., planting trees, minimizing soil erosion or buying inputs41). The precise technologies used depends on availability and production systems; hence impacts could vary significantly. Regardless, cautious optimism for investment for extending access to financial services is warranted and can be predicated based on examples from other countries. For example, just 10 years after launching mobile money in Kenya, 96% of households have at least one user, and the technology has raised nearly 200,000 people out of poverty[42].

Table 10 Performance of the four priority investments assuming no project risks

Project	Number of beneficiaries	Impact per beneficiary (% ± st dev)	Cost (m $)	Cost per beneficiary ($)	NPV* (m $)	Prob. of + NPV* (%)	ROI (%)
National soils	87,000	46 ± 44	31.0	356.3	40.4	80	130
Agrometeorological	312,500	10 ± 15	20.9	66.9	46.7	93	329
Financial services	980,000	46 ± 121	38.4	39.2	794.7	83	2,071
Cassava	90,000	15 ± 57	25.1	212.6	10.4	56	41

*NPV and ROI based on baseline scenario without inclusion of major project risks.
*Probability of a positive NPV is a measure of resilience and represents likelihood of value when faced with six prevailing risks: drought, flood, pests, political instability, community conflict and poor project governance.

42. Suri T and W Jack. 2016

Investments in agrometeorological systems and climate information offer a cost-effective approach to increase incomes and allow for management of risks. Providing farmers with accurate near-term and seasonal forecasts can affect farmer behavior, including stimulating them to adopt more CSA practices. Given the relatively low investment costs (US$20.9 million) and high numbers of potential beneficiaries (312,000), Agromet has significant potential to increase the productivity of farms and the landscape more broadly.

Though the national soil and cassava programs create significant value, they reach fewer people during the five years, which limits the expected benefits of the investments. These investments rely heavily on capacity building of human and institutional infrastructure and often proceed at a slower pace than technology-dependent investments. Yet these investments lay the groundwork for CSA agriculture across crops in terms of the national soil program and with one of the most important emerging food crops. Thus, the foundation these investments build are critical components of a climate-smart future and can be expected to have substantial and additional benefits after the five-year program.

Resilience

The investments show varying degrees of resilience to risks when considering the potential impact of all risks (e.g., political instability, community conflict, drought, flood, etc.). The cassava investment is predicted to perform the most poorly under uncertainty, with NPV falling nearly 40% to US$6.7 million (see appendix for detailed results). By contrast, the value of the investment in agrometeorological services increases by more than 100% in value to US$133.6 million.

All four projects show high degree of resilience when considering only climate-related risks (drought, floods and pests). Expected results were all near, or above, risk free scenarios. Mean NPV of the investments as a percentage change estimated against scenarios with no risk were -2%, 26%, 57% and 186% for National Soil Program, Finance, Cassava and Agrometeorological, respectively. Thus, this analysis suggests high degrees of resilience to climate change impacts.

Table 11 General barriers to adoption and scaling of CSA practices in Côte D'Ivoire. Orange indicates barriers of greater threat; yellow indicates barriers of medium threat.

General barriers to adoption and scaling of CSA practices in Cote d'Ivoire	Barrier level
Donor unwillingness	Greater threat
Drought, floods, pest, disease, locust invasions	Greater threat
Women systematically excluded from capacity building and extension	Greater threat
Poor information access	Medium threat
Farmer-pastoralist conflict	Medium threat
Disincentivizing policy	Medium threat
Political crisis	Medium threat

Despite risks, all four investments present a better than even chance (>50%) of achieving a positive NPV. This suggests that all four may be successful given the parameters used in the model. In all cases, the probability of positive NPV was lower (6%–22.5%) when estimating value including only socio-political risks than only climate risks, suggesting that non-climate risks may be greater than climate risks, given their uncertainty and impacts, at least in this model.

Mitigation

Reducing greenhouse gas emissions and enhancing carbon sequestration is a co-benefit of improving agricultural practice, supporting Côte d'Ivoire's national focus on productivity and adaptation. Although Côte d'Ivoire's has low emissions compared to developed countries, it has committed to reductions. Estimates of the value of reduced emissions were generated based on empirical measurements of emission reductions and assumptions about farm activities. The value of CO_2 was set at US$40/ton in alignment with estimates of the social costs of emissions.

The change in level of emissions varies within the different components of each investment. Taken as a whole, these various practices offer a net reduction or net neutral change in emissions. In some instances, such as when increased fertilizer use is promoted or enabled, emissions are likely to increase. On the other hand, practices such as reduced tillage, terraces and agroforestry reduce emissions. This demonstrates the importance of holistic project implementation in order to ensure net benefits.

If valued, mitigation co-benefits can be a non-trivial addition to investment targeting productivity and adaptation. At US$40/ton CO2 (at least 8 times the current market price), the value of mitigation co-benefits from investments ranged from 7%–13% of total value under all project risks. This results supports other analyses that show large-scale investment programs can help meet mitigation goals[43] even though they target the other CSA pillars.

4-3 Constraints to Design and Implementation

Many of the barriers to CSA design and implementation stem from, or are aggravated by, policy issues. The Ivorian government has undertaken major reforms to bolster the business climate and improve financial management. Nevertheless, gaps between policy and implementation remain. For example, the country has benefitted greatly from a robust regulatory framework regarding fertilizer import quality control and open regulation on private-sector, NGO and cooperative importing of the same. At the same time, registration is costly and implies protracted delays[44]. The Côte D'Ivoire context presents some circumstances that could present themselves as barriers to all of the priority investments. These are summarized in table 11, with red indicating possible barriers of greater threat to investment success, yellow indicating medium barriers, and green indicating low barriers. Table 12 uses the same color scheme to summarize possible risks specifically confronting each of the national and regional priority investments. Investments are listed in order from highest to lowest severity of potential barriers within each grouping.

[43] Richards M, et al 2018

[44] World Bank, 2017

Table 12 Barriers to adoption of proposed CSA investments In Côte d'Ivoire. Orange indicates possible barriers of greater threat to investment success, yellow indicates barriers of medium threat, and green indicates barriers of low threat

NATIONAL INVESTMENTS		RISKS
Agricultural finance services		Diverse producer need segments and geographic dispersion limit economy of scale opportunities
		Low-literacy users unable to access many ICT-based services
Agricultural extension system		Systematic exclusion of women limits potential innovations in woman-produced crops
		Lack of subsidies to encourage fallowing
Soil fertility		Risks are not well understood pending further investments in farmer capacity
Agrometeorological System		Risks are not well understood pending further investments in farmer capacity
REGIONAL INVESTMENTS		**RISKS**
Irrigated and rain-fed rice		Technical and financial capacity of enterprises in infrastructure sector
		Tenure and rent issues within irrigated perimeters; community conflict
Mango value chain		Inconsistent or absent value chain infrastructure, (e.g., tranportation, cold chain, storage facilities)
		Incorrect or excessive use of inputs such as fertilizer
Sustainable cocoa production		Farmer-pastoralist conflict
		Limited feed availability for livestock
Yam production and processing		High market volatility due to labor intensivity and product quality variability
		High crop nutrient demands exhausts soil and encourages slash and burn
Maize development		High market volatility due to product quality variability
		Extremely susceptible to environmental variability
Cassava production and processing		High market volatility due to labor intensivity and product quality variability
Abidjan market vegetable & livestock		Lack of boreholes, pumps, and other infrastructure to facilitate water access

Low barriers to adoption Medium barriers to adoption High barriers to adoption

Côte d'Ivoire currently lacks an effective and enforceable land tenure policy. As with most agricultural innovations, CSA practices tend to be long-term investments. The lack of an effective land tenure system discourages Ivorian farmers from investing in the land they are currently farming, and catalyzes conflict over land use between pastoralists and farmers. The law relative to land tenure was passed in 1998, and updated in 2004 and 2013 to recognize customary law. Yet issues remain[45], including misinterpretation and misuse of the law, lack of targeted actions for women and youth, complex and costly administrative procedures, and involvement by multiple ministries in land tenure procedures[46]. Notably, the current systems dissuade female land ownership, and women currently account for only 10% of landowners in Côte d'Ivoire[47].

Côte d'Ivoire infrastructure development outside of the transportation sector remains far below the country's potential. Water infrastructure, and in particular irrigation, are essential for increasing yields, particularly as drought becomes an increasingly greater risk under climate change. Yet only 1% of land is irrigated, even though Côte d'Ivoire has the capacity to irrigate 475,000 ha[48]. Cold-chain infrastructure is also scarce, and the services that do exist are prohibitively expensive. The near total lack of cold-chain infrastructure accessible to smallholders leads to large-scale post-harvest losses that have become a major challenge to developing the national agricultural sector[49].

Côte d'Ivoire's national market accessibility and trade rank among the world's worst. For example, the Coffee and Cocoa Council imposes drastic price controls on the cocoa sector, virtually excluding all free-market functions. The council reduced cocoa prices by 36% from 2016 to 2017, resulting in substantial income losses for farmers. The recent Ghana-Côte d'Ivoire accord to establish a floor price for the 2018/2019 cocoa season represents a meaningful step toward pro-farmer market regulation.

CSA as a concept is not well known among decision-makers, technical experts, extension agents or farmers themselves. Information and information-sharing systems around CSA remain to be developed in Côte d'Ivoire. Knowledge of optimal CSA practices specifically for the Ivorian context is still under development. Mechanisms for information exchange are disjointed or have not yet been established. These barriers impact CSA adoption, most notably in policy-making and extension services.

Inequality drastically hinders the development of CSA and the Ivorian agricultural sector. The most vulnerable populations, including women, youth and nomadic groups, are those most likely to benefit from CSA, and also the most likely to be excluded from access to agricultural innovation. Côte d'Ivoire has one of the world's highest gender inequality rates, ranking 171st out of 188 countries in the United Nations Gender Equality Index[50]. Women are marginalized in term of access and control of land and agricultural assets[51], and 75% of women live below the poverty line[52]. Although women exclusively manage many staple food crops, women have input on less than 25% of agricultural decisions[53]. While producer cooperatives have seen large gains, policymakers have not yet taken the opportunity to officially promote the participation of vulnerable populations in such organizations.

[45] CIAT, 2018

[46] FAO, 2017

[47] CARE, 2017

[48] CIAT, 2018

[49] CIAT, 2018

[50] World Bank, 2018

[51] CIAT, 2018

[52] Tall, 2013

[53] Tall, 2013; CGAP, 2017

Côte d'Ivoire has the highest deforestation rate in the world[54]. Itinerant farming, also called slash-and-burn, is common in Côte d'Ivoire as a way to boost soil fertility. Firewood and charcoal are the primary energy sources. High population growth pushes conversion of forests to agricultural areas. These drivers, combined with a lack of coordination between sectoral policies, has reduced forest cover from 12 million hectares in 1960 to less than 3 million in 2017[55]. This drastic loss of ground cover has made Côte d'Ivoire particularly vulnerable to flooding[56].

4-4 Opportunities for Design and Implementation

CSA investments enjoy strong support in Côte d'Ivoire once there is awareness. The breadth and depth of stakeholders engaged in developing this CSAIP indicate a strong awareness of and interest in the urgent need to implement CSA approaches. Strong national representation and international support have been crucial to this process. Involvement took the form of consultations prior to the workshops, attendance at workshops, or both. Recent policies, discussed further below, have increasingly addressed issues related to climate change (table 13). There are many earlier efforts that can be built upon and complementary activities underway to support this Ivorian CSAIP, as identified in annex B.

The economy and the agricultural sector have been remarkably dynamic, with GDP growth rates of 7%–9% since the political unrest in 2011[57]. The Ivorian government has proactively implemented numerous policies that set the stage for private-sector-led growth[58]. The Ivorian NDC aims to foster linkages between agriculture, agribusiness and industry to support overall national economic development. Côte d'Ivoire has also received substantial international support, including $2 billion from the World Bank and the IFC under the Country Partnership Framework (CPF), to create better jobs through private-sector-led agricultural growth, including from the Africa Development Bank, World Bank and the Economic Community of West African States.

The private sector represents an important opportunity for the implementation of CSAIP for agriculture, particularly in terms of private-sector-driven service provisions. Both the National Development Plan (NDP) and the National Agricultural Investment Program (NAIP2) seek to increase the private sector's role in boosting Ivorian agriculture. For example, the private sector is best poised to launch credit and lending and bolster services provided by agrodealers. Often, they also have the liquidity and business case to invest in infrastructure, advisory services, the training of agricultural experts and other factors that support expanded production, improved quality and greater market reliability. These services are a critical and integral part of the project concepts presented in this CSAIP. Public-private partnerships may also be important when the private sector cannot make a business case on its own.

Côte d'Ivoire has significant national educational resources, offers Ph.D. programs in agricultural sciences and retains high-capacity nationally trained professionals—all of which allows for rapid capacity building and expansion of CSA. Since Côte d'Ivoire is one of the few francophone countries in the sub-region offering higher degrees, most agricultural professionals are trained nationally. Institutions offering higher education in agricultural sciences include the University of Cocody Abidjan, University Abobo-Adjame and Ecole Superieure d'Agronomie. Most graduates of

[54] UN REDD, 2017.

[55] FAO, 2012; BNEDT, 2015

[56] ClimateWatch 2018

[57] World Bank, 2018

[58] World Bank, 2016.

these programs are employed by the National Rural Development Agency (ANADER) managing farm advisors. There has been significant multi-level support for expanded Ivorian extension services. National policy, regional alliances and international supporters have unified around this effort. Expanded extension services will be crucial to the capacity building and on-farm support necessary for successful implementation and scaling of CSA practices.

Table 13 Ivorian government policies, plans and strategic frameworks addressing concepts relevant to climate change. Mentions of key CSA concepts within each are indicated in green.

POLICY, PLAN, OR FRAMEWORK	ABBREVIATION	DATE	CLIMATE CHANGE	ADAPTATION	MITIGATION	CSA
National Adaptation Plan	NAP	2011				
National Strategy for Disaster Risk Management		2011				
National Cimate Change Program		2012				
Forest Code		2014				
National Communication on Climate Smart Agriculture	NCCSA	2014				
Nationally Determined Contributions	NDC	2015				
Strategic Plan for the Rehabilitation of Forests		2016				
Country Partnership Framework		2016-2019				
Strategic National Plan for the Development of Livestock, Fisheries and Aquaculture	PSDEPA	2014-2020				
National Program on Climate Change	PNCC	2015-2020				
National Development Plan	PND	2016-2020				
National Agricultural Investment Program	PNIA II	2017-2025				

Côte d'Ivoire financial regulation has been improving and now ranks 6th out of 21 sub-Saharan countries[59]. These efforts have generated significant trust and transparency. For instance, in 2015 the West African Monetary Union, of which Côte d'Ivoire is a member, strengthened its regulation concerning branchless banking. The new rules improve consumer protection standards by requiring e-money issuers to guarantee 100% consumer funds protection via a regulated financial institution. Côte d'Ivoire complied with these new regulations, to the direct benefit of Ivorian farmers. Rural producers are increasingly transferring money through mobile phone; 27% of them declared having a registered account[60]. It also diminishes risks and the excessive transaction costs associated with informal agents.

The Warehouse Receipt System has also recently come under new regulation and management[61], increasing opportunities for CSA production increases to be safely stored. This mechanism, by which warehouse owners issue bonds against loss of stored property, is a significant step toward financial inclusion for Ivorian smallholders. Farmers become able to access loans without having to go through a fastidious due-diligence process[62]. As a result of the Agricultural Commodity Exchange Warehouse Receipt scheme (ACE-WR), 72,000 cotton farmers have secured reliable access to fertilizers and pesticides, and across the entire cotton value chain, loans are secured on seeds, inputs and raw cotton through the use of warehouse receipts[63].

[59] World Bank, 2017

[60] CGAP, 2017

[61] WORLD BANK, 2017

[62] WORLD BANK, 2017

[63] Hollinger, 2009; PARM, 2017

The Ivorian transport sector is one of the most developed of West Africa, with roads, railways, seven airports and two international seaports. The country has embarked on an ambitious program of reforms to modernize the national road network, with World Bank support on improving the efficiency of logistic chains and transport service provisions[64]. The result is that Côte d'Ivoire has been ranked as the top performer among all ECOWAS countries in term of 'trucking licenses and operation'. The time to obtain a truck license is now very short (less than ten days), but the cost remains high, at over 20% of income per capita[65]. Inefficiencies also persist in term of deficient infrastructure, tight competition, ageing fleets and delays at customs[66], yet CSA implementation represents a substantial opportunity to leverage existing momentum to continue to bring the transportation network toward its full potential.

Policy has enabled Ivorian producer organizations to grow in number and perform well in criteria indices. Reasonable requirements for establishing producer organizations have led to many new organizations. There are now over 1,500, with 52% of cocoa farmers belonging to a cooperative and 32 cocoa cooperatives engaged in international export. Strong dividend sharing among members[67] and the improvements in warehouse receipt systems and banking services have also been strong contributors to their success. However, the Ministry of Agriculture reports that many of the registered organizations are not active. Supporting producer organizations with capacity building in management and transparency could help catalyze further development of producer organizations as platforms for both advisory and financial services in rural areas.

Smallholder access to inputs and financial services have drastically improved in recent years, increasing the potential for CSA expansion. Ivorian farmers have more than tripled their consumption of fertilizers, from 15 kg/ha in 2009 to 50 kg/ha in 2015. While this remains far below the international average, such significant gains in accessibility have presented considerable opportunities for the use of micro-dosing. Farmers are aware of the potential gains in this regard, with 24% willing to borrow money to purchase inputs[68]. At both farm and national scales, poor access to finances is a major hindrance to uptake and scaling of CSA practices. Yet Ivorian smallholders recognize the importance of having financial services; over 75 % of them consider mobile money accounts and insurances as 'important for their agricultural activities'[69]. Therefore, immense benefits could result from expanding access to both financial services and CSA knowledge and practices.

[64] World Bank, 2016

[65] WORLD BANK, 2017

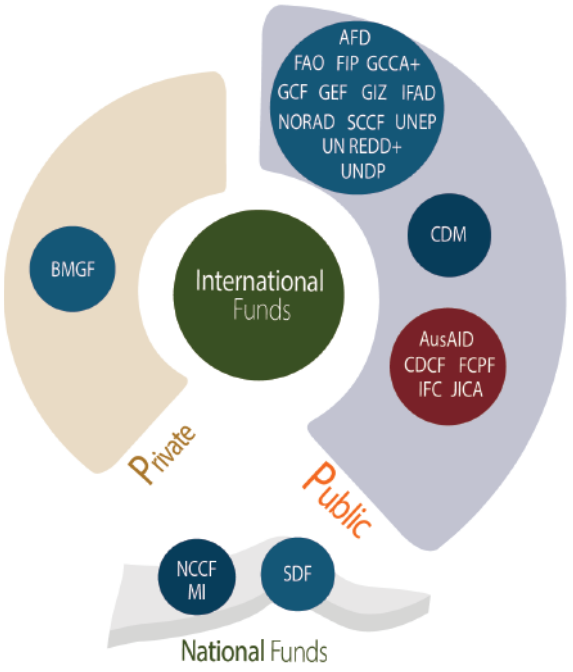
[66] OBG, 2017

[67] WORLD BANK, 2017

[68] CGAP, 2018

[69] CGAP, 2017

Figure 11: CSA financing activities in Côte d'Ivoire[70]



Funds actually accessed by country for CSA purposes
Funds actually accessed by country for purposes other than CSA
Funds not accessed by the country

AFD French Development Agency **AusAID** Australian Agency for International Development **BMGF** Bill and Melinda Gates Foundation **CDCF** Community Development Carbon Fund **CDM** The Netherlands Clean Development Mechanism **FAO** Food and Agriculture Organization of the United Nations **FIP** Forest Investment Program **GCCA+** Global Climate Change Alliance **GCF** Green Climate Fund **GEF** Global Environment Facility **GIZ** German Society for International Cooperation **IFAD** International Fund for Agricultural Development **IFC** International Finance Corporation **JICA** Japan International Cooperation Agency **NORAD** Norwegian Agency for Development and Cooperation **SCCF** Special Climate Change Fund **UNDP** United Nations Development Programme **UNEP** United Nations Environmental Programme **UN REDD** United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation

4-5 Financing Opportunities for CSA Expansion

Côte d'Ivoire is eligible for multiple international finance instruments, although funding for CSA has been limited. Greater effort needs to be placed on accessing international climate finance instruments, while also ensuring availability of local-level public and private financing instruments for investments in CSA. There are many potential private, public and international funders and financing instruments, as shown in figure 11 below and described in annex B-4.

4-6 CSA Investments and Contributions to Supporting National Policies

All investments strongly support two of the three CSA pillars, and many also support national policies and help to overcoming barriers identified in earlier sections (see table 14, on the next page). All investments lead to increased agricultural productivity. As demonstrated in chapter 2, climate change is already affecting production in Côte d'Ivoire, and scenarios show that for many crops, climate change will have significant and negative impacts, especially for crops that are vital for food security. Therefore, all agricultural investments countrywide need to consider climate change and CSA practices, if the investments returns are to be positive and sustainable. All of the investments also contribute to adaptation and enhancing agricultural sector resilience. Although there is less emphasis on supporting mitigation, it is present in half of the crop- and livestock-specific investments.

All CSA Investments directly support many national priorities (cited in table 14 on the next page and annex B). The ways that the different investments support national priorities is quite varied, which is an element to be considered in moving from concept (as presented in this plan) to actual design and implementation. For example, accelerating sustainable private-sector-led

[70] From CSA Côte d'Ivoire.

[71] Country Partnership Framework 2015.

growth is something Côte d'Ivoire is supporting. There are many components of supporting private-sector led growth, including: (i) improving productivity of agriculture/agribusiness value chains; (ii) strengthening economic infrastructure, especially in transport, trade facilitation and energy; (iii) improving the business regulatory framework and access to finance; and (iv) formalizing and enhancing regulatory access to land for business and agriculture[71]. As shown in table 14 on the next page, all of the investments support improving agricultural productivity and/or value chains. Yet many of the investments also support additional elements because of the requirements for production (inputs, credit, etc.), the requirements for infrastructure (e.g., harvest, transport and storage), and the need to improve the regulatory framework (for those crops with export potential). Furthermore, without intervention climate change will lead to declining cacao production, producing adverse consequences. Therefore, investments across a range of commodities—with an emphasis of making them climate-smart—will have positive ripple effects to bring awareness to the private sector. While the example above is focused on the private sector, there are similar benefits extended to other key national policies for Côte d'Ivoire's future development, both for agriculture and climate change.

The four national-scale investments are critical at a foundational level, providing the basic supportive infrastructure for good agricultural decision-making, whether at household, regional or national scales. They provide a strong basis for broader decision-making that is valuable for strategic planning, as well as to the crop and livestock sector investments directly. The four national foundations have the strongest linkages to the private sector (as described above), and also make strong contributions to infrastructure development and to improving the quality of the agriculture extension service. There is also support from some of the national investments to vulnerable populations (e.g., women and youth), enabling policies, access to land and financial services.

All eight priority crop and livestock investments support increasing agricultural productivity, increasing adaptation, private sector growth and expanding extension services. Virtually all also support infrastructure development and expansion of farming networks and organizations. Four of the priority crop and livestock projects address at least two of the following three priorities: financial services, vulnerable populations (e.g., women and youth) and access to land. In moving from concepts to design and implementation, it is possible to undertake actions that maximize the benefits from CSA implementation and to insure that the projects themselves, and the processes associated with how they are implemented, are designed to further support Côte d'Ivoire's desired policy outcomes.

Table 14 Links between CSA investments and national priorities

	CSA 3 PILLARS			PRIORITIES							
	PRODUCTIVITY	ADAPTATION	MITIGATION	PRIVATE SECTOR	INFRASTRUCTURE	FINANCIAL SERV.	ACCESS TO LAND	WOMEN & YOUTH	ENABLING POLICIES	FARMER NETWORKS	EXTENSION EXPANSION
NATIONAL PRIORITY CLIMATE-SMART INVESTMENTS											
Soil fertility											
Agricultural extension system											
Agrometeorological system											
Agricultural finance services											
PRIORITY CROP & LIVESTOCK CSA INVESTMENTS											
Livestock sector in northern CdI											
Sustainable cocoa production											
Irrigated and rain-fed rice											
Yam production and processing											
Cassava production and processing											
Abidjan market vegetable & livestock											
Mango value chain											
Maize development											

Section

5

Key monitoring and evaluation elements for assessing results from Côte d'Ivoire CSA investments

Monitoring and evaluation (M&E) is an essential component of the CSAIP implementation; it lays out the assumptions of how change will occur (theory of change) and provides the evidence and information to implement results-based management (results framework, indicators and M&E systems)[72]. Monitoring and evaluation of the CSAIP will deliver reliable and real-time information in an easily accessible dashboard, allowing the Government of Côte d'Ivoire, development partners and implementing agencies to track progress on activities, outputs, outcomes and impact (box 1) against targets, and also to raise flags when adaptive actions may be necessary[73]. The M&E activities will also create a mechanism for learning lessons, increase accountability and generate information to tell data-driven stories of successes.

Monitoring and evaluation under the CSAIP are paired activities that contribute to collective knowledge of how investments are performing and how the actions are influencing processes of change. Monitoring is the systematic and repeated collection and analysis of data. CSAIP will monitor both processes (i.e., tracking program implementation against work plans and budgets) and results (i.e., tracking indicators of products and changes in behavior)[74]. Complementary to monitoring, evaluation rates the performance of the investments in terms of effectiveness, impact and sustainability. These indicators allow a comprehensive understanding of delivery and value for money. In addition, targeted 'impact evaluations' will be conducted to ascertain the effectiveness of specific interventions, quantitatively describing the factors or chain of events that allowed certain activities to achieve objectives (or not)[75].

[72] International Finance Corporation. 2018. Working with smallholders: A handbook for firms building sustainable supply chains. World Bank Group: Washington, DC, USA. 327 pg.

[73] Lamhauge N, Lanzi ER, Agrawala S. 2012. Monitoring and evaluation for adaptation: Lessons from development co-operation agencies. OECD Environment Working Paper No 38. Paris, France: OECD Publishing

[74] Independent Evaluation Group. 2012. Designing a results framework for achieving results: A how-to guide. World Bank Group: Washington DC, USA. 45 pgs.

[75] Banerjee, A. V. & Duflo, E., 2009. The Experimental Approach to Development Economics. Annual Review of Economics, 1(1), pp.151–178.

Glossary

Outputs: tangible products of project activities including trainings, publications, partnerships, new technologies, policies and infrastructure such as weather stations, etc.
Outcomes: changes in behavior including knowledge, attitudes and skills of stakeholder groups as a result of project activities and outputs.
Impact: high-level objectives identified by stakeholders during the development investment plan (i.e., the project development objective).
Indicators: information used to document current state and changes of activities, outputs, outcomes or impact.
Theory of change: a description and/or diagram of why and how the desired change and objectives are expected to occur.
Impact pathway: built on the theory of change, this visualizes the plausible pathways for change to take place.
Results framework: management tool that is an explicit graphical summary of results expected from particular interventions such as investments, development plans or policies.
Monitoring: continuous/regular data collection to track implementation of budgets and activities (planned vs. achieved).
Evaluation: occasional and in-depth data collection for assessing outcomes and impact and the intervention strategy (e.g., effectiveness).

Monitoring and evaluation of the CSAIP will cross institutions, administrative jurisdictions and scales. The CSAIP targets improvements in agriculture, environment and finance outcomes within other sectors that are currently managed separately by various institutions. With the contribution of CSAIP to multiple agendas, designing the CSAIP M&E system to be interoperable with existing systems is paramount for efficiency and coherence. Furthermore, M&E under the CSAIP will have actions that occur at the individual investment level and for the entire portfolio of investments. This will enable stakeholders at different levels to take evidence-based actions while the system as a whole is internally consistent. This coherence extends beyond CSAIP M&E. Many of the CSAIP objectives are also relevant to national and international targets (e.g., Comprehensive African Agriculture Development Program, Nationally Determined Contributions (NDC) to UNFCCC or the Bonn Challenge to the UNCCD). Therefore, the operations to be put in place for the CSAIP will support national monitoring and reporting needs.

The M&E information will be relevant for government agencies, financial institutions, subnational agencies and communities and other decision-makers. The diversity of types of information and stakeholders using the information will dictate the creation of a CSAIP-specific information management system (IMS). On the back end, the system will contain secure storage for data and data-collection protocols and other documentation. On the front end, accessible through the internet, will be a dashboard to enable easy access to data and information for decision-making. The IMS will be implemented in a flexible way via 'human-centered design'[76] principles, with users of the information at the center of the development process. In this way, the IMS can account for the diversity of information needs and the diversity of actors, local to global.

[76] IDEO. 2015. The field guide to human-centered design. IDEO: Canada.

5-1 Theory of Change

The CSAIP's objective is to sustainably increase agricultural productivity and build resilience of farms, farmers, ranches, landscapes and the food system generally. This goal targets only two pillars of CSA, which typically includes a third (mitigation). The CSAIP emphasizes productivity and resilience because (i) Côte d'Ivoire's agriculture, forest and land use sector has had relatively limited historical and current contribution to the emissions causing global climate change, and (ii) the program is designed to address national food security priorities. This CSAIP, however, will also contribute to climate change mitigation as a co-benefit. Many of the interventions—such as improving livestock diets in the Abidjan Food Basin investment and reducing food waste across the value chains in mango, cacao and other commodity investments—will decrease GHG emissions per unit of product. Furthermore, investments in agroforestry and soil management will accumulate carbon and reduce emissions from farms and landscapes. Therefore, despite targeting resilient productivity, these mitigation co-benefits make this CSAIP contribute to all three CSA goals and to national mitigation commitments made in the NDC.

The portfolio of investment aims to work with diverse beneficiaries across the food system. A significant amount of the effort in the investment is directed toward farmers and livestock keepers. In addition, the CSAIP plans activities that affect the functioning of markets and value chains with the private sector. The program will support government institutions in terms of policy setting and implementation, as well as in research, knowledge development and capacity building. In this way, all the major types of actors in the food system will be engaged by and benefit from the CSAIP.

The CSAIP's objectives of increasing productivity and resilience will be achieved through four primary pathways: increasing incomes, reducing exposure to climate risks, reducing sensitivity and vulnerability to climate risks, and increasing adaptive capacity. This theory emphasizes the importance of both reactive actions (absorb, react, restore and learn) and preventative actions that build robustness while being consistent with a fundamental theory of resilience in social and ecological systems[77].

- **Increasing productivity and incomes.** Increasing on-farm productivity and strengthening market mechanisms (input and output), both existing and new, can have cascading effects through the value chain down to producers, and also have a positive effect on distributors, processors and vendors. Additional incomes lead to accumulation of assets and wealth, both raising persons out of poverty and buffering against natural or social shocks that reinforce poverty traps. Investment in making financial services available will further reinforce the ability to sustain productivity and asset levels. Virtually all of CSAIP's investments name specific management practices and technologies that aim to raise on-farm productivity (e.g., of cocoa, livestock and mango) or make investments along the value chain that increase the amount of food that ultimately reaches the market (such as improving postharvest storage of cassava), help build a more robust food system, and will have influence over wealth of producers and processors.

[77] Walker B, Holling CS, Carpenter SR, and A Kinzig. 2004. Resilience, adaptability and transformability in social-ecological systems. Ecology and Society, 9:5; Tendall DM, Joerin J, Kopainsky B, Edwards P, Shrek A, Le QB, Krueti PK, Grant M, and J Six. 2015. Food system resilience: Defining the concept. Global Food Security, 6:17-23.

- **Reducing exposure to climate hazards[78].** The ability to predict and prepare prior to minor and major weather events can greatly improve the ability of individual farmers, communities and value chains to react. Even simple responses by farmers such as planting at optimal times can have significant impacts on the resilience of production, especially when weather is highly uncertain. This CSAIP reduces exposure by providing information on climate and weather by strengthening the agrometeorological services and through specific investments in rural advisory services using traditional face-to-face training, leveraging social groups and investing in information and communications technologies (ICTs). Such improvements in delivery and dissemination of information have the potential to greatly increase the reach, and more importantly the use, of weather-related information.

- **Reduced sensitivity and vulnerability to climate hazards.** Mitigating or buffering the effects of climate events when they happen is critical to maintaining livelihoods and economic prosperity. Many CSA investments specifically target ways to buffer and absorb shocks and to restore the ability of farms and value chains to rebound from them. One example is the National Soil Fertility Mapping Investment, because improving carbon in the soil increases soil health and fertility, conserves soil moisture and facilitates plant growth during intra-seasonal drought periods[79]. Moreover, the availability of financial services, such as insurance[80], can enable savings that mitigate the impacts of climate shocks on farms and help raise and keep people out of poverty

- **Increasing adaptive capacity.** The ability of farmers and value chains to adjust to shocks as they occur is often a function of the available resources (social, physical and capital) and state of being. The CSAIP investments provide a platform for stronger responses to systemic, climate and other perturbations. This CSAIP aims to strengthen the linkages among providers of information, input and output markets, community groups and others. The increase in social connectivity and access to resources, information and assets serves as a platform to strengthen the entire food and production system. The CSAIP will enable this across all of the investments by strengthening the functioning of institutions and markets; however, investments in financial services, agricultural extension and soil fertility specifically target improved adaptive capacity.

- **Presented above as distinct, the four pathways are in fact expected to influence each other and produce complementary effects.** Complementarities occur when actions directed toward one pathway inadvertently influence another in a positive way[81]. Trade-offs, by contrast, occur when one pathway improves while another degrades. Expected complementarities include (but are not limited to): increasing income and assets can build resilience by providing resources to buffer against or rebound from perturbations (e.g., health concerns or climate shocks); and reducing the sensitivity and vulnerability to such systemic perturbations provides the platform to sustain and grow incomes and wealth.

[78] Hansen J, Helin J, Rosenstock T, Fisher E, Cairns J, Stirling C, Lamanna C, van Etten J, Rose A and B Campbell. 2018. Climate risk management and rural poverty reduction. Agricultural Systems (in press).

[79] Tully K, C Sullivan, R Weil and P Sanchez. 2015. The state of soil degradation in sub-Saharan Africa: Baselines, trajectories and solutions. Sustainability, 7: 6523-6552.

[80] Carter M, de Janvry A, Sadoulet E and A Sarris. Index-based weather insurance for developing countries: A review of the evidence and a set of propositions for up-scaling. Background document for the workshop: "Microfinance products for weather risk management in developing countries: State of the the arts and perspectives." Paris, France.

[81] Duguma L, Minang PA and M van Noordwijk. 2014. Climate change mitigation and adaptation in the land use sector: From complementarity to synergy. Environmental Management, 54: 420-432.

- **The four pathways will be realized through changes in understanding, skills and attitudes of actors throughout the rural landscape, government, private sector and food systems generally.** This includes five primary routes: adoption of new technologies by farmers; use of risk mitigation strategies; strengthening information delivery systems; building an enabling environment including both financial and policies; and engagement of the private sector. Therefore, the CSAIP creates a comprehensive program inclusive of the principal actors in order to catalyze transformative change in the country.

- **The CSAIP M&E system provides a framework to track the implementation of Côte d'Ivoire's NDC, where Côte d'Ivoire targets adaptation and mitigation actions in the agricultural sector.** CSAIPs M&E theory of change and results framework includes impact indicators that are able to quantify the adaptation and mitigation benefits derived from programmatic interventions. The framework, built up on fundamental data characterizing farm, household and value chain activities, will track productivity, resilience, adaptive capacity and greenhouse gas emissions. This approach will allow it to be extended to agricultural interventions outside the CSAIP.

5-2 Results framework and indicators

Investment success will be monitored against activities, outputs and outcomes that will feed into the four pathways to impact derived from the theory of change (see figure 12). This results framework links the twelve investments through six cross-cutting activity areas including (i) finance, (ii) institutions and infrastructure, (iii) on-farm practices, (iv) market functioning, (v) research and knowledge generation and capacity building and (vi) advisory services. Each of the individual investments emphasizes or targets actions within these areas, with an average of four activity areas per investment. Activities funded under the investments will produce countless and diverse types of tangible outputs. Outputs of the activities will be specified only during the next stages of investment development. Types of outputs are already evident in the concept notes (annex F). Individually and together, the outputs form the foundation for the human capacity, physical infrastructure and enabling conditions for change in the country's rural landscape and food system. Within the timeframe of this investment, it can be expected that the outputs will produce changes in behavior: by farmers, such as adoption of CSA technologies and use of climate information and purchase of insurance; by institutions, including though development of new weather forecasting capacities and information and communication technology-based advisory services; by the private sector, through stimulating both new investments by large-scale and small- and medium-sized enterprises in inclusive and resilient business models; and by supporting institutions with harmonized policies; as well as other potential changes. These changes all contribute to the four intermediate impacts and the overall climate-smartness of agriculture and food systems in Côte d'Ivoire. A fifth category of actions will also be monitored: the process of implementation. Process implementation is critical to understand bottlenecks in delivery against the results framework.

Monitoring activities and relevant indicators will be established at the portfolio and individual investment levels. Some indicators will be specifically required to be able to be aggregated to the investment portfolio level, such as number of beneficiaries and budget expenditure. Most often, indicators will be selected for the individual investment according to pre-established criteria: specificity (the indicator needs to be specific); measurability; relevance (there is a clear relationship between the indicator and CSAIP component); usefulness (the indicator captures information that helps move forward the implementation of the CSAIP); feasibility (data can be collected with reasonable and affordable effort); credibility (the indicator has been used and tested previously by other stakeholders); and distinctiveness (the indicator does not measure something already captured

by other indicators). This approach allows portfolio-level indicators to provide a high-level readout on CSAIP performance, whereas individual investment-level indicators can be tailored to specific programmatic goals.

Portfolio-level, cross-investment results will be monitored against a limited number of primary indicators. These indicators will be (i) direct project beneficiaries; (ii) percentage change in productivity of selected agricultural commodities supported by the project; (iii) change in resilience using the Resilience Index Measurement and Analysis (RIMA-II)[82] approach; (iv) percentage change in mitigation using GHG intensity of the investment; and (v) execution of work plan and budget. These indicators will capture the progress toward the three pillars of climate-smartness through the four pathways to CSA in the results framework with internationally recognized indicators.

Selection of individual investment indicators will take place during the full proposal development phase, dependent upon the investments funded. Indicators will track progress on all parts of the results framework above (impact, outcomes, output and activities) as well as the process of implementation (table 12). Indicators will be selected based on expert and stakeholder consultation according to the road map detailed below. A long list of indicators is already available. It includes more than 500 indicators that are already being collected or planned to be collected in at least seven M&E systems in Côte d'Ivoire[83] across the various agricultural and rural development communities, many of which are relevant for CSA. This gives potential opportunities to leverage existing capacities and efforts. Building synergies with existing systems would position this CSAIP to improve long-term sustainability of M&E efforts in Côte d'Ivoire, and contribute to cross-ministry data needs, such as reporting on progress toward the NDC. When necessary, additional indicators will be detailed, consulting existing lists first such as the CCAFS Programming and Indicator Tool[84] to understand what other programs have successfully implemented, and then creating unique indicators when necessary.

Indicators of productivity and climate change mitigation, two of CSA's three pillars, are well established. Yields, profitability, area under specific types of management, GHG emissions and other indicators are all commonly used to describe the state and changes in these outcomes. In many cases, Cote d'Ivoire already collects this information. Thus, the CSAIP M&E strengthens and will be able to build upon existing efforts when possible.

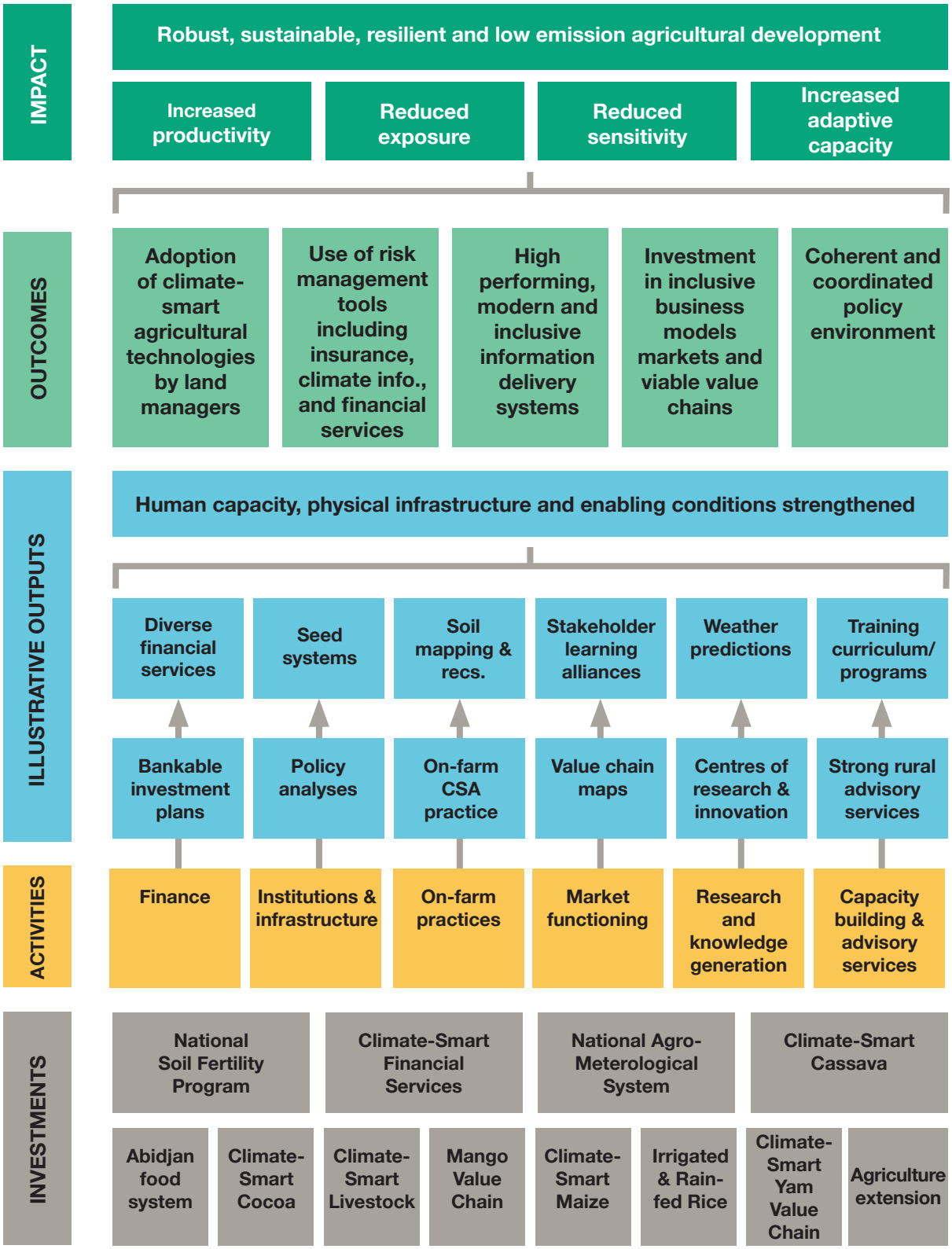
Of the three CSA pillars, resilience is particularly challenging to monitor. Monitoring and evaluation activities under this CSAIP proposes to use the RIMA-II methodology, which groups 18 variables into four categories that reflect different facets of resilience and is a systematic approach for characterizing resilience to food insecurity.

[82] FAO. 2016. Resilience Index Measurement and Analysis-II (RIMA-II). Food and Agriculture Organization of the United Nations: Rome. 80 pgs.

[83] hese include: (i) the Annual Work Plan of the Ministry of Health, Environment and Sustainable Development (2018), which covers outcome, output and activity indicators for the three programs under the ministry (general administration, health, environment and sustainable development); (ii) the Multiannual Public Expenditures Programming Document of the Ministry of Waters and Forests (2018), which highlights objectives, actions and performance indicators for each ministry-led programme (general administration, sustainable management of forest resources and of wildlife resources, and integrated water resource management; (iii) the comprehensive Monitoring and Evaluation Manual (2016) developed by the Ministry of Agriculture and Rural Development to guide the collection of data and analysis of progress towards the implementation of the National Rice Development Strategy (NRDS); (ivv) the National Agricultural Investmen Plan Phase I (2013) and Phase II (2017) M&E frameworks; (vi, vii) the M&E plans under the Regional Programme for the Development of Livestock in coastal areas - Cote d'Ivoire (2016) and the Project for Disease Control of Ruminants in the central region of Cote d'Ivoire (2017) developed by the Ministry of Livestock and Fisheries Resources.

[84] https://ccafs.cgiar.org/csa-programming-and-indicator-tool#.XBa2EBNKjUL

Figure 12 Impact pathway for this CSIP. Twelve investments (those selected for economic analyses in dark green) using six action areas lead to four intermediate outcomes and climate-smart (productive, resilient and low-emission) agriculture



It collects information on five pillars: access to basic services, assets, social safety nets, sensitivity and adaptive capacity. These factors align well with three of the four pathways of impact with the CSAIP and are consistent with best practice for measurement of resilience[85]. Data collected with RIMA-II also aligns with many other indicators commonly associated with resilience, such as the Coping Strategy Index and Food Consumption Score. The RIMA-II approach has the additional benefit that it has been adopted by the African Union for reporting under the AU Scorecard. With use of RIMA-II, this CSAIP will introduce and contribute to Côte d'Ivoire's broader reporting requirements. Furthermore, RIMA-II has an additional benefit: it may become integrated into other investments across Africa, and thus resilience would be measured in a consistent and comparable way. However, RIMA-II focuses solely on households. It does not measure anything related to ecological or institutional resilience.

Table 12 Modified logical framework for monitoring the CSAIP with select indicators for CSA objectives and relevant Investments

RESULTS FRAMEWORK COMPONENT	INDICATOR	MEASURE	CSA OBJECTIVE	RELEVANT INVESTMENT
Cross-Investment (program) indicators				
Beneficiaries	c1.1 Number of beneficiaries (disaggregated by gender and project component)	# of women and # of men beneficiaries	Triple-win	All investments
Increased productivity	c2.1 Productivity of agricultural commodities supported by the project	kg/ha	Productivity	All investments
Improved resilience	c3.1 Farm resilience to food insecurity (Resilience Index Measurement and Analysis (RIMA-II)	Resilience capacity index	Resilience	All investments
Contribution to climate change mitigation	c4.1 Greenhouse gas intensity (per investment)	tCO_{2e}/ normalization factor	Mitigation	All investments
Impact indicators (examples)				
Increased incomes and assets	i1.1 Increased average farm income (disaggregated by crop/livestock activity, gender)	CFA/year	Productivity	Crop and livestock CSA investments
	i1.2 Increased proportion of small and medium enterprises (SMEs) benefiting from funding (by value-chain commodity)	% of SMEs	Productivity	Crop and livestock CSA investments; CSA finance services and products
	i1.3 Increased productivity (by value-chain commodity)	kg/ha	Productivity	Crop and livestock CSA investments
	i1.4 Reduced post-harvest losses (by target value-chain commodity)	kg	Productivity	Crop CSA investments
Reduced exposure to climate risks	i2.1 Improved effectiveness of agrometeorological services and extension systems in reducing exposure to climate risks (perceptions)	Qualitative scale	Resilience, Productivity	National agrometeo. system for CSA
Reduced sensitivity and vulnerability to climate risks	i3.1 Improved coping strategy index*	weighted score	Resilience, Productivity	All investments
	i3.2 Operational federal agricultural disaster fund established	#	Resilience, Productivity	CSA finance services and products
Increased adaptive capacity	i4.1 Improved adaptive capacity index	composite score	Resilience, Productivity	All investments

[85] FSIN. 2014. Resilience Measurement Principles. World Food Program: Rome. 35 pgs

RESULTS FRAMEWORK COMPONENT	INDICATOR	MEASURE	CSA OBJECTIVE	RELEVANT INVESTMENT
Outcome indicators (examples by action area)				
Adoption of climate-smart agricultural (CSA) technologies	o1.1 Increased rate of producers/land managers adopting CSA technologies	% of total producers/land managers	Triple-win	Crop and livestock CSA investments
	o1.2 Increased area under CSA practices and technologies	% of total agricultural land	Triple-win	Crop and livestock CSA investments
	o1.3 Increased rate of producers using integrated soil fertility management (ISFM) strategies	% of total producers	Triple-win	National soil fertility program; Crop CSA investments
	o1.4 Increased territory covered by forests	% of total land in the country	Mitigation	Crop and livestock CSA investments
Use of risk management tools (e.g., insurance, climate, financial service)	o2.1 Targeted beneficiaries' satisfaction with risk management tools available (disaggregated by gender and tool type; referring to timeliness, usefulness and relevance of tool)	Likert scale (very unsatisfied, unsatisfied, neutral, satisfied, very satisfied)	Resilience, Productivity	National CSA investments (soil, finance agrometeorological, extension);
High-performing, modern and inclusive information delivery systems	o3.1 Targeted beneficiaries' satisfaction with information services provided (disaggregated by gender and service type; referring to timeliness, usefulness, relevance and frequency of services)	Likert scale (very unsatisfied, unsatisfied, neutral, satisfied, very satisfied)	Resilience, Productivity	National CSA investments (soil, finance agrometeorological, extension);
	o3.2 Improved capacity of advisory officers to deliver relevant, timely information to farmers (by information type)	qualitative scale	Resilience, Productivity	
	o3.3 Improved capacity of farmers to use information (climate, soil, etc.) in farm decision-making (by information type)	qualitative scale	Resilience, Productivity	
Investment in inclusive business models, markets and viable value chains	o4.1 Increased number and amount of investments in inclusive business models, markets and value chains (by type of investment)	#, amount (CFA)	Triple-win	CSA finance services and products; CSA crop and livestock investments
Coherent and coordinated policy environment	o5.1 Establishment of institutional arrangements bringing together climate information providers, agricultural research and extension, national policymakers, and farmer representatives	# of institutional arrangements	Triple-win	National agrometeo. system for CSA
	o5.2 Increased number and type of policies and plans incorporating climate information and predictions	# of policies, type of policies and plans	Triple-win	National agrometeo. system for CSA
Outputs/results indicators (examples)				
Diverse financial services	r1.1 Number of national CSA financial services systems (FSS) to provide savings, credit and insurance products for agricultural producers seeking to adopt CSA practices and manage climate-related risks	# of CSA FSS in place	Resilience, Productivity	CSA finance services and products
	r1.2 Number and type of financial services available to producers (credit and financing, insurance and risk instruments, savings and payment services)	#, type of financial service	Resilience, Productivity	CSA finance services and products
	r1.3 Number of beneficiaries of available financial services (by service type)	#	Resilience, Productivity	CSA Finance services and products

RESULTS FRAMEWORK COMPONENT	INDICATOR	MEASURE	CSA OBJECTIVE	RELEVANT INVESTMENT
Seed systems	r2.1 Number of new varieties/breeds available on the market (by value-chain commodity)	#	Resilience, Productivity	CSA crop and livestock investments
	r2.2 Proportion of users of new varieties/ breeds (by value-chain commodity)	% of agricultural producers	Resilience, Productivity	
Soil mapping & recommendations	r3.1 Number and type (mobile-based, non-mobile) of soil information services (SIS) developed for rapid and low-cost analysis of soil properties and plant nutrients and for recommending location-based management practices	# of SIS in place	Resilience, Productivity	National soil fertility program
	r3.2 Proportion of producers using soil information services (SIS) for implementing location-based farm management practices (by SIS type: mobile, non-mobile)	% of all agricultural producers	Resilience, Productivity	National soil fertility program
Monitoring systems	r4.1 Coverage of national climate observation network	% of national territory	Resilience, productivity	Remote sensing, national agroclimatic information system, soil services
	r4.2 Number of weather stations installed and maintained	#	Resilience, productivity	
	r4.3 System to integrate historical weather data with new weather data as well as agricultural and phenological data	# of systems	Resilience, productivity	
Stakeholder learning alliances Weather predictions	r4.1 Number of value-chain maps developed (by value-chain commodity)	#	Triple-win	Sustainable cocoa production; climate-smart development of the mango value chain
	r4.2 Number of stakeholder learning alliances set up (by value-chain commodity)	#	Triple-win	
	r4.3 Number or stakeholders by type of learning alliance	#	Triple-win	
Weather predictions	r5.1 Coverage of national climate observation network	% of national territory	Resilience, Productivity	National agrometeo. system for CSA
	r5.2 Number of weather stations installed and maintained	#	Resilience, Productivity	
	r5.3 Number of systems to integrate historical weather data with new weather data as well as agricultural and phenological data	# of systems	Resilience, Productivity	
	r5.4 Number of services available to communicate climate information to farmers (by service type, e.g., mobile (SMS, call) services; radio broadcasting; web-GIS portal; newsletters, etc.)	#	Resilience, Productivity	
	r5.5 Proportion of producers using climate advisory services (disaggregated by gender and service type: mobile, non-mobile)	% of agricultural producers	Resilience, Productivity	
	r5.6 Frequency of access to climate advisory services by producers (disaggregated by gender and service type: mobile, non-mobile)	times/month or times/season	Resilience, Productivity	

RESULTS FRAMEWORK COMPONENT	INDICATOR	MEASURE	CSA OBJECTIVE	RELEVANT INVESTMENT
Training curriculum/ programs	r6.1 Ratio of advisory officers to producers	ratio	Resilience, Productivity	National CSA extension system
	r6.2 Number of trainings and number of farm advisors attaining trainings in cutting-edge CSA aspects	#, type	Resilience, Productivity	National CSA extension system
	r6.3 Number and type of systems available for dissemination of CSA information to producers (field schools, ICT, additional advisory satellite offices, etc.)	#, type	Resilience, Productivity	National CSA extension system
	r6.4 Number of curricula developed and piloted	# of curricula developed # of curricula piloted	Resilience, Productivity	National CSA extension system
	r6.5 Frequency of access to CSA information by producers (disaggregated by gender)	times/month or times/season	Resilience, Productivity	National CSA extension system
M&E Process indicators				
Organizational structure	p1.1 Number of investments and projects approved for implementation	#	-	All investments
	p1.2 Number of units/ divisions with M&E responsibilities in place	#		All investments
	p1.3 Number of M&E frameworks developed (for each investment area and project)	#	-	All investments
Human and technical capacity	p2.1 Number of staff carrying out work related to M&E of CSAIP	#	-	All investments
	p2.2 Level of human capacity to carry out M&E activities (design work plan, carry out routine monitoring, compile and manage databases, disseminate information)	Qualitative scale	-	All investments
	p2.3 Level of technical capacity to carry out M&E activities (design work plan, carry out routine monitoring, compile and manage databases, disseminate information)	Qualitative scale	-	All investments
Budget execution rate	p3.1 Total budget allocated for M&E of CSAIP	CFA	-	All investments
	p3.1 Percentage of M&E budget spent on M&E activities	% out of total M&E budget	-	All investments

Additional indicators such as soil carbon (Mg/ha), tree cover (%) and perceptions of institutional capacity may be used to complement the RIMA-II for quantification of resilience.

The M&E information will be relevant for government agencies, financial institutions, subnational agencies and communities and other decision-makers. The diversity of types of information and stakeholders using the information will dictate the creation of a CSAIP-specific information management system (IMS). On the back end, the system will contain secure storage for data and data-collection protocols and other documentation. On the front end, accessible through the internet, will be a dashboard to enable easy access to data and information for decision-making. The IMS will be implemented in a flexible way via 'human-centered design'[86] principles, with users of the information at the center of the development process. In this way, the IMS can account for the diversity of information needs and the diversity of actors, local to global.

The CSAIP M&E system will be consistent with the M&E systems used under the National Development Plan (NDP) and National Agricultural Investment Plan 2017-2025 (NAIP2). Proposed outcome areas of the CSAIP align with the effect areas described in the two policies. Outcome in the CSAIP are targeted to specific issues that map under the wider agricultural outcomes in the existing programs. The NDP and NAIP2 and outcome areas are supported by at least one of the five outcome areas of the CSAIP. It is not possible to map outputs/products between the two policies and the CSAIP because the components of the CSAIP are only concepts at this time. However, based on the activities and component areas described already, it is reasonable to envisage that much, if not all, of the CSAIP outputs will contribute to the products targeted by these other policies.

[86] IDEO. 2015. The field guide to human-centered design. IDEO: Canada

Table 13 Coherence among National Development Program, National Agricultural Investment Plan and Climate-Smart Agriculture Investment Plan Outcomes. Outputs shaded grey are included in 12 concept notes of the CSAIP. Adapted from Ministrere de l'Agriculture (2013)

NATIONAL DEVELOPMENT PROGRAM		NATIONAL AGRICULTURAL INVESTMENT PLAN		CLIMATE-SMART AGRICULTURE INVESTMENT PLAN
Outcome	Outputs	Effects	Products	Outcomes
OUTCOME 1: The governance of the agricultural sector is improved	E11: The legal and regulatory framework is reinforced	OUTCOME 3: Sector governance is strengthened to ensure that the effectiveness of actions the State and other agricultural sector	P1: The legal and regulatory framework of the agricultural sector is reinforced	OUTCOME 5: Coherent and coordinated policy environment & OUTCOME 4: Investment in inclusive business models, markets and viable value chains
	E13: The institutional environment of the farming professions is improved		P3: The promotion of the professions of farmer and fisher is ensured	
	E14: Laws governing rural lands are being implemented		P4: Laws governing rural lands are being implemented	
	E15: A funding mechanism in the agricultural sector is implemented		P5: A sustainable and appropriate financing mechanism in the agricultural sector is implemented	
OUTCOME 2: The capacities of the stakeholders involved in the development of agriculture and of resources animal and fisheries are reinforced	E21: Agricultural sector sectors are structured and production	OUTCOME 4: The capacities of all agricultural development actors to achieve the objectives of expected growth are reinforced	P1: Agricultural sector sectors are structured and production capacities are strengthened	OUTCOME 3: High performing, modern and inclusive information delivery system & OUTCOME 1: Adoption of climate-smart agricultural technologies by land managers & OUTCOME 2: Use of risk management tools including insurance, climate information and financial services
	E22: Agricultural statistics and decision support information systems are reinforced		P2: Agricultural statistics and decision-making information systems are strengthened	
	E23: Technical capabilities of servicesin charge of planning, programming, and monitoring and evaluation of the agricultural sector are strengthened		P3: Human and institutional capacities of agricultural planning and monitoring and evaluation services are strengthened	
	E24: Vocational training and agricultural technical education are reinforced		P4: Vocational training and agricultural technical education are strengthened	
			P5: The capacities of the Ivorian administration are being strengthened	

NATIONAL DEVELOPMENT PROGRAM		NATIONAL AGRICULTURAL INVESTMENT PLAN		CLIMATE-SMART AGRICULTURE INVESTMENT PLAN
Outcome	Outputs	Effects	Products	Outcomes
Outcome 3: The agricultural, animal and fisheries sectors are developed	E31: The business environment of the crop sector is strengthened	EFFECT 2: Sectors for which Côte d'Ivoire has a comparative advantage are developed	P1: The land and legal frameworks of the agricultural sector is strengthened	OUTCOME 1: Adoption of climate-smart agricultural technologies by land managers
	E32: Increased production of export products		P2: The potential of export products is enhanced	
	E33: Crop production is increased		P3: Crop and animal food production and fisheries are being revitalized	
			P4: The processing and storage of agricultural, animal and fisheries production are advanced	
Outcome 4: The competitiveness of Ivorian agriculture and its ability to remunerate producers sufficiently are reinforced	E41: The accessibility and use of agricultural inputs has improved	EFFECT 1: The competitiveness of Ivorian agriculture and its ability to adequately remunerate producers while ensuring food security is strengthened	P1: Accessibility and use of inputs and veterinary services are improved	OUTCOME 4: Investment in inclusive business models, markets and viable value chains & OUTCOME 2: Use of risk management tools including insurance, climate information and financial services & OUTCOME 1: Adoption of climate-smart technologies by land managers
	E42: The promotion of mechanization of farms and small agricultural production processing units is ensured		P2: Promoting the mechanization of farms and small processing units of agricultural production is ensured	
	E43: Agricultural advisory services, research/ development and training are strengthened		P3: Agricultural advisory services, research services, development and training are strengthened	
	E44: Improved water management is ensured		P4: The promotion of water control is ensured	
	E45: Increased sustainable land management		P5: Land management is sustainable	

5-3 A road map for M&E

Additional information is needed to define the components of the M&E system, establish the roles and responsibilities of participating institutions (i.e., institutional arrangements), create the tools for implementation, establish data management protocols, and refine logistics. A recent multicountry analysis recommends 11 activities to elaborate the M&E (figure 13; Rosenstock, et al., 2018). These actions help define the space for the M&E system and ensure long-term sustainability. Here the suggested activities are formed into a road map to create and implement the CSAIP M&E system.

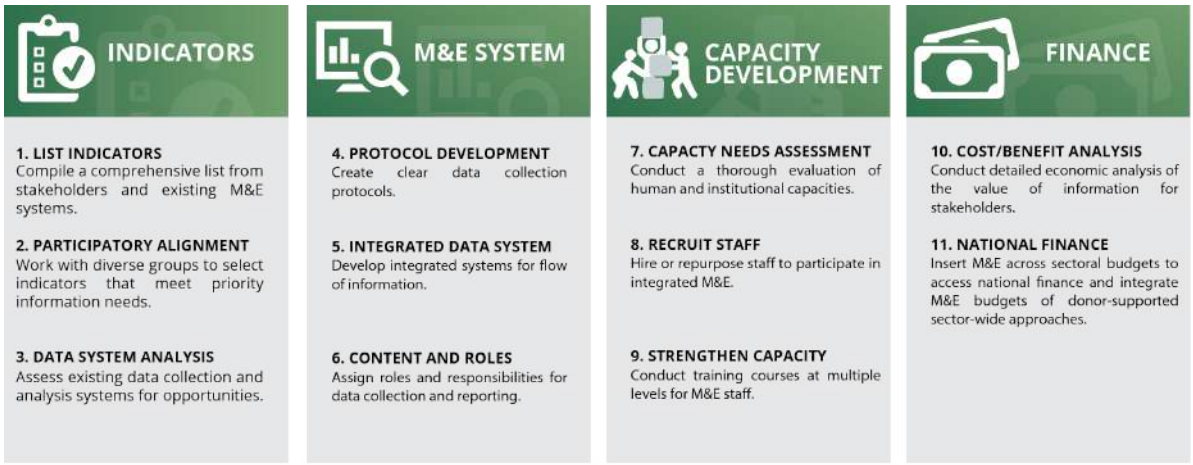
The list of indicators in table 13 shows a first appraisal of potential opportunities for Côte d'Ivoire based on current levels of elaboration in the concept notes. The next steps require that the list of indicators be refined and aligned according to the needs of users of the information. This needs to take place in a participatory way using both one-on-one interviews with key informants and workshops with government, donors and implementation partners such as local government authorities and persons expected to collect, compile and analyze the information. As part of the assessment, a detailed analysis of existing data systems, describing the implementation arrangements and information flows (workflows, permissions, etc.), will be outlined.

The results of the assessment, describing user needs, indicators and existing systems, provide the input to elaborate the CSAIP M&E systems, which will be formalized in an M&E manual. The manual will describe the who, what, how and when of data collection, analysis and reporting. By and large, it is expected that M&E activities will be conducted by staff working on/with CSAIP implementation and implementers including extension agents, local government agencies, staff and others, with operation being overseen by an M&E coordinator. External evaluators will be engaged for auditing and to conduct specific evaluations such as impact evaluations. The CSAIP will use a set of M&E approaches (farm trials, surveys, qualitative assessments) that mix repeated measurements of progress and specific impact evaluations using experimental and quasi-experimental approaches on key questions. Monitoring for both types will be based on initial baselines set by household surveys, field sampling and earth observation with remote sensing, depending on the indicator and user need. This baseline, which will be differentiated based on stakeholder group, will characterize the initial state of households, farms, landscapes and value-chain actors and provide an understanding of local perceptions of current systems, services and tools for improved productivity and resilience. The process to carry out the M&E activities will need to be formalized into data collection templates and then codified into the M&E online database system, both of which will need to be designed, iteratively field tested, validated by investment partners and revised when needed. The capacity assessment will also identify gaps, including where it will be necessary to recruit CSAIP-specific M&E staff and when it will be possible to simply strengthen capacities of existing personnel.

The manual describes the structure of the M&E system, and specific actions are needed to move into practice. First, an initial capacity assessment will be carried out with CSAIP staff (including extension agents, local government agencies, etc.) to understand existing capacities to track and report on planned outcomes, outputs and aligned indicators. This will help ensure a results-based reporting approach throughout the CSAIP implementation period. The capacity assessment will explore: (i) organizational structures (existing or potential specialized M&E units, M&E work plans and guidelines formulated for each investment, etc.); (ii) technical and human capacities (full-time staff available to carry out M&E functions, clear M&E responsibilities and division of labor, M&E knowledge and competencies, etc.); (iii) financial resources available for preparatory activities, data collection and management, data quality control and reporting; and challenges and weaknesses regarding

M&E capacity. Findings from the M&E capacity assessment survey tool will guide and strengthen the implementation, monitoring and evaluation of CSAIP activities, expected results and impacts. With improved capacity, CSAIP participants will be ready to implement M&E. Assessment activities will guide subsequent capacity building efforts in monitoring and evaluation and beyond for the relevant ministries and implementing partners.

Figure 13: Eleven steps to create a coherent CSA M&E system based on finding from a country-centric assessment of needs, systems and opportunities



Though the funds for establishment of CSAIP M&E activities (assessments, capacity strengthening, data systems, data collection, etc.) will be derived from the CSAIP budget, CSAIP M&E will track and analyze costs and benefits of improved M&E to build the case for investment in such activities beyond the scope of the program. Governments and development partners require information on activities and effectiveness. Nearly all institutions track key performance indicators of various types and use these values to allocate effort. Given that the indicators for the CSAIP intersect with other institutional needs such as budget allocations to agriculture, GHG emissions of the agriculture, land use and forestry sector, etc., it is envisaged that the CSAIP M&E will play a catalytic role in strengthening the use of data in decision-making. Specific analyses that investigate the value of the information for identifying effective programming and reducing the data collection burden will be embedded in the M&E systems.

Conclusion

The CSAIP provides direction for M&E activities, but additional time and actions are needed to detail the M&E systems and approaches that will be used. This is in part due to the lack of clarity regarding which investments will be funded. Once these decisions are made, subsequent activities—including assessing complementary systems, indicators, capacities and implementation arrangements; detailing a manual of who, how and when; strengthening capacity; and making the financial case for M&E—will help build long-term sustainability of the investments in M&E under the CSAIP, contributing to improved value for money and ultimately the efficiency and efficacy of the CSAIP.

It should be noted that the CSAIP M&E system will serve purposes beyond CSA. The systems including indicators, roles and responsibilities and IMS will align with other programs and policies such as the NDP, NAIP2 and NDC. In this way, the investments in M&E will build the institutional and human capacity for using data for decisions and helping the Government of Côte d'Ivoire tell robust and evidence-based stories of change with the CSAIP.

Annex A: Climate Smart Agriculture Investment Plan Methodology

Article 2

Agriculture for Development, **30** (2017)

'CSA-Plan': strategies to put Climate-Smart Agriculture (CSA) into practice

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Abstract

Large-scale investment is needed to create climate-smart agriculture (CSA) systems. While many government and development agencies are integrating CSA into their policies, programmes, plans and projects, there is little guidance for operational planning and implementation on ways to be climate-smart. Here we present 'CSA-Plan'. CSA-Plan frames actions needed to design and execute CSA programmes into four components – (i) situation analysis, (ii) targeting and prioritising, (iii) programme design, and (iv) monitoring and evaluation. Each component yields concrete information to operationalise CSA development, separating it from traditional agriculture development. Already, CSA-Plan has shown the capacity to change the discussion around CSA implementation. With iterative co-development, the approaches will become ever more useful, relevant and legitimate to governments, civil society and the private sector alike.

Introduction

Climate-smart agriculture (CSA) is an approach to agriculture that promotes three objectives: sustainably increasing productivity; building the resilience of farming systems; and reducing greenhouse gas emissions, where possible (FAO, 2013). CSA does not prescribe interventions: instead, climate risks are addressed through tackling trade-offs and synergies between the three objectives (Rosenstock *et al,* 2016). This then separates CSA from other approaches to agricultural development that either specify practices or technologies, such as conservation agriculture or agroforestry. Thus, CSA requires identifying what is climate-smart for the biophysical, agricultural, and socio-economic context of a given place.

Major development investors are rallying behind CSA, with large investments being planned or made by the international financial institutions and aid organisations, including the *Green Climate Fund*, the International Fund for Agricultural Development (IFAD), and international aid agencies such as the United Kingdom Department for International Development (DFID) and the United States Agency for International Development (USAID). National governments and their development partners are looking to move forward with large-scale CSA implementation. The private sector is also recognising the importance of making their supply and value chains climate-smart, as evidenced by the engagement of the World Business Council for Sustainable Development in

CSA. New multi-sector CSA partnerships have formed, such as the Global Alliance for Climate Smart Agriculture (GACSA) and seven regional/national alliances, with goals of sharing knowledge, supporting investments, and scaling-up implementation.

Putting CSA into practice requires knowing what is climate-smart in different locations and designing projects to fit the context for implementation. What works for one type of farmer may not work for another (*eg* related to labour availability), and a CSA practice with desirable outcomes in one location does not necessarily deliver desirable outcomes under all agro-ecological conditions. There are often trade-offs amongst the three goals of CSA – sustainable productivity, resilience, and mitigation – so stakeholder priorities are important to consider when selecting which CSA practice to implement. There is a need for assessing value-for-money, climate-smartness, development impact, and scaling potential to establish effective CSA programmes. One major problem is that decision-makers do not have frameworks in place that link science and stakeholder engagement to plan, implement, and monitor CSA to achieve impact at the scale needed.

This paper presents an operational guide for putting CSA programming into practice – 'CSA-Plan' – which contains four main components for CSA planning and implementation (Figure 1): (i) situation analysis; (ii) prioritising interventions; (iii) programme design and implementation; and (iv) monitoring, evaluation, and learning. A suite of approaches are available for each component, and can be used to answer specific challenges that obstruct planning and progress. The components of CSA-Plan can be implemented sequentially or by themselves depending on stakeholder needs. Underlying CSA-Plan is a suite of CSA indicators to provide an evidence base to the decision-making, implementation, and monitoring components. Moreover, given the participatory nature of the approaches, capacity strengthening is critical for success and broad use.

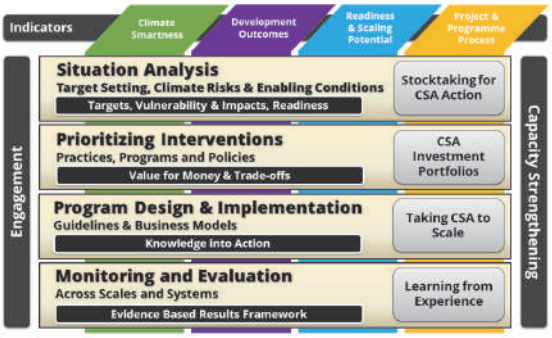

Figure 1. CSA-Plan Framework includes Situation Analysis, Prioritising Interventions, Programme Design and Implementation; Monitoring and Evaluation. Different types of Indicators are important to utilise across the CSA-Plan components to measure climate-smartness, development outcomes, readiness and scaling potential, and project/programme process. Engagement and capacity strengthening are needed for application of the CSA-Plan information and approaches within the context of agricultural development.

Situation Analysis

Before any decisions can be made on CSA programmes, policies, and initiatives, a fundamental understanding is needed of the context where they will be implemented. This includes not only information on the farming activities, but on stakeholders' goals, constraints, livelihood strategies, *etc*. A CSA situation analysis should provide information on the climate risks and impacts, but more widely the agricultural, political, social, and economic conditions for which CSA actions are being taken. The situation analysis specifically identifies the entry points for CSA actions by looking at: (i) the importance of agriculture in society; (ii) risks and vulnerabilities of the agricultural sector; (iii) existing and promising CSA practices and services; (iv) institutional and policy environment related to CSA – both barriers and enabling; and (v) finance opportunities and challenges for CSA initiatives. An engagement plan is needed to ensure key stakeholders are part of the process from the beginning, and that it is inclusive. At this stage, a long list of current and promising CSA practices and services relevant to specific agricultural systems and agro-ecological conditions can be identified for further analysis. Identification of finance mechanisms and institutional and policy entry points demonstrates current alignment with public and private sector policies and investment plans with CSA. A range of different specific CSA approaches that have been/can be used for situation analysis include the International Centre for Tropical Agriculture (CIAT)/CCAFS *CSA Profiles*, which summarise the CSA context at national or sub-national levels (World Bank & CIAT, 2015) and FAO's *scoping studies for CSA East Africa* (FAO, 2015), among many others. The commonality being that they provide a foundation for CSA actions that can address climate risks, engage stakeholders, and enable further analyses and planning (Figure 2).

Figure 2. National stakeholder workshop in Nairobi on responding to climate shocks at community level. New climate-smart profiles offer Kenya a roadmap to implement climate-smart agriculture at country level. (Photo: Georgina Smit (CIAT))

Targeting and prioritising to identify CSA investment portfolios

A range of technological, institutional, and policy options for climate-smart interventions exist that have varying impacts on the CSA goals and economic costs and benefits. CSA-Plan's targeting and prioritising component builds on this premise by using advanced analytical techniques, nested within participatory processes, to narrow down an extensive list of

possible practices, services, and policies to a range of best-fit options that provide value for money and can be scaled-out. The outcome of this step is a stakeholder-selected and evidence-based portfolio of high-interest CSA options.

CSA-Plan puts forward a general prioritisation approach based on the CIAT/CCAFS *CSA Prioritisation Framework* (Campbell *et al,* 2016; Sain *et al,* 2016; Corner-Dolloff *et al,* 2017). Stakeholders first assess the context for the CSA intervention in question and set criteria for prioritisation. This includes a set of specific measurable indicators under each of the three CSA goals. A long list of potential CSA interventions – practices, services, and policies – is then established to provide a starting point for prioritisation. Next, through stakeholder and expert interrogation of indicator analyses of the potential outcomes of CSA interventions, the long list is narrowed down to a short list of high interest interventions for further analysis. Then, the selected practices are evaluated for their economic costs and benefits, implications for gender and social inclusiveness, adaptability, and scalability. And finally, through stakeholder and expert input, ensuring inclusivity, investment portfolios are developed either for different farmer types, different implementers, or different scales, aiming to maximise or minimise specific synergies and tradeoffs across the portfolio.

A range of specific CSA prioritisation tools and approaches have been developed that can be used (Shikuku *et al,* 2017; Mwongera *et al*, 2017; Notenbaert *et al*, 2017). Different tools and processes can be used for different types of stakeholders and levels of decision-making (*eg* national *vs* community), allowing implementers to tailor their prioritisation approach and successfully engage target stakeholders.

Programme design and implementation

Programme design and implementation supports taking prioritised CSA actions to scale. It provides specific information that underlies the implementation of the interventions selected. It is important to have a 'theory of change' for how the intervention will lead to positive impact; a common pitfall is to simply come up with a list of interventions rather than strategically designed interventions that can be scaled-up to many beneficiaries. The diversity of products, users, and implementation conditions dictates equally diverse approaches and models. Principles of co-design can be useful to innovate in product design, iterate with end-users to field test, refine and improve materials, and share products on learning platforms to facilitate access by others.

There are a range of approaches and tools to use for programme design and implementation, including climate-smart value chain models, outgrower models, extension, farmer field schools, early-warning systems, financial mechanisms, weather-based insurance, and technical guides for technology implementation, among others. For example, the *Link 2.0 methodology* (Lundy *et al,* 2014) is one such approach that has been used for designing innovative and inclusive climate-smart value chain business models. Financial savings approaches, such as village savings and loan associations (Allen & Staehle, 2007), provide simple savings and loan facilities in a community that can provide a mechanism for facilitating uptake of CSA interventions. Innovative agricultural business models, such as outgrower or contract farming schemes, can be a mechanism for scaling of CSA interventions, such as has occurred in Kenyan tea outgrower schemes (Milder *et al,* 2015). Climate services, warning systems, and agro-advisory services provide means for providing timely and site-specific information to farmers to help them respond to weather and climate (Hewitt *et al,* 2012). Technical guides and manuals for implementation are needed for guiding development projects in how to implement interventions on the ground under different conditions (Rioux *et al,* 2016). Climate risk can be offset using weather-based index insurance products for crops and livestock (Miranda & Mulangu, 2016). Depending on the social, environmental and economic context of the location, different programme models and tools will be useful or not. All in all, programme design is a wide area of work focused on engaging stakeholders in designing interventions that work for them.

Monitoring, evaluation, and learning

CSA-Plan's monitoring, evaluation, and learning (ME&L) component develops strategies and tools to track progress of implementation, evaluate impact, as well as facilitate iterative learning to improve CSA planning and implementation. CSA-Plan's ME&L delivers processes and products to support achieving and documenting programme goals and adaptively managing implementation. However, there are many challenges in measuring CSA. It has multi-objective complexity, given the multiple goals of CSA. The scale of impact can range from the farm to the national or international level. There are often multiple institutions involved in ME&L, each of whom might bring their own priorities and approaches.

The CSA-Plan approach considers various aspects of ME&L to address these challenges. The programme and stakeholder priorities are used to determine specifically what the ME&L is addressing. Then specific indicators must be selected and linked to priority outcomes using tools such as the *CSA Indicators Database* (Quinney *et al,* 2016). There are *CSA outcome indicators* needed to measure medium/long-term impact on the three CSA objectives – sustainable productivity, adaptation/resilience, and greenhouse gas mitigation. There are indicators related to *broader development outcomes* (*eg* Sustainable Development Goals), such as incomes, nutrition, markets, *etc*. There are *readiness and scaling potential indicators* reflecting the capacity to plan, implement and monitor investments and activities related to CSA implementation that help measure the ability for the intervention to be scaled-up. Finally, there are *project and programme process indicators* to monitor programmes for meeting implementation process objectives. It is important to note that even though indicators clearly are important for the ME&L, these indicator sets are important across the different components of CSA-Plan.

Specific tools and instruments have been developed for monitoring sets of indicators. The CGIAR-CCAFS *Monitoring Instrument for Resilience* can be used for tracking changes in resilience in agricultural projects and programmes (Hills *et al,* 2015). Operationalising the concept of resilience (*ie* the ability

to withstand change, stresses and shocks) is a challenge, and this tool demands tracking and reporting changes efficiently and using the information commonly available within development initiatives. Similarly, the *Toolkit for the indicators of resilience in socio-ecological production landscapes and seascapes* provides practical guidance for engaging local communities in adaptive management and can increase their capacity to respond to pressures and shocks. Monitoring CSA can also be done in a holistic, multi-objective way. For example, the *Rural Household Multi-Indicator Survey (RHoMIS)* provides a rapid and cost-effective instrument to track changes in poverty, gender equity, nutrition, climate and productivity outcomes – all measures of climate-smartness (van Wijk *et al,* 2016). *RHoMIS* is modular, so implementers can select or add indicators which fit their context and needs, and has been used in Africa, Latin America and Asia. Specific attention should be paid to gender, a critical cross-cutting part of CSA, and monitoring can also be done using approaches such as the *Woman's Empowerment in Agriculture Index* (Johnson & Diego-Rosell, 2015).

Engagement and capacity strengthening

Engagement and capacity strengthening are critical to help governments and others implementing agricultural development to integrate CSA into their policies, programmes, plans and projects (*eg* National Agriculture Investment Plans, Nationally Determined Contributions, and Climate Change Action Plans). CSA-Plan provides operational approaches that can be directly integrated into the planning processes, but the CSA-Plan process must be owned by the stakeholders and decision-makers involved.

Capacity strengthening is also critical for mainstreaming CSA, and the CSA-Plan approach, in institutions, policies and businesses across levels (community to national to global). This can be accomplished by working through the National Agriculture Research Systems (NARS), through academia, government, NGO, or the private sector. There are various alliances forming to provide formal engagement, knowledge, and training, for example GACSA and the Africa CSA Alliance. The bottom line is that without good engagement and capacity strengthening, CSA-Plan lacks purpose.

Conclusions

With the growing demand by governments, NGOs, and the private sector for integrating climate into agricultural development, there are many opportunities for CSA-Plan components to be applied from regional to sub-national levels. The CSA-Plan components – situation analysis, prioritising interventions, programme design and implementation, and monitoring, evaluation, and learning – have already been applied in many countries with partners including the World Bank, USAID and DFID, among others. For example, climate risk profiles are being developed for 24 Kenyan counties to provide technical support to the US$ 250 million *World Bank Kenya CSA Project*. Prioritisation of CSA intervention areas is then being developed within counties, and specific interventions being designed and implemented within the county Common Interest Groups and Public-Private Partnerships developing innovative implementation plans.

Responding to the needs of the stakeholders and decision-makers is critically important if evidence is to be translated into policies and programmes, but this is also a challenge to accomplish. Each set of stakeholders requires slightly different information and processes. For this reason, the CSA-Plan components are not static, but rather CSA-Plan provides a range of information, tools, and approaches that can be modified to address the needs of the specific stakeholders, with new tools and approaches added as they become available. Capacity strengthening of key institutions is also needed as evidence presented is only helpful if decision-makers are able to use it. Training manuals and workshops are useful starting points for capacity building interventions. Given that famers and others at the local level are the ones actually taking decisions, there is a need for information, tools and approaches to be accessible across levels to operationalise mainstreaming of CSA into both on-farm business planning and larger-scale investments aimed at catalysing action. While the number of examples is growing, there is great opportunity for increased uptake of the CSA-Plan approach by governments, NGOs, and the private sector to mainstream CSA into agricultural development globally.

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News from the Field

Climate information use implications for climate risk mitigation in West Africa

The necessity for climate information services in West Africa

With projections of a 70 percent increase in demand for staple cereals by 2050 in order to feed the growing human population (FAO, 2010), combined with the current declining per capita food production and a dwindling natural resource base, 'feeding West Africa' and increasing the resilience of livelihood systems may be well beyond reach. This has been attributed to multiple factors such as land tenure challenges, declining soil fertility, poor markets, climate hazards and variability, inadequate funding and poor infrastructural development (Ouedraogo *et al*, 2016; Partey *et al*, 2016). The current state of food insecurity and poor rural livelihoods are expected to be further exacerbated by climate change and variability which has emerged as one of the major threats to development in West Africa (Zougmoré *et al*, 2016).

While the Paris Agreement places great emphasis on reducing greenhouse gas emissions and creating carbon sinks, the impact on climate change mitigation will not be seen immediately even if the most effective mitigation measures are implemented.

As vulnerable farmers in West Africa experience greater climate variability (Cooper *et al*, 2008) it is important that climate-smart agricultural (CSA) technologies that reduce vulnerability to climate risks are prioritised. The establishment of the *Global Framework for Climate Services* (WMO, 2013) by the World Meteorological Organisation (WMO) clearly confirms climate information services (CIS) as one opportunity for managing climate change and variability risks. With increased drought, unpredictable rainfall patterns, destructive flooding and the growing evidence of climate change negatively impacting farm production systems, access and use of climate information should help farmers make crucial decisions that enable them

Annex B: Situation analysis: Policy and programmatic context for CSAIP Côte d'Ivoire

A supportive policy context and the existing enabling conditions are a critical component of the situation analysis for CSA investments. This section briefly highlights:

B-1 International and Regional Commitments, Frameworks, and Plans
B-2 National Policies and Plans
B-3 Other Legal Frameworks
B-4 Potential Financing Mechanisms for CSAIP in Côte d'Ivoire

B-1 International and Regional Commitments, Frameworks, and Plans

- UN Framework Convention on Climate Change (UNFCCC)
- ECOWAS Regional Agricultural Policy of West Africa (ECOWAP) ECOWAP + 10
- 2014 Malabo Declaration on the Transformation of Agriculture
- Sustainable Development Goals (SDGs)
- Comprehensive Africa Agriculture Development Program (CAADP)
- West Africa Agricultural Productivity Program (WAAPP): objective is to increase productivity in West Africa's major agricultural sectors, aligned with national and regional priorities.

B-2 National Policies and Plans

National Development Plan (NDP) 2016–2020 of Côte d'Ivoire. This provides the overarching context for how the government is working to make Côte d'Ivoire an emerging economy. Côte d'Ivoire has a tradition of strong planning efforts to stimulate and coordinate its many development facets. The NDP aims to create a close link between agriculture, agribusiness and industry to support this emergence. The 2016–2020 NDP anticipated and took into account sub-regional, regional and international initiatives that influence Côte d'Ivoire's strategic choices and the orientation of its economic policy. These initiatives concern: (i) the post-2015 development agenda; (ii) Agenda 2063; (iii) the common position of Africa; (iv) the action plan of the African Union; (v) the 2020 vision of ECOWAS; and (vi) the WAEMU Regional Economic Program.

Country Partnership Framework (CPF), approved in 2015, shows how the World Bank Group supports national plans for FY16–FY19, through lending and investments ($1 billion each from the World Bank and IFC) to create a competitive, equitable and inclusive economy. The CPF's two main goals are: (i)

creating better-quality jobs, especially in agriculture and agribusiness, through sustainable growth led by the private sector; and (ii) building human capital to generate inclusive growth and improve social expenditures to enhance access to basic services.

National Agricultural Investment Program (NAIP II)[88] provides a coherent framework for programming public and private investment in the sector for the next eight years (2017–2025). It covers the sub-sectors of agriculture, livestock, fisheries, aquaculture and environmental management. Its overall objective is to stimulate sectoral growth to reduce poverty by half, and to reach zero hunger by 2025. The NAIP II was formulated under the aegis of a technical secretariat composed of the planning directorates of the four ministries directly involved in the agro-silvopastoral and fisheries sector (MINADER, MIRAH, MINEF and MINSEDD). The NAIP II is aligned with its regional and international commitments. For example, for agricultural sector climate mitigation, the main measures are (i) to articulate national planning and rural spatial planning to develop agriculture and the forestry sector; (ii) to promote agricultural development without extension on the remaining forest areas and less emitting GHGs (agriculture zero deforestation); (iii) to promote intensification of environmentally sound agricultural, livestock and fisheries production to prevent deforestation; (iv) to promote sustainable and integrated practices to improve agricultural production capacities and enhance the resources of the environment; (v) to support forest sector development through sustainable forest management and improvement of forest governance; and (vi) to help develop sustainable domestic energy solutions for the cooking needs of populations. For adaptation, five sectors are prioritized: (i) water resources, (ii) agriculture, livestock and fisheries, (iii) forest and land use, (iv) coastal area and (v) energy. For the agriculture, livestock and fisheries sector, the main objective is to reduce vulnerability and increase resilience through the development of the agro-ecological approach, the improvement of technologies through access to improved and adapted inputs, the development of storage and conservation units to limit high post-harvest losses, the development of seasonal forecasts that strengthen the resilience to climate change of farming practices, etc. CSA is mentioned in the reference section within the adaptation subsection.

B-3 Other Legal Frameworks

National Program for Climate Change (PNCC) 2015–2020 was adopted at the end of 2014, integrating the five pillars initially defined in Bali during the UNFCCC COP13 in 2007: shared vision, adaptation, mitigation, technology transfer and funding. To meet these commitments to addressing climate change in Côte d'Ivoire, the Ministry of the Environment, Urban Sanitation and Sustainable Development (MINESUDD) initiated the National Program for the Mitigation of Greenhouse Gas Effect and Adaptation to Climate Change (PNCC) to coordinate, propose and promote measures and strategies for combating climate change. This program aims to be national and cross-cutting, with a scientific committee of reflection and orientation that ensures the participation of all national stakeholders. Specifically, the National Climate Change Strategy highlights the need to address seven strategic axes:

- Promote the integration of climate change into sectoral policies and strategies and into development planning, and strengthen the institutional and legal framework;
- Improve national knowledge about climate change and strengthen the technical and human capacities of the National Climate Change Program;
- Promote measures to mitigate the effects of climate change in all sectors (REDD+, CDM);
- Strengthen and promote adaptation actions to climate change;

[88] as part of the AU-NEPAD Comprehensive African Agricultural Development Program (CAADP)

- Promote national-level research, development and technology transfer in climate change;
- Manage the risks of natural disasters; and
- Strengthen international cooperation and mobilize funding for the implementation of the National CC Policy

Côte d'Ivoire submitted its UNFCCC nationally determined contributions (NDC) in 2015, reaffirming the country's commitment to climate change adaptation and mitigation. Agriculture and forestry are key areas for both adaptation and mitigation in the NDC, especially through addressing deforestation, land degradation and woodfuel use by farmers. The NDC proposes a contribution based on the efforts to reduce greenhouse gas contained in the sectoral strategic development plans. In agriculture and forestry, the NDC aims to articulate main agricultural issues (research of self-sufficiency and food security and improvement of productivity and competitiveness) and those of the forestry sector (sustainable management of forests and 20% national forest cover in the 2014 Forest Code) through the concept of "zero deforestation agriculture."

- National Climate Change Program (2012)
- Second National Investment Plan for Agriculture (PNIA2, 2017–2025);
- Strategic National Plan for the Development of Livestock, Fisheries and Aquaculture (PSDEPA, 2014–2020);
- Forest Code (2014)

B-4 Potential Financing Mechanisms for CSAIP in Côte d'Ivoire

There are many potential sources of financing for CSAIP activities. Many of these are shown in chapter 4, with potential examples of financing described below.

Adaptation for Smallholder Agriculture Program (ASAP) channels climate finance to smallholder farmers, allowing them to access the information tools and technologies necessary for building resilience to climate change. ASAP is currently the largest global financing source dedicated to supporting the adaptation of poor smallholder farmers to climate change. It uses climate finance to make rural development programs more climate-resilient. Focused on adaptation, ASAP co-finances IFAD loans and grants.

Africa Enterprise Challenge Fund: Agribusiness Africa Window (AAW) is a special fund of the AECF that supports business ideas in the fields of agribusiness, financial services and value chains that extend across Africa and international markets. Business ideas that qualify for funding must have a positive impact on the rural poor by delivering increased employment, reduced costs and improved productivity. Supporting adaptation, it is a co-financing funding instrument.

Global Environment Facility: Climate Change Mitigation Focal Area supports mitigation-focused management practices in the land use, land use change and forestry sector (LULUCF) and in CSA initiatives that include mitigation objectives, as well as policies and financial mechanisms to maintain and enhance carbon stocks or reduce emissions from LULUCF and agriculture. The two types of financing instruments available are grants and non-grant instruments (i.e., credit guarantee, performance risk guarantee, structured financing, etc.).

Global Environment Facility: Commodities Signature Program aims to take deforestation out of the supply chains of critical commodities (beef, soy, oil palm and pulp paper) by supporting action with producers, buyers, financial institutions and national governments who are committed to this

overall goal. The program focuses on REDD mitigation and aims to transform supply chains where each chain link produces, buys or sells sustainable, deforestation-free products as a major part of their business model and that sustainable production, processing and supply of these commodities is rewarded throughout the supply chain. Countries receive allocations based on a specific resource allocation framework (STAR). Countries with total STAR allocations of less than US$7 million will have full flexibility to program the allocation across the three focal areas. In GEF-6, 49 countries will benefit from this flexibility rule. Countries above this threshold will have an allowed marginal adjustment of US$2 million.

Global Environment Facility: Food Security Signature Program on Sustainability and Resilience for Food Security in sub-Saharan Africa is focused on catalyzing investments to scale-up best practices, policy options and institutional frameworks to enhance sustainability and resilience of smallholder agriculture and food value chains, and generate global environmental benefits. The fund, focused on adaptation and general mitigation, is financed by grants and non-grant instruments.

Global Environment Facility: Land Degradation Focal Area provides a window for investing in sustainable land management to improve or restore ecosystem services in production systems. It supports efforts by eligible countries to combat land degradation, specifically desertification and deforestation, in rural production landscapes. The fund focuses on adaptation and both general and REDD mitigation, and is financed by grants and non-grant instruments. Countries receive allocations based on a specific resource allocation framework (STAR). Countries with total STAR allocations of less than US$7 million will have full flexibility to program the allocation across the three focal areas. In GEF-6, 49 countries will benefit from this flexibility rule. Countries above this threshold will have an allowed marginal adjustment of US$2 million.

Green Climate Fund (GCF) promotes low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change, taking into account the needs of those developing countries particularly vulnerable to the adverse effects of climate change. It will work through a wholesale model offering grants, concessional loans and intermediaries that fulfill special fiduciary standards and may also offer risk guarantees and equity investments. The fund focuses on adaptation, general mitigation and REDD mitigation.

KfW Development & Climate Finance is working towards achieving the goal of limiting the increase in global warming by promoting climate-friendly projects. KfW Development Bank links many development projects with programs designed to protect the climate and the environment as well as facilitate adaptation to climate change. Climate-related projects and programs in developing and emerging countries are funded over long periods with a mix of grants, participations and low-interest loans. KFW funding models include pure grants and loans from budget funds, but also loans that combine budget funds and KfW's own funds. The conditions for these kinds of loans are particularly favourable (interest, term). KfW also grants loans that are only comprised of KfW's own funds at terms and conditions commensurate to risk. The fund focuses on adaptation, general mitigation and REDD mitigation.

Special Climate Change Fund (SCCF) is a voluntary trust fund which finances activities, programs and measures related to climate change that are complementary to those funded through the climate change focal area of the GEF. The SCCF supports adaptation and technology transfer in all developing country parties to the UNFCCC, supporting both long-term and short-term adaptation activities. Grants (ODA) cover full project costs: projects over US$1 million are referred to as full-sized

projects (FSP), while those US$1 million or below are referred to as medium-sized projects (MSP). MSPs follow a further streamlined project cycle compared to FSPs. In addition, there are two funding windows: the SCCF Adaptation Program (SCCF-A) and the Program for Technology Transfer (SCCF-B).

Annex C: Prioritizing interventions: from long-lists to finalists

This section summarizes the process used in prioritizing investments, with sections on:

C-1 **Producing a Long List of Investments**
C-2 **Producing a Short List of Investments**
C-3 **CSA Investment Practices, Location, Risks and Institutions**
C-4 **Participants at Prioritizing Workshop**

C-1 Producing a Long List of Investments

To develop the long list of CSA investments, first key strategic national documents (plan, strategy, policy) and research results (CSA profile, national diagnostic on CSA practices etc.) related to CSA, agriculture, climate change and adaptation were identified and reviewed. Then practices mentioned in these documents with a potential impact on CSA pillars (adaptation, mitigation and productivity) were extracted to build a database. In parallel, a country zoning process was carried out taking into account the agropoles mentioned in the National Agricultural Investment Program (NAIP2) 2017–2025. According to the NAIP, agropoles consist of zones based on agro-ecological, administrative, social and economic criteria. At the level of each zone, investments will target the development of key sectors focused on both ensuring food security and creating added value. Finally, practices were grouped into investments at the agropole level and at national levels according to their importance in the zone. This process was done with local experts supported by CGIAR expertise at a meeting in Côte d'Ivoire from May 29–June 1, 2018 (see end of this annex for participant list). The long list of investments identified is shown in table C-1, showing the groupings used to categorize potential investments. These investments were divided into four categories: agricultural system, fishery and livestock system, forest and sustainable management of water and soils and CSA services.
Soils and CSA services:

Table C-1 Investment long-list of programs for Côte d'Ivoire, by category

AGRICULTURAL SYSTEMS	
1	Climate-Smart Irrigated Rice Development Program
2	Climate-Smart Rainfed Rice Development Program
3	Climate-Smart Cotton Development Program
4	Climate-Smart Maize Development Program
5	Program for the Climate-Smart Development of High Value Vegetable and Small Livestock Production for the Abidjan Market (Bassin Vivrier Abdijanais)
6	Climate-Smart Soy Development Program
7	Program for the Development of the Climate-Smart Production and Processing of Yam (Igname)
8	Climate-Smart Cassava Production and Processing Program
9	Climate-Smart Plantain Development Program
10	Development Program of Financial Products for the Climate
11	Program for Exploiting the Hydrological Potential for Vegetable and Protein Crops
FISH AND LIVESTOCK SYSTEMS	
12	Climate-Smart Coastal Zone Development Program (Fishery and Coconut)
13	Climate-Smart Aquaculture Development Program
14	Program for the Climate-Smart Development of the Livestock Sector (Cattle and Small Ruminants)
15	Climate-Smart Livestock Development Program (Cattle, Sheep and Goat)
16	Forestry, tree crop systems, agroforestry and sustainable land and water management
17	Climate-Smart Cocoa Development Program
18	High Value and Nutrient Dense Agroforestry System (Cacao, Ginger, OFSP, etc.) Development Program in Isolated Low Rainfall Zone
19	High Value (Coffee, Cacao, etc.) Perennial Cropping System Development Program at High Elevation
20	Climate-Smart Cashew (Nuts and Fruits) Development Program
21	Climate Smart Palm Oil (Tropical Forest Alliance 2020) and Rubber Development Program
22	Forest Protection, Protected Areas and Reforestation Development Program
CSA SERVICES	
23	Agrometeorological Stations Development Program, By Region
24	Climate Smart Bio-Energy Development Program
25	Insurance Products For Climate Risks Development Program
26	Grain Banks Development Program
27	National Monitoring System of GHG Emissions and Forest Areas Development Program (REDD+ Implementation)
28	Agricultural Mechanization, Harvest, Processing and Storage Infrastructure Development Program
29	Payment for Environmental Services (PES) Development Program
30	Climate-Smart Agriculture Extension Capacity-Building Development Program

C-2 Producing a Short List of Investments

To reduce this long list of potential investments to a shorter list, two main steps were followed. First, participants were divided into 4 groups (Saharo-Sahelian zone, Sudano-Sahelian zone, Guineo-Sudanian zone and national zone) and asked to prioritize 5 to 6 investments based on the specificity

of their zone. (Names for these have been abridged from those in the workshop for simplicity.) The priorities for each of the zones are the Program for:

Savannah Zone	Maize Development
	Mango Value Chain
	Cashew Value Chain
	Livestock Sector
	Yam Prod. & Processing
	Irrigated Rice
Central Zone	Cassava Production
	Rain-fed Rice
	Plantain Development
	Value Chains for Palm Oil & Man's Arabica Coffee
	Fish Farming
	Yam Prod. & Processing
Forest Zone	Abidjan Market
	Cassava Production
	Plantain Development
	Old Cocoa Loop (South-east of the country)
	Non-coffee, Cocoa (Palm Oil & Rubber Tree) Crops (Tropical Forest Alliance 2020)
	Forest-friendly Cacaovin Pioneer Frontier Zone
National Zone	Agro-Meteorological System
	Agricultural Finance Services
	Hydrological Potential for Vegetable and Protein Crops
	Agricultural Extension System
	Mechanization Technologies

Participants were then asked to prioritize the top six investments using a point system, producing the ranking shown in table C-2.

Table C-2 Investments as ranked in order of priority by workshop participants

INVESTMENTS	RANKING	REGION
Climate Smart Cassava Production and Processing Program	1	Regional
Program for the Development of a National Agrometeorological System	2	National
Program for the Climate-Smart Development of the Livestock Sector (Cattle and Small Ruminants) in northern Côte d'Ivoire	3	Regional
Program for the Climate-Smart Development of High-Value Vegetable and Small Livestock Production for the Abidjan market ("Bassin Vivrier Abidjanais")	4	Regional
Program for the Development of a National Climate-Smart Agricultural Extension System	5	National
Climate-Smart Irrigated and Rainfed Rice Development Program	6	Regional
Sustainable Cocoa Production Program	7	Regional
Program for the Development of Climate-Smart Agricultural Finance Services and Products	8	National
Program for the Climate-Smart Development of the Mango Value Chain	9	Regional
Climate-Smart Maize Development Program	10	Regional
Program for the Development of the Climate-Smart Production and Processing of Yam (Igname)	11	Regional
National Soil Fertility Program	12	National

C-3 Investment CSA practices, location, risks and institutions

Participants then considered each of the 12 CSA investments to inform the development of the concept notes, discussing leading institutions, the CSA practices that were needed, the needed scope of the project, proposed geographic reach, risks and other relevant information. They also involved key actors in fostering the adoption of the CSA practices. For each actor, needed changes in knowledge, skills and practices and related activities were identified. This information was used to make more detailed proposed projects and to develop outcomes, activities and component for each investment/program. All of these were used to develop the project concepts found in annex G. Workshop information was included and supplemented in the development of these concepts. Also, the alignment of these proposed investments with the NDC Partnership was considered (see chapter 3).

C-4 Participants at prioritizing workshop

The prioritization meeting was held in Côte d'Ivoire from May 29–June 1, 2018

NAME	INSTITUTION
N'zlle Augustin	SODEXAM
Cdt Guy- Serge Guillaume Bekoin	MINEF
Dje Kouakou Bernard	Consultant
Doumbia Sekou	Consultant
Agbri Lako	MINADER/DMEME
Benard Comoe	DPPF/ MINADER
Ballo Koffi	CNRA
Kone Mouhamedou	MIRAH/DPE
Coulibaly Faguoro N'golo	MIRAH/DPSP/DS
Riad Balaghi	Initiative AAA
Kouadio Alladé Yvonne	BREID
Kouakou Aphely Amon	SEP-REDD+
Tre Jean- Philippe	Banque Mondiale
Nebout Florence	MINADER/DMEME
Daubrey Marc	Green Invest.
Georgette Zamble Balie	FIRCA/genre
Sosthene Kouadco	MEF
Gbo D. Amin	ANADER
Zion Aime	MENSEDD/DSPS
Agbri lako	MINADER/DMEME
Affessi A. Wenceslas	Consultant
Bio Jesus	INS
Kunadjo Georges	Directeur des peches/ MIRAH
Djigbe Kouah Noé	ONDR
Coulibaly Bema	Le conseil du Café Cacao
N'Guessan Koffi Rodrigue	MINADER
Ynpo Asso.	Consultant
Kouassi Kouassitres	Conseil du Café Cacao
Richard Dreys	Coop. Allemande- GIZ

Tiho Seydou	Université Nangui Abrogova
Zakma Gale F.	MIRFEDD/ DLCC
Aboukoua Herve Brice	SODEFER
Zoue Desiree	BREID

Annex D: Structure and results of the scenario modeling analysis (RCP + SSPS) Côte d'Ivoire

D-1 About Shared Socioeconomic Pathways (SSPs)
D-2 Combinations of Representative Concentration Pathways (RCPs) and SSPs
D-3 IMPACT Model and Modeling Combinations of RCPs and SSPs
D-4 Scenarios Purpose for Modeling
D-5 Methodology
D-6 Standard Measuring and Interpreting the Results
D-7 Preliminary Data For Côte d'Ivoire From IIASA Database
D-8 Results: Heatmap

D-1 About shared socioeconomic pathways (SSPs)

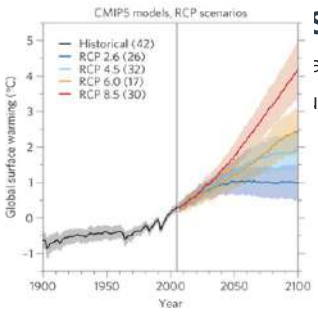
Shared Socioeconomic Pathways (SSPs) are scenarios of global development and contain many elements. Each scenario was given an evocative name to describe a development path the world might take and how this path would affect society's ability to respond to climate change. The following figure shows how the five SSPs were envisioned with respect to society's ability to deal with climate change89. The SSPs are future scenarios with narratives, which include quantitative elements such as population, urbanization, rates of technological change, income, human development index, income distribution, etc. Using the narratives obtained from Riahi et al. (2016), the next table displays the narratives for each Shared Socioeconomic Pathways-SSP scenario**.**

Table D-1 Summary of SSP narratives.

SSP1	**Sustainability – Taking the Green Road (Low challenges to mitigation and adaptation).** The world shifts gradually, but pervasively, toward sustainability, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, with the emphasis on economic growth shifting toward a broader emphasis on human well-being.
SSP2	**Middle of the Road (Medium challenges to mitigation and adaptation).** The world follows a path in which social, economic and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate, leveling off after 2050.
SSP3	**Regional Rivalry – A Rocky Road (High challenges to mitigation and adaptation).** A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries.

SSP4	**Inequality – A Road Divided (Low challenges to mitigation, high challenges to adaptation).** Highly unequal investments in human capital, and increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. A widening gap exists between an internationally connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies with labor-intensive, low-tech economies. In the high-tech economy and sector, technology development is high and the globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, and low-carbon energy sources. Environmental policies focus on local issues around middle and high income areas.
SSP5	**Fossil-fueled Development – Taking the Highway (High challenges to mitigation, low challenges to adaptation).** This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated, with strong investments in health, education and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource- and energy-intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed.

D-2 Combinations of Representative Concentration I SSPs



Each cell in the matrix indicates a combination of socioeconomic de ate outcome based on a particular forcing pathway that current integrat ins have shown feasible[90].

Table D-2 Scenario matrix architecture and RCP future pathways

		SSP1	SSP2	SSP3	SSP4	SSP5
RCP Replication	Reference	x	x	x	x	x
	8.5 Wm^{-2}			x		
	6.0 Wm^{-2}		x	x	x	x
	4.5 Wm^{-2}	x	x	x	x	x
	2.6 Wm^{-2}	x	x		x	

D-3 IMPACT model and modeling combinations of RCPs and SSP

IPCC has developed a measure of the compatibility of SSPs and RCPs. Table D-3 summarizes this compatibility matrix. The square with an X represents an SSP-RCP combination that is not considered plausible. The darker the shading, the higher would be the costs to society that would be needed to mitigate greenhouse gas emissions to allow for the compatibility of an SSP with an RCP. For example, if no climate policies are pursued to mitigate climate change under SSP 2, we would expect somewhere between RCP 6.0 and 8.5. However, with some mitigation RCP 6.0 is possible, and with heavier investment 4.5 and 2.6 may also be possible[91].

Table D-3 RCP and SSP compatibility matrix and cost of mitigation.

Scenario Specifications	SSP1	SSP2	SSP3	SSP4	SSP5
RCP 8.5	X				
RCP 6.0					
RCP 4.5					
RCP 2.6					

Source: International Panel on Climate Change (2013,2014).

Note: RCP = Representative Concentration Pathway: SSP = Shared Socioeconomic Pathway.

[90] Riahi et al., 2016

[91] Robinson et al. 2015

Each RCP represents global climate change through the role of greenhouse gas emissions and radiative forcing. This is just one physical dynamic that determines climate and weather. To simulate all of these systems that determine climate and to provide weather as inputs to crop models, the RCPs must be simulated in Earth system models (ESMs, formerly called general circulation models or GCMs). The ESMs are complex models that simulate earth's biogeochemical cycles and combine modules that simulate physical climate, atmospheric circulation, and ocean and ice dynamics. Each ESM has somewhat different assumptions about how each of these complex dynamics works and interacts, which means that each ESM's realization of the RCP will be somewhat different. This diversity of results creates model uncertainty, as it is not possible to determine which ESM realization is more likely. To better handle this uncertainty, and to expand the climate possibility space in which IMPACT scenarios can be tested, it was decided to use multiple ESM realizations of each RCP and allow the use of a multimodel ensemble to test climate uncertainty. The ESMs currently used to provide climatic data to the Decision Support System for Agrotechnology Transfer crop models are the following: GFDL-ESM2M, HADGEM2-ES, IPSL-CM5A-LR, MIROC-ESM and NORESM1-M.

D-4 Scenarios purpose for modeling

Concentration Pathways (RCP), and (iii) a Shared Socioeconomic Pathway (SSPs). These combinations were explained on the prior tables; however, the modeling allows or analysis of how these scenarios effect future climate conditions (e.g., precipitation and temperature) and other relevant factors, such as population growth and food demand.

D-5 Methodology

It is important to remember that IMPACT model results are not predictions but rather scenarios that describe the future potential performance of crops under specific climate and policy conditions. IMPACT model results factor in several key assumptions regarding the structure of the socioeconomic system, national investment in agriculture, and climate. Thus, in interpreting the results that follow, it is important to think of the modeled trends as plausible, not predicted, futures. As the IMPACT model is a partial equilibrium model of the agriculture sector, it is largely driven by supply and demand of the modeled commodities. Moreover, table D-4 displays some outcomes variables for each scenario modelled for a period from 2020 to 2050.

Table D-4 Based on IMPACT model description version 3 (Robinson et al., 2015)

No	Variable Name
1	Total production (000 mt)
2	Total demand for commodity (000 mt)
3	Crop yields (mt/ha)
4	Total area (000 ha)
5	Net trade (000 mt)
6	Exports for each country and traded commodity(000 mt)
7	Export share of production (%)

8	Imports for each country and traded commodity(000 mt)
9	Net trade share of production (%)
10	Net trade share of demand (%)
11	Solution total commodity supply

D-6 Standard Measuring and Interpreting the Results

The impacts of climate change (include SSPs pathways) on a given indicator of interest are calculated as the difference in percentage changes in 2050 over the baseline year 2020 with and without climate change. For example, the impact of climate change on yield Ydiff(pp) is assessed as follows.

$$Y_{diff(pp)} = \%\Delta y_{CC} - \%\Delta y_{NoCC} \quad (1)$$

where

$$\%\Delta y_{CC} = \frac{y_{CC2050} - y_{CC2020}}{y_{CC2020}} \quad (2)$$

$$\%\Delta y_{NoCC} = \frac{y_{NoCC2050} - y_{NoCC2020}}{y_{NoCC2020}} \quad (3)$$

When calculated in this way, impacts are reported in terms of a percentage point difference. Impacts can also be assessed as a percentage difference of the indicator's 2050 value under CC with respect to its 2050 value under the No-CC scenario. For yield this would be:

$$Y_{diff(\%)} = \frac{y_{CC2050} - y_{NoCC2050}}{y_{NoCC2050}} \quad (4)$$

When calculated in this way, impacts are reported in terms of percentages.

D-7 Exploration of preliminary data for Côte d'Ivoire from IIASA database

Figure D-1 Population change under different scenarios

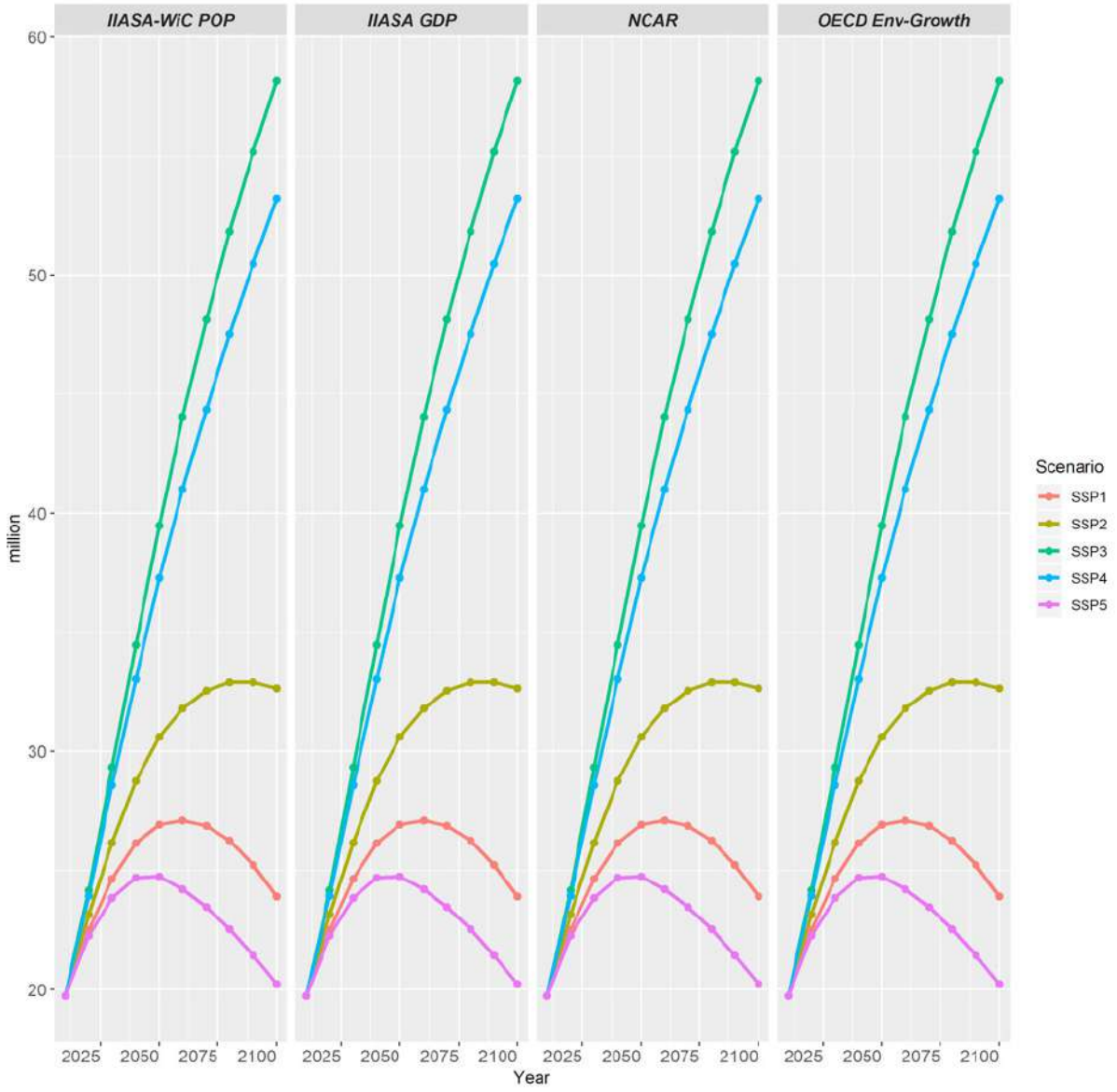


Figure D-2 GDP Change under different SSPs

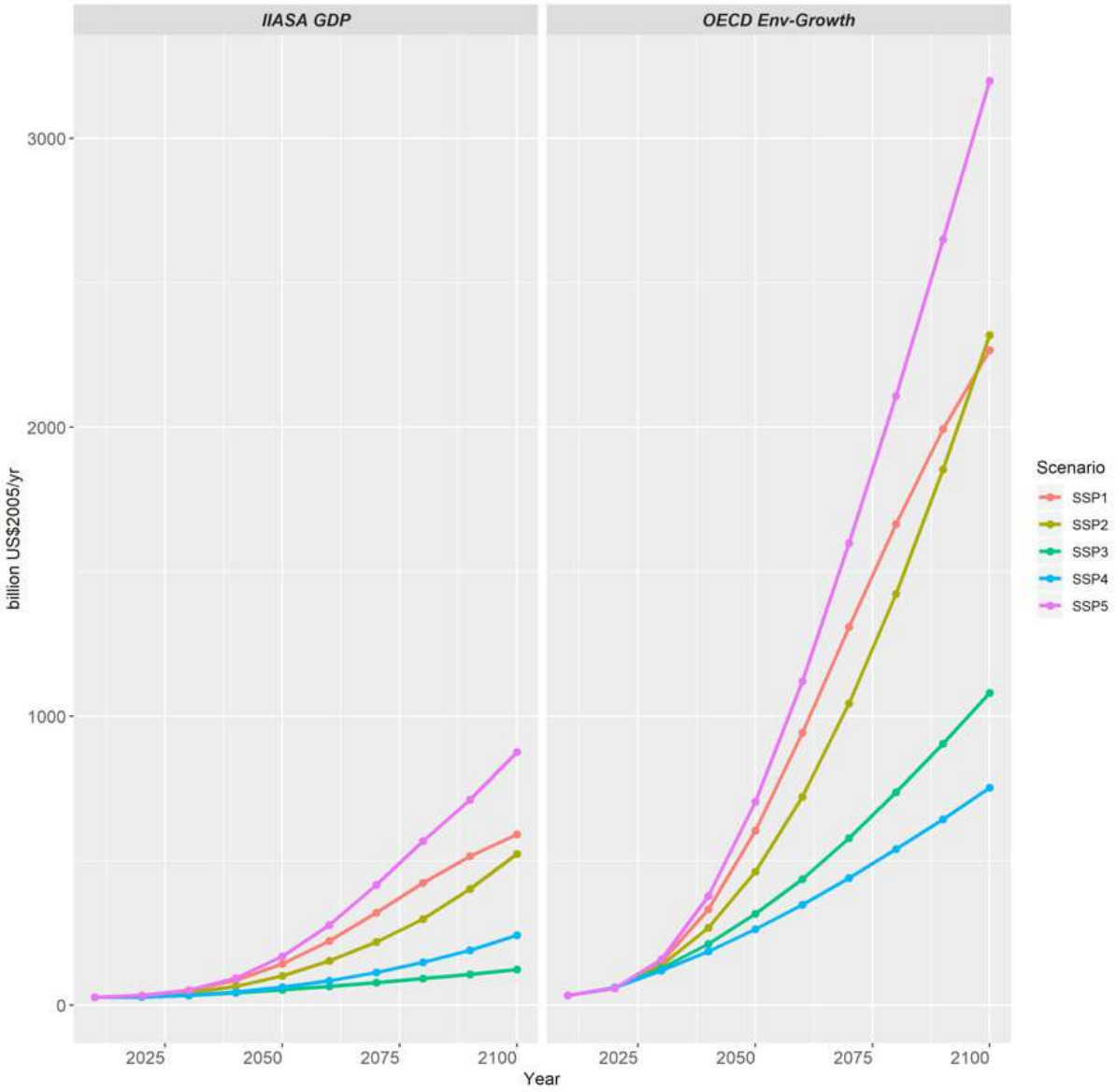
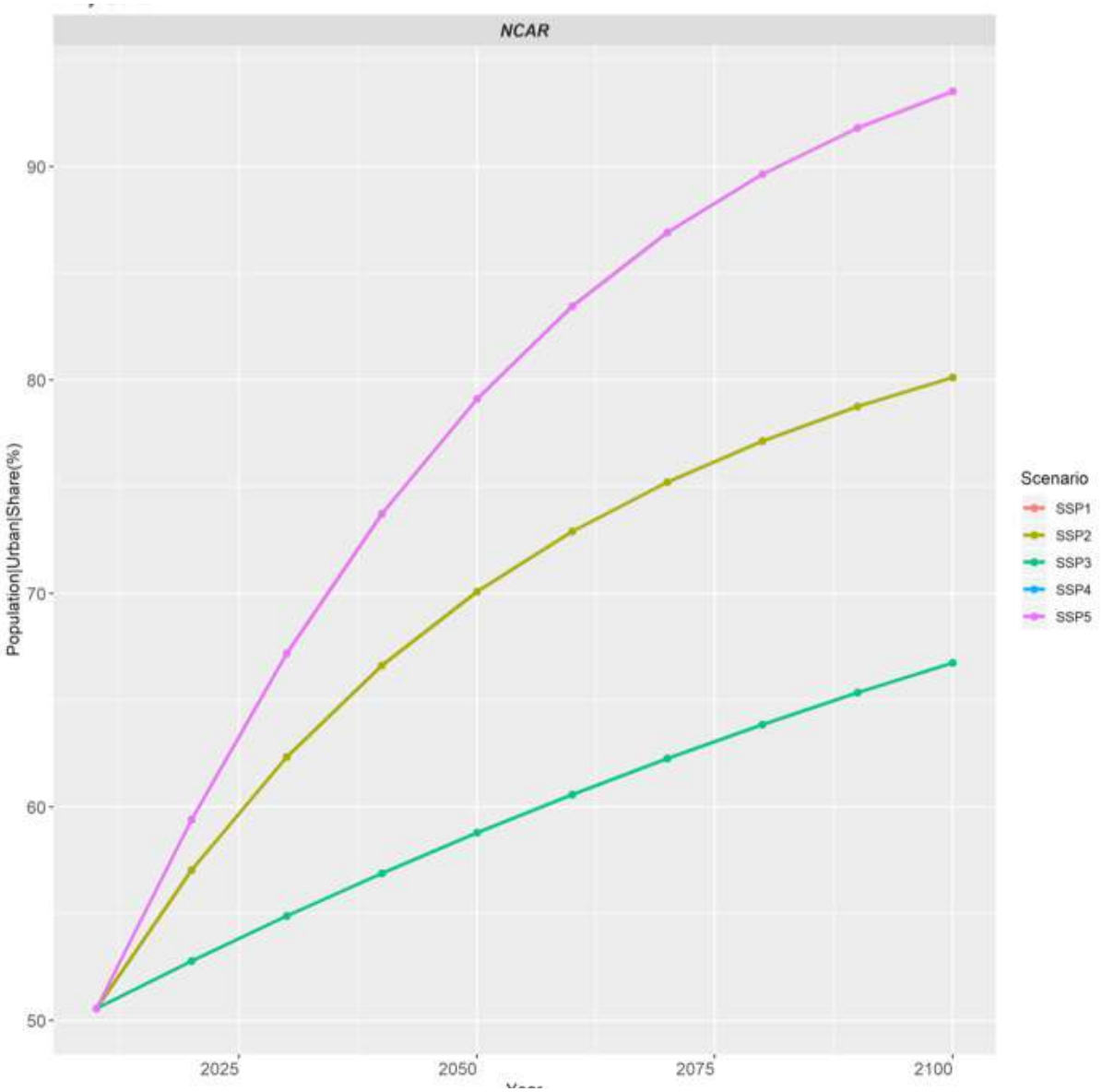


Figure D-3 Urban Population Change under different SSPs



D-8 Results: Comprehensive Heatmap tables

Figure D-4: Percent different in area cultivated for various agricultural commodities by 2050 under different RCPs and SSPs.

	2018 Baseline Value (ha)	Percent Difference in Area Cultivated by 2050														
		RCP2.6			RCP4.5					RCP6.0	RCP8.5				Average
		SSP2	SSP4	SSP5	SSP1	SSP2	SSP3	SSP4	SSP5	SSP2	SSP2	SSP3	SSP4	SSP5	
Sugarcane	29	2.0	2.2	1.6	3.6	3.7	3.8	4.1	3.1	3.4	5.2	5.5	5.9	4.4	3.7
Plantain	501	1.7	1.7	1.6	3.3	3.4	3.4	3.4	3.3	2.5	3.9	4.6	4.6	4.5	3.2
Rice	420	0.9	1.0	0.8	1.9	1.9	1.9	1.9	2.0	2.4	3.7	4.8	4.7	5.5	2.6
Palm Fruit	278	2.0	2.0	2.1	2.4	2.1	1.9	2.0	2.7	2.6	2.2	2.5	2.8	3.9	2.4
Coffee	766	0.7	0.7	0.7	1.7	1.7	1.7	1.7	1.6	1.4	1.8	2.3	2.3	2.2	1.6
Banana	11	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.3	1.6	1.8	1.8	1.9	1.5
Tropical Fruit	134	0.2	0.2	0.2	1.4	1.4	1.4	1.4	1.4	1.0	1.8	2.3	2.3	2.4	1.4
Cacao	2295	1.0	1.0	1.0	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.4	1.5	1.3	1.2
Yams	689	0.9	1.0	0.9	1.2	1.2	1.3	1.2	1.2	1.0	1.2	1.2	1.3	1.1	1.1
Cotton	261	-1.3	-1.3	-1.3	1.0	1.1	1.1	1.0	1.2	0.4	2.1	3.3	3.1	3.8	1.1
Maize	337	-0.1	-0.2	-0.3	1.2	1.3	1.5	1.2	1.4	-0.2	2.3	2.0	1.7	2.2	1.1
Cassava	319	0.8	0.8	0.8	1.0	1.0	1.1	1.0	0.9	0.7	0.9	1.2	1.2	0.9	1.0
Sweet Potato	24	-0.2	-0.2	-0.2	0.0	0.0	0.0	0.0	-0.1	0.2	0.1	0.2	0.2	0.1	0.0
Groundnut	104	-2.4	-2.4	-2.3	-0.7	-0.7	-0.7	-0.8	-0.6	-1.7	0.3	1.3	1.2	1.6	-0.6
Soybean	1	-1.2	-1.2	-1.3	-1.4	-1.3	-1.3	-1.3	-1.4	-1.5	-1.4	-1.4	-1.4	-1.5	-1.4
Vegetables	193	-1.2	-1.3	-1.2	-2.0	-2.0	-2.1	-2.1	-1.9	-1.4	-1.5	-1.4	-1.4	-1.2	-1.6
Sorghum	80	-2.4	-2.4	-2.4	-0.5	-0.4	-0.4	-0.4	-0.5	-3.4	-1.7	-2.2	-2.2	-2.4	-1.6
Millet	64	-3.3	-3.3	-3.2	-1.0	-1.0	-1.0	-1.0	-1.0	-3.2	-0.7	-1.2	-1.2	-1.3	-1.7
Beans	33	-5.9	-5.9	-6.0	-6.5	-6.4	-6.4	-6.4	-6.4	-7.6	-6.6	-6.7	-6.8	-6.4	-6.5

Figure D-5 Percent different in yield for various agricultural commodities by 2050 under different RCPs and SSPs.

	2018 Baseline Value (MT/ha)	Percent Difference in Yield by 2050													
		RCP2.6			RCP4.5					RCP6.0	RCP8.5				Average
		SSP2	SSP4	SSP5	SSP1	SSP2	SSP3	SSP4	SSP5	SSP2	SSP2	SSP3	SSP4	SSP5	
Sugarcane	29	-0.4	-0.4	-0.4	1.1	1.1	1.1	1.1	1.1	0.2	1.5	1.3	1.3	1.3	0.8
Plantain	501	-1.6	-1.6	-1.6	1.0	1.0	1.0	1.0	1.0	-0.6	1.8	1.6	1.5	1.7	0.5
Rice	420	-1.3	-1.3	-1.3	0.1	0.1	0.1	0.1	0.1	-0.4	0.8	0.6	0.5	0.6	-0.1
Palm Fruit	278	-2.1	-2.1	-2.1	0.1	0.1	0.1	0.1	0.1	-1.2	0.6	0.3	0.3	0.4	-0.4
Coffee	766	-1.1	-1.1	-1.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.9	0.2	-0.2	-0.2	-0.2	-0.4
Banana	11	-2.4	-2.4	-2.4	-0.1	-0.1	-0.1	-0.1	-0.1	-1.5	0.5	0.2	0.2	0.4	-0.6
Tropical Fruit	134	-2.0	-2.0	-2.0	-0.3	-0.3	-0.3	-0.3	-0.3	-1.5	0.1	-0.4	-0.4	-0.3	-0.8
Cacao	2295	-3.0	-3.0	-3.0	-1.1	-1.1	-1.1	-1.1	-1.0	-2.3	-0.5	-1.1	-1.1	-0.9	-1.6
Yams	689	-2.9	-2.9	-2.8	-1.4	-1.4	-1.4	-1.4	-1.3	-2.5	-1.0	-2.0	-2.0	-1.8	-1.9
Cotton	261	-1.3	-1.2	-1.3	-2.4	-2.4	-2.4	-2.4	-2.3	-1.8	-1.5	-2.0	-2.0	-1.7	-1.9
Maize	337	-1.2	-1.2	-1.2	-2.5	-2.6	-2.6	-2.6	-2.5	-2.0	-1.4	-2.3	-2.3	-2.1	-2.0
Cassava	319	-2.2	-2.2	-2.2	-3.9	-3.9	-3.9	-3.9	-3.8	-3.2	-2.9	-3.8	-3.9	-3.6	-3.3
Sweet Potato	24	-6.5	-6.5	-6.4	-5.4	-5.4	-5.4	-5.4	-5.4	-8.8	-8.9	-8.9	-9.0	-8.9	-7.0
Groundnut	104	-6.4	-6.4	-6.3	-5.4	-5.4	-5.4	-5.4	-5.4	-8.8	-9.1	-9.1	-9.1	-9.0	-7.0
Soybean	1	-6.5	-6.5	-6.5	-7.1	-7.1	-7.1	-7.1	-7.0	-8.1	-6.3	-8.4	-8.5	-8.2	-7.3
Vegetables	193	-4.4	-4.4	-4.5	-7.8	-7.8	-7.8	-7.8	-7.9	-7.3	-10.7	-10.7	-10.7	-10.8	-7.9
Sorghum	80	-10.2	-10.2	-10.2	-9.6	-9.6	-9.5	-9.6	-9.5	-12.7	-14.4	-14.2	-14.3	-14.0	-11.4
Millet	64	-10.6	-10.6	-10.6	-13.3	-13.3	-13.3	-13.3	-13.3	-13.2	-12.1	-15.8	-15.9	-15.8	-13.2
Beans	33	-12.3	-12.3	-12.3	-13.7	-13.7	-13.7	-13.7	-13.7	-15.2	-13.8	-17.1	-17.1	-17.0	-14.3

Figure D-6 Percent different in production for various agricultural commodities by 2050 under different RCPs and SSPs.

	2018 Baseline Value (MT)	Percent Difference in Production by 2050													Average
		RCP2.6			RCP4.5					RCP6.0	RCP8.5				
		SSP2	SSP4	SSP5	SSP1	SSP2	SSP3	SSP4	SSP5	SSP2	SSP2	SSP3	SSP4	SSP5	
Plantain	2500	0.1	0.1	0.1	4.4	4.4	4.4	4.4	4.4	1.8	5.7	6.2	6.2	6.3	3.7
Yams	6744	0.6	0.6	0.6	2.3	2.3	2.3	2.3	2.3	1.2	2.7	2.6	2.6	2.5	1.9
Coffee	180	-1.4	-1.4	-1.4	1.8	1.8	1.8	1.8	1.8	0.1	2.4	2.6	2.6	2.6	1.2
Tropical Fruit	534	-2.2	-2.1	-2.1	1.3	1.3	1.3	1.3	1.4	-0.4	2.3	2.6	2.5	2.9	0.8
Rice	705	-0.4	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5	-0.3	0.6	2.2	2.7	2.6	3.8	0.6
Cassava	3015	-0.3	-0.3	-0.4	0.8	0.9	1.0	0.9	0.8	-0.2	1.1	1.0	0.9	0.7	0.5
Palm Fruit	2073	-0.9	-1.0	-0.8	1.0	0.7	0.4	0.6	1.3	0.1	1.1	0.5	0.7	1.9	0.4
Cacao	1716	-1.1	-1.1	-1.1	0.9	0.9	0.9	0.9	0.9	-0.4	1.2	1.1	1.1	1.0	0.4
Lamb	20	0.0	0.0	0.0	0.2	0.2	0.2	0.1	0.2	0.1	0.3	0.4	0.4	0.6	0.2
Sweet Potato	58	-1.6	-1.6	-1.6	0.0	0.1	0.1	0.1	0.0	-0.3	0.9	0.8	0.7	0.6	-0.1
Pork	12	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.1	-0.3
Beef	45	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.2	-0.4
Cotton	147	-4.3	-4.3	-4.2	0.0	0.0	0.0	-0.1	0.2	-1.8	1.5	2.1	1.9	2.8	-0.5
Banana	593	0.1	0.1	0.2	-1.2	-1.2	-1.2	-1.2	-1.1	-0.7	0.1	-0.5	-0.6	-0.3	-0.6
Poultry	40	-0.8	-0.8	-0.8	-0.7	-0.7	-0.7	-0.7	-0.6	-0.7	-0.8	-0.5	-0.5	-0.2	-0.7
Eggs	37	-0.7	-0.7	-0.6	-0.7	-0.7	-0.7	-0.7	-0.6	-0.7	-1.0	-0.8	-0.8	-0.6	-0.7
Dairy	43	-0.6	-0.6	-0.6	-0.7	-0.7	-0.8	-0.7	-0.7	-0.7	-1.1	-1.0	-1.0	-0.9	-0.8
Sugarcane	1979	-2.6	-2.3	-3.0	-4.5	-4.4	-4.3	-4.0	-5.1	-4.2	-6.1	-5.9	-5.5	-6.9	-4.5
Vegetables	892	-3.4	-3.4	-3.3	-5.8	-5.8	-5.9	-5.9	-5.6	-4.5	-4.3	-5.2	-5.2	-4.7	-4.8
Sorghum	58	-8.4	-8.4	-8.4	-5.7	-5.7	-5.6	-5.6	-5.7	-11.8	-10.4	-10.9	-11.0	-11.0	-8.4
Millet	58	-9.4	-9.4	-9.3	-6.3	-6.3	-6.3	-6.3	-6.3	-11.6	-9.5	-9.9	-9.9	-9.9	-8.5
Maize	962	-10.2	-10.2	-10.3	-8.4	-8.2	-8.1	-8.4	-8.2	-12.8	-12.3	-12.3	-12.8	-12.0	-10.3
Beans	36	-12.0	-12.0	-12.1	-13.0	-13.0	-13.0	-13.0	-12.9	-15.0	-12.3	-14.4	-14.6	-14.0	-13.2
Soybean	1	-11.7	-11.7	-11.7	-14.5	-14.4	-14.4	-14.4	-14.5	-14.4	-13.1	-16.9	-17.0	-16.9	-14.3
Groundnut	115	-14.3	-14.3	-14.3	-14.2	-14.3	-14.3	-14.3	-14.2	-16.3	-13.3	-15.8	-15.9	-15.5	-14.7

Figure D-7 Percent different in total demand for various agricultural commodities by 2050 under different RCPs and SSPs.

	2018 Baseline Value (MT)	Percent Difference in Total Demand by 2050													Average
		RCP2.6			RCP4.5					RCP6.0	RCP8.5				
		SSP2	SSP4	SSP5	SSP1	SSP2	SSP3	SSP4	SSP5	SSP2	SSP2	SSP3	SSP4	SSP5	
Wheat	380	2.9	2.9	3.3	3.4	2.5	1.7	2.4	2.5	2.5	3.1	0.6	1.5	0.1	2.2
Barley	38	3.3	3.3	3.2	2.4	2.4	2.4	2.5	2.0	2.7	2.1	1.0	1.2	-0.1	2.2
Palm Kernel	92	-0.2	-0.3	-0.2	0.9	0.7	0.5	0.6	1.1	0.4	0.9	0.7	0.9	1.7	0.6
Palm Fruit	2073	-0.9	-1.0	-0.8	1.0	0.7	0.4	0.6	1.3	0.1	1.1	0.5	0.7	1.9	0.4
Sunflower Oil	2	1.0	0.9	1.2	0.3	0.3	0.3	0.3	0.3	0.6	-0.1	-0.5	-0.5	-1.0	0.3
Lamb	16	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.1	-0.1	-0.1	0.0
Dairy	224	0.1	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.2	-0.2	-0.2	-0.4	-0.1
Rapeseed	1	1.8	1.8	1.7	0.1	0.2	0.3	0.2	-0.2	0.7	-0.7	-2.2	-2.2	-3.2	-0.1
Beef	56	0.2	0.2	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	-0.3	-0.5	-0.4	-0.7	-0.1
Eggs	42	0.0	0.0	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.4	-0.6	-0.5	-0.7	-0.2
Pork	18	0.0	0.0	0.0	-0.4	-0.4	-0.4	-0.4	-0.5	-0.3	-0.8	-1.0	-0.9	-1.2	-0.5
Poultry	43	0.0	0.0	0.0	-0.4	-0.4	-0.4	-0.4	-0.5	-0.3	-0.8	-1.1	-1.0	-1.4	-0.5
Vegetables	1000	-0.1	-0.1	-0.1	-0.7	-0.7	-0.7	-0.7	-0.8	-0.6	-1.1	-1.8	-1.7	-2.0	-0.9
Sweet Potato	60	-0.3	-0.3	-0.3	-0.8	-0.8	-0.8	-0.8	-0.8	-1.0	-1.1	-1.8	-1.7	-1.7	-0.9
Beans	34	-0.4	-0.4	-0.4	-1.1	-1.1	-1.1	-1.1	-1.1	-0.8	-1.1	-2.2	-2.1	-2.4	-1.2
Cassava	2752	-1.4	-1.4	-1.4	-2.0	-2.1	-2.1	-2.0	-2.1	-1.6	-2.1	-3.0	-3.0	-3.0	-2.1
Cotton	10	-0.6	-0.6	-0.6	-1.9	-1.9	-1.9	-1.9	-2.1	-1.7	-2.6	-3.9	-3.8	-4.3	-2.1
Yams	7114	-1.8	-1.7	-1.8	-2.5	-2.5	-2.5	-2.5	-2.5	-2.2	-2.6	-3.3	-3.3	-3.4	-2.5
Millet	54	-0.9	-0.9	-0.9	-2.2	-2.2	-2.2	-2.2	-2.3	-2.0	-4.0	-4.3	-4.3	-4.5	-2.5
Tropical Fruit	332	-1.3	-1.3	-1.3	-2.5	-2.5	-2.5	-2.5	-2.5	-2.3	-3.0	-4.0	-4.0	-4.3	-2.6
Tea	2	-1.5	-1.5	-1.5	-2.6	-2.6	-2.6	-2.6	-2.7	-2.5	-3.5	-4.7	-4.7	-4.9	-2.9
Cacao	198	-2.2	-2.2	-2.2	-2.9	-2.9	-2.9	-2.9	-2.9	-2.8	-3.1	-4.4	-4.3	-4.5	-3.1
Sorghum	52	-1.8	-1.8	-1.9	-3.2	-3.1	-3.1	-3.1	-3.2	-2.6	-4.5	-4.6	-4.6	-4.9	-3.3
Banana	92	-1.9	-1.9	-1.9	-3.3	-3.3	-3.2	-3.2	-3.3	-2.9	-3.9	-5.0	-4.9	-5.1	-3.4
Coffee	51	-1.9	-1.9	-1.9	-3.3	-3.3	-3.3	-3.3	-3.3	-3.0	-3.7	-5.1	-5.0	-5.2	-3.4
Rice	1671	-1.2	-1.3	-1.1	-3.2	-3.2	-3.2	-3.2	-3.2	-3.0	-4.3	-5.9	-5.8	-6.2	-3.4
Potato	20	-1.3	-1.3	-1.3	-3.6	-3.6	-3.6	-3.6	-3.7	-2.4	-4.8	-5.7	-5.7	-5.9	-3.6
Soybean	1	-1.7	-1.7	-1.6	-3.6	-3.7	-3.7	-3.7	-3.7	-2.9	-3.7	-6.1	-5.9	-6.1	-3.7
Plantain	2062	-2.6	-2.6	-2.6	-4.1	-4.1	-4.1	-4.1	-4.1	-3.5	-4.6	-5.7	-5.6	-5.7	-4.1
Sugarcane	1979	-2.6	-2.3	-3.0	-4.5	-4.4	-4.3	-4.0	-5.1	-4.2	-6.1	-5.9	-5.5	-6.9	-4.5
Groundnut	61	-3.1	-3.0	-3.2	-4.6	-4.6	-4.7	-4.6	-4.7	-4.6	-5.5	-7.1	-7.1	-7.1	-4.9
Maize	908	-5.2	-5.3	-5.3	-8.0	-7.7	-7.5	-7.7	-7.9	-6.8	-11.7	-11.4	-11.4	-12.0	-8.3

Annex E: Climate-Smart economic appraisal: methodology and extended results

E-1 Model Design
E-2 Parameter Estimation
E-3 NPV AND ROI Results for the Four Priority Projects Under Various Risk Scenarios
E-4 Value Of Mitigation Benefits From Four Priority Investments

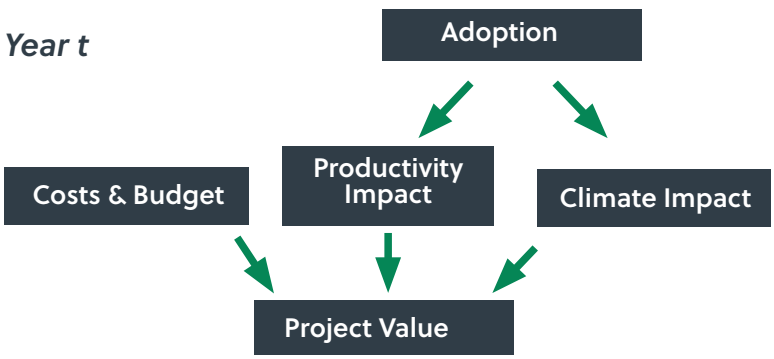
We modeled investment performance using Bayesian Networks (BN), which excel when the goal is to predict outcomes of investments with high degrees of uncertainty, nonlinearity and feedback between components. These characteristics are common features of climate, agriculture and rural development projects. Specifically, we used a BN model for two reasons. First, providing accurate estimates for project costs, returns and adoption is a main challenge in project evaluation. The parameter uncertainty of all of these variables can be explicitly modelled in the BN and is taken into account. That is, instead of assigning a point value for the targeted number of beneficiaries or their income, in BN we assign a probability distribution that represents our degree of confidence around this estimate. Probability distributions are used for all variables in the model. Second, different risk scenarios, climate and non-climate, and their uncertainty can be simulated. The model takes the likelihood (frequency) and impact (severity) of risk factors into account when modeling project performance. In the following sections, we describe the structure, parameterization and simulation of the model.

E-1 Model Design

The BN model aims to prioritize project alternatives based on their net present value (NPV) and discounted return on investment (ROI). The project's impact is monetized, discounted and calculated considering the gradual adoption of the project by the target beneficiaries. Figure E-1 shows an overview of the model. Each node in figure E-1 represents a fragment of BN that contains multiple nodes and relations. The BN assumes that the project is evaluated over five years, a common length of projects. The cumulative NPV and ROI distribution of the project is calculated accounting for the adoption, impact and costs that incur in each year. In the remainder of this section, we describe the content of each fragment in figure E-1.

Figure E-1 BN Overview in Time t

$$AR_t = \frac{1-e^{-(p+q)t}}{1+\left(\frac{q}{p}\right)e^{-(p+q)t}} \quad (1)$$



Adoption. In the model, a project's scope is defined by the targeted total number of beneficiaries. Both of these measures are uncertain and defined by a probability distribution. Interventions, in this case climate-smart agriculture, are gradually adopted over a period of time. The percentage of targeted beneficiaries that adopt the project is modelled by the Bass model[92]. The Bass model uses rate of innovation *p* and rate of imitation q to estimate the adoption rate (AR) over a specified time period *t* to reach the target beneficiary total as:

$$p = \sum_i P(AdoptionRisk = i)\, p_i \quad (2)$$

$$q = \sum_i P(AdoptionRisk = i)\, q_i \quad (3)$$

Project risks, such as lack of community acceptance or drought, can affect the adoption rate. To reflect this, the rate of innovation and imitation are modelled as a mixture distributions conditioned on the risk factors in the model.

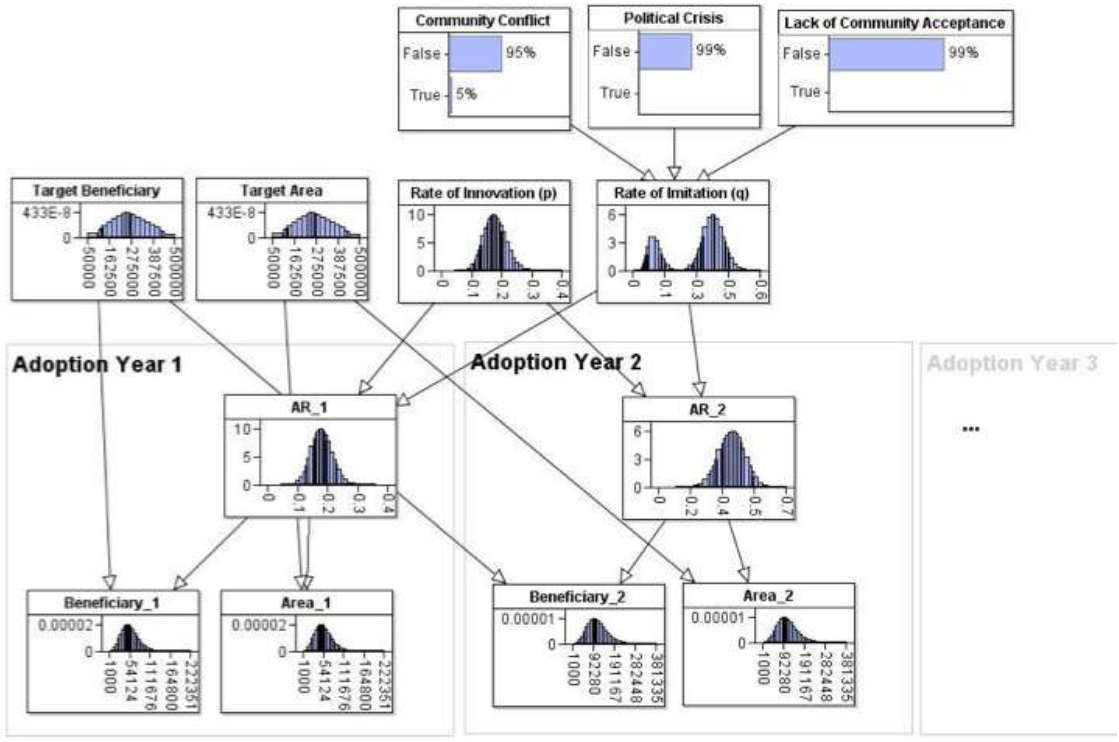
$$Beneficiaries_t = AR_t \times Target_Beneficiary \quad (4)$$

$$Area_t = AR_t \times Target_Area \quad (5)$$

Where p_i is the adoption rate when adoption risk i is present. The adoption rate was modelled with a Beta or a similar probability distribution to reflect its parameter uncertainty. The total number of beneficiaries and area that adopts the project changes every year due to adoption rate. Figure E-2 shows the BN fragment modelling adoption.

$$Productivity_t = IP_t^{adj} - IB_t^{adj} \quad (6)$$

Figure E-2: Adoption BN fragment



A project's impact is evaluated as the difference between a beneficiary's income before the project and after adopting the project.

Several natural risk factors, such as drought and pests, can affect beneficiary income and the performance of CSA interventions. Moreover, the effect of these risk factors could be different for project adopters and non-adopters. For example, while a drought can decrease the income for both project beneficiaries and other farmers, its impact can be more severe for the farmers who did not adopt CSA practices. To model this, we first adjust project and baseline income estimates based on risk factors that realize in different years. Let *IB* and *IP*, respectively, be the income of a beneficiary before and after adopting the project, EB_t and EP_t be the combined effect of natural risk factors at t. The adjusted income for before and after adopting project at t, i.e. IP_t^{adj} and IB_t^{adj} are:

$$IP_t^{adj} = IP \times EP_t \quad (7)$$

$$IB_t^{adj} = IB \times EB_t \quad (8)$$

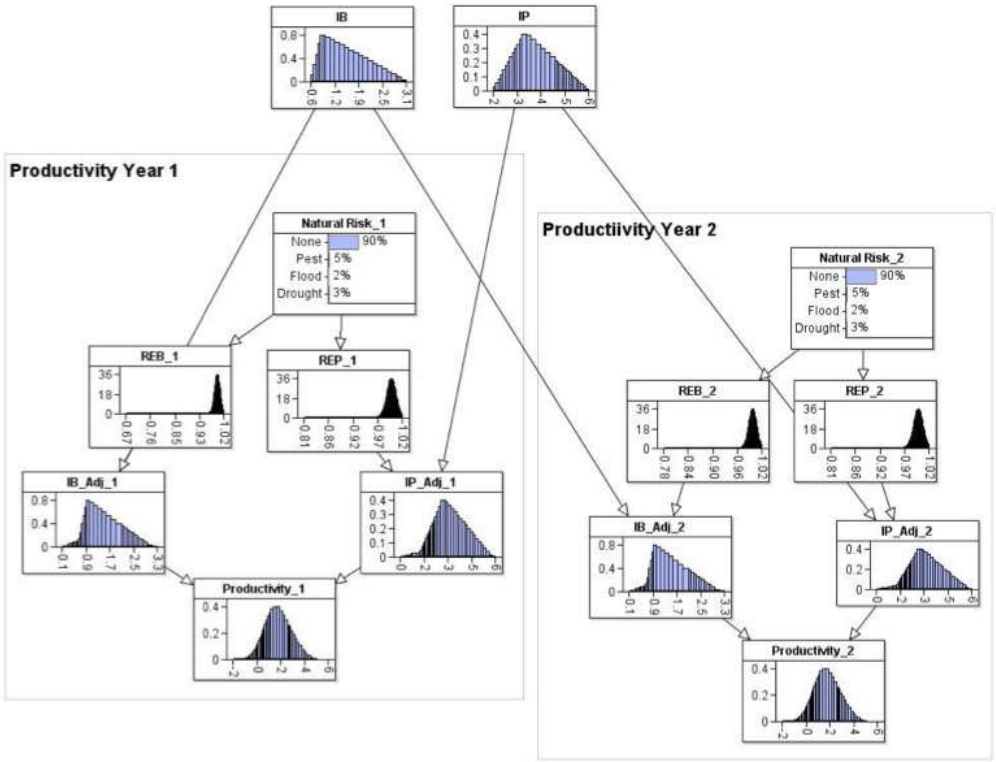
The combined effect of risk factors for project beneficiaries and other farmers are modelled as a mixture distribution conditioned on the natural risk factor:

$$EP_t = \sum_i P(NaturalRisk = i)_t EP_i \quad (9)$$

$$EB_t = \sum_i P(NaturalRisk = i)_t EB_i \quad (10)$$

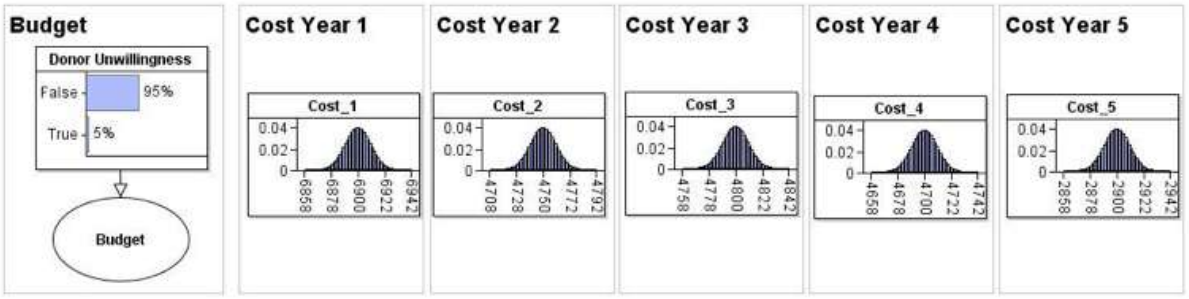
Where $P\ (NaturalRisk = i)_t$ is the probability that natural risk factor i realises at time t, and EP_i and EB_i are the effect of the risk factor i for project beneficiaries and other farmers, respectively. Figure E-3 shows the BN fragment that estimates the productivity impact for different years.

Figure E-3: Productivity impact BN fragment



Costs are estimated on a yearly basis and modelled by probability distributions that represents the degree of uncertainty around these estimates. The standard deviation around the cost estimates are increased each to reflect higher uncertainty regarding long-term estimates. The project costs and budget can be adjusted based on relevant risk factors. For example, a donor's unwillingness risk factor decreases the project budget.

Figure E-4: Project Cost and Budget Estimates



The project's present value in year t is calculated in the project value fragment using the above adoption, productivity and cost estimates calculated in the previous sections.

$$R_t = (Adj_Impact_t - Cost_t) / (1 + Discount_Rate)^t \quad (11)$$

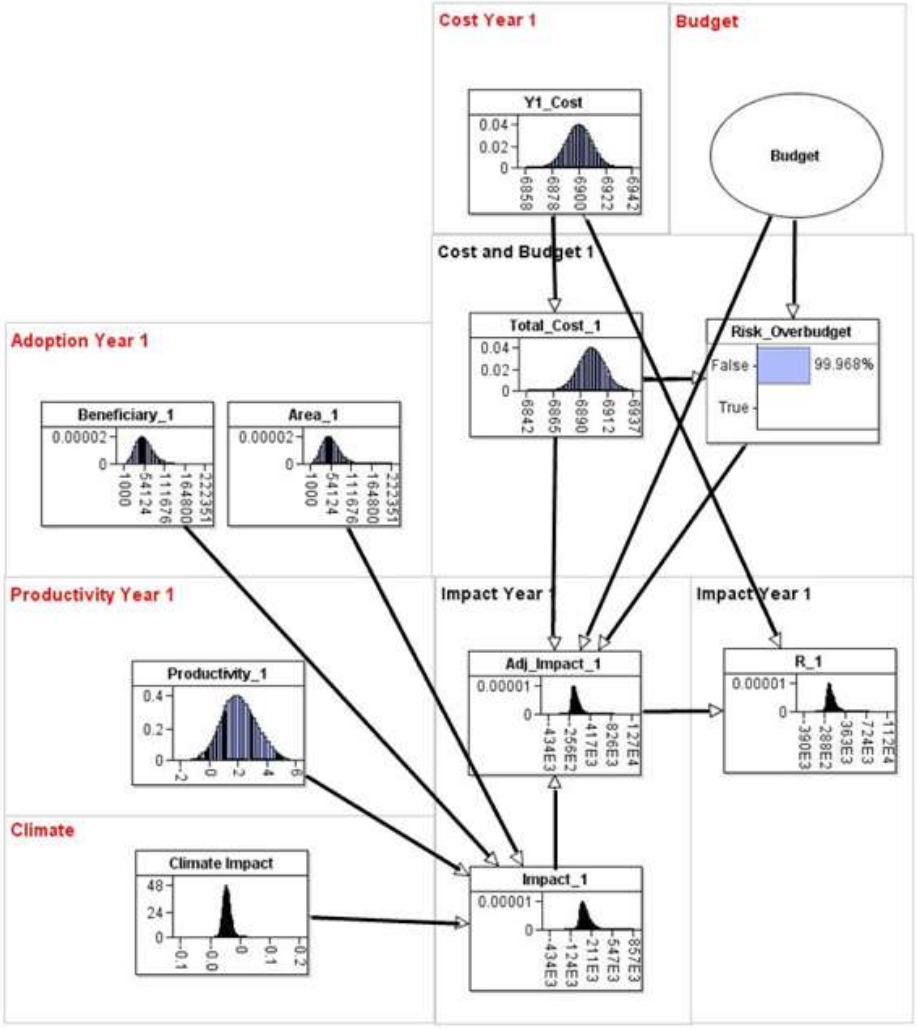
NPV is the sum of discounted benefit over the project duration k and ROI is the ratio of NPV over total discounted cost of the project.

$$NPV = \sum_{t=1}^{k} R_t \quad (12)$$

$$ROI = NPV/Total_Cost_k \quad (13)$$

Figure E-5 shows the BN fragment that calculates Rt. Note that, the parts that are linked to other BN fragments are coloured red in this figure.

Figure E-5: Project Value in Year 1 BN Fragment



E-2 Parameter Estimation

The parameters of the BN model were defined based on a combination of domain expert knowledge and external data sources where available. Expert knowledge was elicited through an online questionnaire of participants following the in-person workshops (annex C). The responses of multiple experts were combined with available external data to elicit the distribution of the BN parameters (table E-1).

Table E-1: Sources of information on model parameters

PARAMETER	EXPERT KNOWLEDGE	EXTERNAL DATA
Number Beneficiaries	x	x
Adoption Rates	x	
Income before project	x	x
Income after project	x	x
Project Costs	x	
Risk Frequency	x	x
Risk Impact on Project	x	

We used a multi-step process to guide experts in estimating project parameters with as little bias as possible. Domain experts were recruited from assessment workshop participants, and parameter estimation took place via online questionnaires after the workshop due to time constraints. The questionnaire followed a tested format for parameter elicitation in BN_s[93], and used two types of questions: interval questions and multiple-choice questions. Interval questions were used to elicit the distributions of continuous parameters, such as income, after based on the specific type of project and target beneficiaries. Participants were asked to define an interval that would include the highest and lowest possible estimates, as well as a best guess for the real value. Multiple-choice questions were used to elicit the probability and effect of discrete risk factors. Questionnaire respondents were trained in these elicitation methods by first explaining common biases and heuristics in estimation, and then giving them a sample parameter to estimate. The elicitation questionnaires were sent to multiple experts, and weighted linear pooling was used on their answers. In this approach, the pooled parameter estimated $f(\theta)$ is the weighted average of individual estimates of the domain experts where w_i and $f(\theta)$ are respectively the weight and parameter estimate of expert *i*:

$$f(\theta) = \frac{\sum_{i=1}^{n} w_i f(\theta)_i}{n} \qquad (14)$$

The weight given to each expert was defined based on the accuracy of their response. In the questionnaire, we elicited beneficiary income before and after the project. From this, the domain expert's estimate on productivity impact of the project could be calculated. We also obtained the same parameter for each project from the scientific literature and used this parameter as a seed parameter for assessing experts' accuracy. We used Bojke et al.'s approach94 to assign weights to experts based on the seed parameter, sampling from the distribution elicited from the experts and the distribution from the scientific literature. In every sample, the expert closest to the CSA sample is given one point. The weight of each expert is calculated by dividing their points to the total number of samples. Finally, we fit a probability distribution to the pooled parameter estimates and used these distributions as inputs to the BN model.

In addition to expert knowledge, we also incorporated external data sources to improve the accuracy of estimates and consistency of estimates across projects.

A. Number of Beneficiaries. We used census data from the specified project regions to estimate the potential number of beneficiaries. However, not all potential beneficiaries will adopt any given technology, so the number of beneficiaries was scaled by adoption rates relevant to the complexity of the system. In addition to the total number of beneficiaries reached, we also estimated implementation curves for each project (table E-2). Projects with slow implementation curves take longer to develop technologies and materials and to begin implementation, so they are slower in reaching the full number of beneficiaries. In contrast, fast projects can quickly begin to reach beneficiaries with technologies that are readily available and/or simple to implement. Projects were assigned to one of the three implementation curves based on experts' judgement of the time needed to implement planned project activities.

[93] Yet et al. 2016.

[94] Bojke L, et all 2010

Table E-2 Implementation Curves Used to Estimate Annual Adoption

% BENEFICIARIES REACHED (PER YEAR)					
SPEED	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Slow	5	10	30	60	100
Medium	10	20	40	70	100
Fast	15	30	50	75	100

B. Adoption Rates were estimated based on expert opinion of the likelihood that project participants would continue using project technologies or services over the lifetime of the project. Roughly estimated as low (10-30%), medium (30-50%) or high (50-70%) adoption rates. In general, projects that involve complex technologies or multiple changes to current practices will have low adoption rates, whereas projects that require few changes will have higher adoption rates.

C. Income before project was based on expert estimation of household income across all projects in country to calculate a mean and variance in household income used for each project.

D. Income post project. For projects that rely primarily on farm-management practices, we estimated change in income after project implementation using the Climate-Smart Agriculture Compendium, a dataset, compiled from more than 1,500 peer-reviewed articles, containing more than 150,000 data points that compare 45 different outcomes of productivity, resilience and mitigation for 100 different farm practices in Africa[95]. This includes data on changes in yield, costs and net returns with adoption of CSA. This one-of-a-kind resource provides a rich evidence base for estimating the performance of practices across a wide range of agroecological conditions and farm management scenarios.

- **Climate-Smart Cassava.** Impact was estimated through a meta-analysis of data on change in yield, income and costs of cassava farming in the West Africa region for CSA practices specified in the concept note (agroforestry, crop residue, crop rotation, intercropping, inorganic fertilizer, manure, improved varieties, fallowing, irrigation, mulching, reduced tillage and ridging).

- **National Soil Fertility Program.** Impact was estimated through analysis of change in yield, income and costs for cereal production (maize, millet, sorghum and rice) after implementation of climate-smart practices (e.g., agroforestry, crop rotation, crop residues, mulching, intercropping, water harvesting, manure, reduced tillage) in West Africa.

- **Financial Services.** Impacts of use of financial services for agriculture on rural household income were estimated based on reported changes in household income from using improved varieties, inorganic fertilizers, agroforestry or water harvesting through ridges, terraces, bunds or other techniques. These practices were chosen because they rely on external inputs (seeds, seedlings, fertilizers, tools and labor) that may be affordable to people utilizing financial services for agriculture.

[95] Rosenstock TS, Lamanna C et al. 2015

- **Agrometeorological Services.** Implementation impact was estimated based on potential use of the resulting information by farmers, particularly by improving planting dates based on weather forecasts and by improving variety choice based on soil and weather information. Mean and variation in impact of agrometeorological information on crop yield and household income was taken from a modeling study of the benefits of climate information for millet growers in Niger[96].

E. Costs. Detailed project budgets and costs were developed in consultation with investment 'champions' after the stakeholder workshop. These champions included experts and government officials with specific domain information relevant for the concept note. Budgets aimed to target programs in the US$20–60 million range to be of rapidly bankable size.

F. Risk frequency. We used a multi-step process to identify risks and estimate likelihood and impact parameters from multiple sources. During the assessment workshops, participants listed risks to each project and gave a qualitative estimation (low, medium, high) of the risk likelihood and risk impact to project (see above). This generated a list of risks that was used to elicit quantitative risk parameters from domain experts and external data sources. Both the domain expert estimations and the external data were used to generate final probability distributions for risk likelihood and impact to the project in the Bayesian Network. Approach used to estimate the parameters for each of the six modeled risks are described below.

- **Drought.** We estimated drought likelihood from the historic drought frequency in Côte d'Ivoire over the period 1991–2010[97]. Drought events were defined as periods when the actual rainfall over the preceding 12 months was more than one standard deviation below the long-term average (Standardized Precipitation Index SPI-12 < -1) based on globally gridded precipitation data. A drought period would begin in a month where the SPI-12 reached -1 and ended in a month where the SPI-12 again reached 0, or average rainfall conditions. The number of such events from 1991–2010 was the reported drought frequency. We calculated mean and variance in number of drought events in each country by dividing the country into 16 grid cells and measuring the mean number of droughts per cell. Drought likelihood was then the average number of drought events per year. For example, if the area averaged 1 drought per decade, then we estimated a 10% chance of drought in any given year.

- **Floods.** Similar to drought likelihood, we estimated flood likelihood from historic flood data in Côte d'Ivoire. Reported flood frequency was obtained from the United Nation's Office for Disaster Risk Reduction's (UNISDR) knowledge platform PreventionWeb[98] for the period 2005–2014. Although some flooding occurs annually in Côte d'Ivoire during the rainy season, particularly in coastal and urban areas, flood events recorded in PreventionWeb are Internationally Reported Losses, and thus would be potentially disruptive to project activities. As in drought, flood likelihood was estimated based on the number of observed flood disaster events per year.

- **Pests.** Data on the frequency of major (and thus project-disrupting) pest outbreaks in Africa is difficult to find. We assessed the likelihood of pest outbreaks using several data sources. Côte d'Ivoire is susceptible to invasions of desert locusts. Locust plagues occurred on five occasions in the period 1900–2000[99], which yields a conservative (because outbreaks may last from one

[96] Roudier P, et al. 2016

[97] Spinoni J, et al. 2014

[98] www.preventionweb.net

[99] United Nations Food and Agriculture Organization. Locust Watch. www.fao.org/ag/locusts

to many years) estimate of likelihood of 5% in any given year. Additionally, novel or 'shock' pest and disease outbreaks have occurred in sub-Saharan Africa approximately 5 times in the past 20 years[100], including the most recent outbreak of fall army worm across the continent. This gives a conservative upper limit estimate of 25% likelihood of a significant pest outbreak in any given year. These estimates were combined to yield the final likelihood of a disruptive pest outbreak in any given year.

- **Political Instability.** Côte d'Ivoire has experienced a political crisis and conflict in the last decade, suggesting a relatively high risk of political instability. To estimate the likelihood of political instability, we used the World Bank's World Governance Indicator[101] Political Stability and Absence of Violence (PSAV). We converted WGI PSAV scores to likelihood of political instability by establishing a linear scale of 100% chance of instability for a score of -3 (generally those countries in active conflict without functioning governments) and a 0% chance of instability to a score of 2 (the highest given in the dataset). We computed the mean and sd in PSAV score in Côte d'Ivoire over the 1996–2017 period and converted this to a mean and sd in likelihood of political instability using our linear scale.

- **Poor governance.** Similar to political instability, we estimated the likelihood of poor governance affecting project implementation using the World Bank's World Governance Indicator10 Government Effectiveness (GE). GE Scores were converted to likelihood of poor governance using a linear scale where the lowest score (-2.5) corresponded to a 100% chance of poor governance affecting the project and the highest score (+2.5) corresponded to a 0% chance of poor governance. We computed the mean and standard deviation in GE score for Côte d'Ivoire over the 1996–2017 period and converted this to a mean and standard deviation in likelihood of poor governance using our linear scale.

- **Community conflict.** Community conflict, particularly between agriculturalists and pastoralists or between different ethnic groups, is a potential project risk identified by stakeholders in Côte d'Ivoire. We estimated likelihood of community conflict using the Institutional Profiles Database[102] indicators of social conflict (A203). The social conflict variable includes estimations of ethnic and religious conflict, conflict over land in rural areas, and other types of social conflict. We converted social conflict scores to likelihood of conflict using a linear scale, where a score of 0 (serious social conflict) was a 100% chance of conflict and a score of 4 (no social conflict) was a 0% chance of conflict. We used the standard deviation of a country's scores across the five variables that contribute to the social conflict indicator to estimate the uncertainty around the likelihood of conflict.

G. Risk impact was estimated as both the potential effect of the occurrence of a risk on a project beneficiary's income, as well as the effect on project adoption. While some risks such as drought will primarily affect project impact (e.g., reducing yields), others such as community conflict will primarily affect project participation (e.g., inability to access project sites or activities).

[100] Smith J. 2015.

[101] World Bank Group. Worldwide Governance Indicators. http://info.worldbank.org/governance/wgi/

[102] Institutional Profiles Database: http://www.cepii.fr/institutions/EN/ipd.asp

Table E-3: Risk Frequency and Impact Estimates

	RISK IMPACT ON INCOME/ADOPTION[a]					
RISK	ANNUAL CHANCE (% ± SD)	BUSINESS AS USUAL[b]	CLIMATE- SMART CASSAVA	SOIL FERTILITY PROGRAM	FINANCIAL SERVICES	AGROMET SERVICES
Drought	30 ± 6	--/NA	-/+	-/+	-/+	0/++
Flood	10 ± 10	--/NA	-/+	-/0	-/+	0/+
Pests	15 ± 10	--/NA	-/0	-/0	-/+	-/+
Political instability	67 ± 12	0/NA	0/-	0/-	0/-	0/-
Poor governance	69 ± 6	0/NA	0/-	0/-	0/-	0/-
Community conflict	50 ± 18	0/NA	0/-	0/-	0/-	0/-

[a] Symbols represent probability distributions for impact on beneficiary income and adoption rates in the analysis. For income: -- up to complete loss of income, - up to a moderate loss of income, 0 small gain to small loss, + up to moderate gain in income, ++ up doubling or more of income. For adoption -- up to complete loss of participation, - small to moderate loss of participation, 0 small loss to small gain in participation, + small to moderate gain in participation, ++ moderate to large gain in participation.

[b] Business as usual represents the impact of risks on a farmer similar to project beneficiaries, but who does not participate in the project, e.g., a without-project scenario.

E-3 NPV and ROI results for the four priority projects under various risk scenarios

Each project was run under four risk scenarios: no risks, climate risks only, social risks only and all risks possible. If a risk was not included in a scenario, its likelihood of occurrence was explicitly set to zero for that run. Otherwise, all risks were allowed to occur according to their frequencies in table E-3. For each scenario and project, we calculated the mean and variance in NPV and ROI, as well as the likelihood of a positive NPV given the risks (table E-4).

Table E-4 NPV and ROI For CSA Projects Under Various Risk Scenarios

RISK SCENARIO	NPV (M$ ± SD)	ROI (% ± SD)	% POSITIVE NPV
Climate-Smart cassava			
No Risks	10.4 ± 58.3	41 ± 229	57
Climate Risks Only	16.3 ± 54.5	64 ± 215	61
Social Risks Only	2.4 ± 42.8	9 ± 169	52
All Risks	6.7 ± 40.4	26 ± 159	56
National soil fertility program			
No Risks	40.4 ± 34.1	130 ± 110	89
Climate Risks Only	39.7 ± 36.1	128 ± 117	88
Social Risks Only	22.8 ± 25.8	73 ± 83	82
All Risks	22.3 ± 26.9	72 ± 87	8
Financial Services for Agriculture			
No Risks	794.7 ± 1120.9	2071 ± 2929	77

Climate Risks Only	1000.4 ± 1093.9	2605 ± 2856	83
Social Risks Only	624.3 ± 902.0	1627 ± 2354	76
All Risks	789.1± 880.6	2065 ± 2299	83
Agrometeorological Services			
No Risks	46.7 ± 47.2	329 ± 334	85
Climate Risks Only	133.6 ± 98.7	941 ± 698	94
Social Risks Only	35.2 ± 38.3	248 ± 275	83
All Risks	104.7 ± 92.7	737 ± 661	93

E-4 Value of mitigation benefits from four priority investments

Economic value of mitigation benefits for each investment were estimated using the social costs of carbon (US$40/ton CO_2). This analysis was based on best available data for likely changes in emissions based on the types of actions the interventions would stimulate for the expected number of project beneficiaries. Overall, the relative value of mitigation benefits ranged between US$0.9 million to US$72.9 million, depending on intervention and risks (table E-5). This suggests that mitigation co-benefits could add an additional roughly 10% of benefits from the projects. However, it must be noted that these analysis are very uncertain given the lack of information on emissions and sequestration rates in the targeted agroecosystems and the lack of information concerning the number of beneficiaries implementing each type of intervention.

Table E-5 Value of mitigation benefits assuming carbon price of US$40/ton CO_2

	VALUE (MILLION US$)	
Investment	NO RISKS	ALL RISK
Climate-Smart Cassava	1.4 ± 0.2	0.9 ± 0.2
National Soil Fertility Program	3.6 ± 0.5	2.6 ± 0.5
Financial Services for Agriculture	72.9 ± 23.1	57.8 ± 19.2
Agrometerological Services	19.6 ± 5.9	15.6 ± 5.0

Annex F: Climate Smart Agricultural Investment Plans in Côte d'Ivoire

NATIONAL-SCALE CLIMATE-SMART INVESTMENTS

F-1 National Soil Fertility Program
F-2 Development of Climate-Smart Agricultural Finance Services and Products
F-3 Development of a National Agrometeorological System for CSA
F-4 Development of a National Climate-Smart Agricultural Extension System

CROP AND LIVESTOCK CLIMATE-SMART INVESTMENTS

F-5 Climate-Smart Cassava Production and Processing Program Project Concept
F-6 Climate-Smart High-Value Vegetable and Livestock for Abidjan Market
F-7 Sustainable Cocoa Production
F-8 Development of a Climate-Smart Livestock Sector in northern Côte d'Ivoire
F-9 Climate-Smart Development of the Mango Value Chain
F-10 Climate-Smart Maize Development
F-11 Irrigated and Rainfed Rice Development
F-12 Development of Climate Smart Production And Processing Of Yam

NATIONAL-SCALE CLIMATE-SMART INVESTMENTS

INVESTMENT	BENEFICIARIES	PROPOSED DEVELOPMENT OUTCOME (PDO)
Soil fertility	**87,000** agricultural workers and their households nationally	**Increase agricultural producers' ability to practice CSA** by providing producers and extension agents with location-tailored information on soil characteristics and best management practice recommendations, and the tools, products, partnerships and policy environment to implement recommendations.
Financial services	**980,000** agricultural workers and their households nationally	**Sustainably increase productivity by improving agricultural producers'** access and ability to successfully leverage financial products and services, and increase their ability to manage climate-related risks.
Agromet	**312,000** agricultural workers and their households nationally	**Increase farm productivity and mitigate climate-related risks by providing timely, accurate agrometeorological information** to producers, extension agents and agribusiness.
Extension services	**235,800** agricultural workers and their households nationally	**Improving the quality and quantity of CSA-informed recommendations** that farm advisors give producers will increase farm productivity and minimize climate-related risks.

F-1 National soil fertility program

Introduction and strategic context: geospatial information and geoinformatics for Climate-Smart Agriculture

Soil health is essential to climate-smart agriculture. Healthy soils regulate nutrient and water cycles, increasing soil fertility while contributing to carbon sequestration and agricultural productivity and buffering climate change and variability.

Agriculture typically has negative effects on soils. Cropping and tillage deplete nutrients and reduce carbon, which are exported off the field in crop biomass. There is a general trend of nutrient loss in sub-Saharan cropping systems. Even with current rates of manure and fertilizer applications, African agriculture falls short of replenishing nutrient uptake by crops by at least 20kg/ha N, 10kg/ha P, and 20kg/ha K every year[103]. As a result, soil degradation threatens at least 25% of African arable land and impedes agricultural production and intensification[104].

African smallholders have limited access to amendments to improve soil fertility. Lack of subsidies, poor infrastructure, low biomass production and limited opportunities to acquire credit put the quantities of fertilizers necessary to optimize crop productivity out of reach for most smallholders. As such, optimizing crop productivity through integrated soil fertility management (ISFM)—that is, targeted, location-specific optimization of interactions between fertilizers, organic inputs and improved varieties—is crucial to achieving soil fertility and crop productivity. Identifying ISFM best practices for a given farm require significant location-specific knowledge of soil characteristics, such as soil type, depth, texture, fertility, organic matter content, etc.

Soil information systems (SIS) have been shown to enable ISFM on a large scale. The World Agroforestry Centre (ICRAF) has developed spectral diagnostics[105] using infrared and x-ray technology that allow for rapid and low-cost analysis of soil properties and plant nutrients, which can then be applied at scale for digital mapping[106]. The level of detail, accuracy and geographic scale that this technology offers at low cost promises to shift the soil management paradigm[107]. The Africa Soil Information Service (AfSIS)[108] has applied this technology to generate detailed national SIS in Ethiopia, Ghana, Nigeria and Tanzania and at smaller scales in Côte d'Ivoire. Organizations such as SoilCares[109], the Crop Nutrition Services Laboratory, the Gates Foundation, One Acre Fund[110] and FoodAfrica have leveraged ICRAF's spectral diagnostic technology to generate soil maps[111], plan projects and conduct testing services across Africa

[103] Stoorvogel and Smaling, "Assessment of Soil Nutrient Depletion in Sub-Saharan Africa: 1983-2000."

[104] Vanlauwe et al., "Looking Back and Moving Forward"; Jones et al., Soil Atlas of Africa.

[105] Soil-Plant Spectral Diagnostics Lab, "Network of Dry Spectroscopy Laboratories."

[106] World Agroforestry Centre, "Soil-Plant Spectral Diagnostics Laboratory."

[107] World Agroforestry Centre, "Testimonials."

[108] Africa Soils, "Africa Soil Information Service."

[109] SoilCares, "Soil analysis for farmers."

[110] One Acre Fund, "2017 Annual Report."

[111] ISRIC, "SoilGrids"; Africa Soils, "Africa Soil Information Service."

Country Context

Ivorian soils present considerable agricultural management challenges. Soil characteristics are typical of sub-humid tropical forests: deeply weathered, low-fertility, clay-rich, iron-rich, aluminum-rich and acidic. Plinthosols, acrisols, alisols and ferralsols are particularly abundant. These soil types range in characteristic issues from irreversible hardpanning to erosion susceptibility to aluminum toxicity. Low-input, aluminum-tolerant crops such as cashew, rubber, oil trees, and pineapple are the best crop options for these soils[112]; food crops can be difficult to produce.

Ivorian smallholders' degree of access to fertilizers creates demand for IFSM efforts. Ongoing efforts on the part of governments, NGOs and international organizations have significantly improved fertilizer access and usage in the last decade. Average fertilizer consumption has increased from 15kg/ha of arable land in 2009 to 50kg/ha in 2015. This remains far below both the global average of 133kg/ha[113] and the amount necessary to optimize crop productivity (i.e., fertilizer industry-recommended application rates). Nonetheless, the 330% improved accessibility offers an important opportunity for implementing of ISFM practices using targeted dosing of inorganic fertilizers as informed by a national SIS.

Institutional and Sectoral Alignment

Improving producers' access to SIS is a high priority for the Ivorian Ministry of Agriculture. MINAGRI has undertaken significant efforts to improve soil management support tools; most recently, the CNRA has undertaken updating maps of recommended areas for coffee and cocoa production based on soil characteristics. The 2017–2025 governmental investment plan has prioritized scientific investigation of soil quality and fertility issues, and it recognizes particular need for soil quality interventions in Agropoles 2, 4, 6 and 7[114].

This national priority aligns with the aims of multiple international alliances and organizations. This project directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 12: Responsible Production; Goal 13: Climate Action; and Goal 15: Life on Land. It indirectly supports Goal 8: Economic Growth and Goal 10: Reduced Inequalities[115]. The Economic Community of West African States has partnered with the International Fertilizer Development Center and the West Africa Fertilizer Program to model and map site-specific fertilizer recommendations for major food crops across West Africa, including in Côte d'Ivoire[116]. USAID has invested heavily in soil modeling and mapping in Côte d'Ivoire through the West Africa Fertilizer Program[117]. Crop boards, such as the World Cocoa Foundation, have recognized the need for ISFM in Côte d'Ivoire in the face of fertilizer prices that exceed the means of most smallholders[118].

[112] FAO, "Mineral Soils Conditioned by a Wet (Sub)Tropical Climate."

[113] World Bank, "Fertilizer Consumption (Kilograms per Hectare of Arable Land)"; FAO, "Ivory Coast Fertilizer Use - Data, Chart."

[114] Côte d'Ivoire Ministry of Agriculture and Rural Development, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report."

[115] Knoema, "Sustainable Development Goals of Côte d'Ivoire - Côte d'Ivoire Data Portal."

[116] ISRIC, "Taking Fertilizer Recommendations to Scale for Major Crops in West Africa."

[117] ISRIC.

[118] World Cocoa Foundation, "Soil Fertility Management for Cocoa Production in Ivory Coast."

Proposed Development Objectives and Results

Proposed development objective: This project aims to increase agricultural producers' ability to practice CSA by providing producers and extension agents with location-tailored information on soil characteristics and best management practice recommendations, as well as the tools, products, partnerships and policy environment to implement those recommendations.

Beneficiaries: The initial phase of this project will benefit the 87,000 farmers ages 15 and up who reside in Agropole 2[119]. The mobile-based SIS subcomponent will reach approximately 29%[120] of the beneficiaries. Integration of SIS into existing climate information services, participatory training, public awareness campaigns and/or extension agent advisory services will reach the remaining beneficiaries, who are non-mobile subscribers. Subsequent project phases will expand to Agropoles 4, 6 and 7. Over time, all 7.3 million rural Ivorian agriculturalists ages 15 and up and their households could indirectly benefit from the project.

Project description: This project is designed to support producers' soil management decisions with a national SIS. This will contribute to the goal of promoting CSA practices in Côte d'Ivoire. The project will address (i) development of an SIS, (ii) development and dissemination of decision-support tools and products including via stakeholder partnerships, (iii) extension agent capacity to utilize and recommend these tools and products, and (iv) producer capacity to fully leverage these tools and products in management decision support. The project has been informed by outputs of an in-country expert convening, as well as the extensive institutional knowledge of Côte d'Ivoire's MINADER, CGIAR and other agricultural research and development organizations.

Project Components

COMPONENT 1: Support Soil Management Research
Key actors: universities, CNRA, CGIAR, MINADER

This component will gather the foundational knowledge necessary to establish a national SIS. Subcomponents will include: (i) conduct soil fertility management optimization trials in all soil regions, (ii) conduct biological soil process management optimization trials in all soil regions, (iii) employ spectral technology to characterize soil profiles nationally at 1 km specificity, (iv) develop and communicate best management practice recommendations for each 1 km area based on results of i-iii, and (v) develop tools and products (e.g., fertilizer blends, lab analyses, field test kits, hedge saplings, clean cover crop seed, soil amendments) to support recommended management practices[121].

[119] The population of Agropole 2 is approximately 1.23 million. Given that 46% of the total Ivorian population works in agriculture, we assume that approximately 75% of rural populations are employed by agriculture. 32% of the Ivorian population is women over the age of 14. Index Mundi, "Côte d'Ivoire Demographics Profile 2018"; Statoids, "Côte d'Ivoire Regions."

[120] As of 2016, mobile technology unique subscriber penetration was 83% of the adult Ivorian population; we can assume the rate is very similar for youth ages 15-17. Assuming unique subscriber penetration among urban individuals (54% of population) is 100%, thn about 29% of rural individuals ages 15 and up are current mobile subscribers. Index Mundi, "Côte d'Ivoire Demographics Profile 2018"; Arese Lucini and Bahia, "Côte d'Ivoire: Driving Mobile-Enabled Digital Transformation"; World Population Review, "Ivory Coast Population 2018 (Demographics, Maps, Graphs)."

[121] Expert Panel Workshop, Theorie du Changement SolsCSA Côte d'Ivoire; Africa Soils, "Africa Soil Information Service"; ISRIC, "Taking Fertilizer Recommendations to Scale for Major Crops in West Africa."

COMPONENT 2: Develop National Soil Information Service

Key actors: MINADER, CNRA, universities, CGIAR

This component will develop a national SIS tool to support producer management decisions. Specifically, this will involve: (i) establishing and training governmental staff dedicated to developing and maintaining the SIS, (ii) generate publicly accessible SIS, including digital soil maps, based on the results of Component 1, (iii) maintain and update SIS based on new research findings, (iv) formalize a communication channel between staff and research organizations to ensure that the most up-to-date information and recommendations are integrated into the SIS in a timely fashion, and (v) establish private industry partnerships (e.g., agribusiness, analysis laboratories, research facilities) to create or significantly increase availability of the tools and products recommended by research organizations to producers and extension agents[122]. Examples: AfSIS' EthioSIS, Ethiopia; GhaSIS, Ghana; NiSIS, Nigeria; and TanSIS, Tanzania[123].

COMPONENT 3: Extension Worker Technical Assistance and Linkages

Key actors: MINADER, ANADER, NGOs

This component will increase extension agent capacity to use the SIS to support producer best management practices. Subcomponents include (i) technical assistance on accessing and navigating the SIS, (ii) orientation on accessing and utilizing the tools and products developed by research organizations and made available through private industry collaborations, and (iii) formalizing a multi-way communication system between extension agents, research organizations and producers[124].

COMPONENT 4: Producer Technical Assistance

Key actors: MINADER, ANADER, NGOs

This component will increase producer capacity to leverage the SIS to support management decision-making. Specifically, it will (i) conduct public awareness campaigns on general good management practices (e.g., composting, biofertilizers, targeted fertilizer micro-dosing, crop rotation, crop association, improved fallow, leguminous cover cropping, intercropping, agroforestry), (ii) integrate best management practice recommendations by soil region into existing communication and technical assistance channels (e.g., participatory training, extension advising, climate information systems), (iii) develop practical decision-making support tools based on the SIS for use by producers and extension agents (e.g., mobile information system, national call center, participatory training tools), and (iv) via all channels specified in i-iii, ensure producer awareness of tools and products recommended by research institutions and practical steps for accessing them[125].

[122] Expert Panel Workshop, Theorie du Changement SolsCSA Côte d'Ivoire; World Agroforestry Centre, "Soil-Plant Spectral Diagnosticsç

[123] Laboratory"; Hengl et al., "Soil Nutrient Maps of Sub-Saharan Africa"; Soil-Plant Spectral Diagnostics Lab, "Network of Dry Spectroscopy Laboratories."

[124] Africa Soils, "Africa Soil Information Service."

[125] Expert Panel Workshop, Theorie du Changement SolsCSA Côte d'Ivoire.

COMPONENT 5: Support Producer Long-term Decision Making

Key actors: MINAGRI

This component will increase producer likelihood to invest in long-term soil health. Specific steps include: (i) strengthening property rights and registries to increase producer willingness to invest in their land, (ii) conducting public awareness campaigns of soil as a nonrenewable resource, (iii) increasing producer access to credit via means such as: (a) strengthening microfinance sector performance via greater regulation[126], (b) regulating banking agents to improve the percentage of rural adults with access to formal financial service points (this is already underway via FISF)[127], and (c) allowing and encouraging the use of crops, inventory or equipment as collateral[128].

F-2 Development of Climate-Smart Agricultural finance services and products

Mobility of capital and financial risk management are crucial to agricultural development and transformation because they spur entrepreneurship, risk-taking and innovation. In developing countries where agriculture comprises a large portion of the national economy, the inherent risk and high volatility of the agricultural sector often translates into underperformance at the macroeconomic level[129]. However, good access to financial products and services enables agricultural producers and agribusinesses to leverage collateral, decrease transaction costs and reduce risk[130]. Producers and other value chain actors are consequently more able and willing to invest in inputs and other technologies that increase productivity and resilience, such as improved seeds, soil amendments, diversification, agroforestry and other CSA approaches. Financial services broadly include (i) credit and financing, (ii) insurance and risk instruments, (iii) savings services and (iv) payment services.

Credit and financing services provide capital for investment in CSA and/or improvements in productivity. Customizing credit and financing services to meet the specific needs of producers directly or indirectly improves resilience, value of collateral and ability to invest[131]. These services include input loans and credit, crop loans, value-chain finance, equity investments, equipment loans or leases, warehouse receipts and group loans[132].

[126] Expert Panel Workshop.

[127] World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[128] World Bank.

[129] MINADER and FAO, "Stratégie Nationale Pour L'Agriculture Intelligente Face Au Climat (SNAIC) En Côte d'Ivoire"; WSBI-ESBG, "Africa Post Offices Give Migrants New Financial Network Access."

[130] Palmer, "Making Climate Finance Work in Agriculture"; Ruben, Wattel, and van Asseldonk, "Rural Finance to Support Climate Change Adaptation: Experiences, Lessons and Policy Perspectives"; Wattel and van Asseldonk, "Financial Service Supply with Potential for Supporting Climatesmart Agriculture Quick Scan around the CCAFS Climate-Smart Village AR4D Sites of the CGIAR-CCAFS Research Program in 20 Countries"; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[131] Palmer, "Making Climate Finance Work in Agriculture."

[132] Palmer; Ruben, Wattel, and van Asseldonk, "Rural Finance to Support Climate Change Adaptation: Experiences, Lessons and Policy Perspectives"; Wattel and van Asseldonk, "Financial Service Supply with Potential for Supporting Climatesmart Agriculture Quick Scan around the CCAFS Climate-Smart Village AR4D Sites of the CGIAR-CCAFS Research Program in 20 Countries"; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

Risk instruments sustain producers' ability to invest in CSA by protecting them against the major costs of unforeseen events. Agriculture-specific risk instruments such as index-based insurance and disaster-relief funds protect producers against unforeseen events such as extreme weather[133]. Partial guarantee funds, warehouse receipts and value-chain finance enable producers to leverage their collateral, decreasing creditor risk in lending to producers[134]. General risk instruments such as social security, pensions, funeral societies and life, health and accident insurance protect producers against other costly unexpected life events that can indirect reduce their ability to invest time and money in CSA[135].

Savings services sustain and improve producers' ability to invest in CSA. Planned savings as well as savings accounts ensure savings security, and low-risk investments prevent loss of value due to inflation[136]. In-home cash savings, on the other hand, expose producers to loss from theft and misplacement. Additionally, unlike low-risk investments, cash does not accrue interest and thus loses value across time via inflation.

Payment services improve producers' ability to invest in CSA by eliminating the risks of cash and the costs of traveling. Mobile money, utility bill pay, domestic and international transfer services, and community currencies enable producers to make and receive payments without the risk of cash loss or theft, and without investing time and money in traveling[137]. These services also enable secure and documented person-to-person capital flow, fostering local informal economies and financial exchange between distant family members[138].

Country context for financial services

Financial services in Côte d'Ivoire disproportionately serve urban populations. Of the more than 4,000 access points in the country, nearly 60% serve the residents of Abidjan, who comprise only 20% of the total population[139]. Banks and ICT-based services together comprise 82% of all access points, and tend to be found primarily in urban centers[140]. Microfinance institutions, postal service locations and cooperatives are found in both urban and rural areas[141].

[133] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire; Palmer, "Making Climate Finance Work in Agriculture"; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[134] Palmer, "Making Climate Finance Work in Agriculture"; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[135] Wattel and van Asseldonk, "Financial Service Supply with Potential for Supporting Climatesmart Agriculture Quick Scan around the CCAFS Climate-Smart Village AR4D Sites of the CGIAR-CCAFS Research Program in 20 Countries."

[136] Ruben, Wattel, and van Asseldonk, "Rural Finance to Support Climate Change Adaptation: Experiences, Lessons and Policy Perspectives"; Wattel and van Asseldonk, "Financial Service Supply with Potential for Supporting Climatesmart Agriculture Quick Scan around the CCAFS Climate-Smart Village AR4D Sites of the CGIAR-CCAFS Research Program in 20 Countries."

[137] CCAFS, "10 Best Bet Innovations for Adaptation in Agriculture: A Supplement to the UNFCCC NAP Technical Guidelines"; Wattel and van Asseldonk, "Financial Service Supply with Potential for Supporting Climatesmart Agriculture Quick Scan around the CCAFS Climate-Smart Village AR4D Sites of the CGIAR-CCAFS Research Program in 20 Countries."

[138] Palmer, "Making Climate Finance Work in Agriculture."

[139] MINADER and FAO, "Stratégie Nationale Pour L'Agriculture Intelligente Face Au Climat (SNAIC) En Côte d'Ivoire"; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[140] MINADER and FAO, "Stratégie Nationale Pour L'Agriculture Intelligente Face Au Climat (SNAIC) En Côte d'Ivoire"; WSBI-ESBG, "Africa Post Offices Give Migrants New Financial Network Access."

[141] WSBI-ESBG, "Africa Post Offices Give Migrants New Financial Network Access."

Ivorian agricultural producers are underrepresented among financial service clientele. Agriculture employs 48% of active adults and accounts for 23% of the GDP, yet only about 6% of bank lending and 10% of microfinance lending go to agricultural producers[142]. Less than 10% of producers obtain credit from banks, cooperatives or other financial service providers[143]. About 33% of producers hold a bank account, but many do not use or fully leverage this service; nearly 75% of producers hold their savings as cash at home[144].

Financial services for Ivorian agricultural producers is not without risk. Since 1991, three major public-sector agricultural credit institutions have failed or been closed[145]. Highly unpredictable factors, such as weather and natural disaster, strongly affect agriculture[146]. Agricultural producers are geographically dispersed in sparsely populated regions, drastically reducing potential for economies of scale. Producers' diverse needs require careful segmentation and customization of services[147]. Along with ICTs, the financial services providers already serving rural areas—microfinance, post offices, and cooperatives—are best poised overcome these challenges[148].

Microfinance institutions, cooperatives, postal service locations and ICTs offer the necessary foundation to reach rural populations with diverse financial services. Already, these sectors service a significant fraction of the population (microfinance serves 3.5% of the population, and there are 3,000 cooperatives). There are opportunities to increase efficiency and performance, expand coverage and build out new services around short-term loans, informal financial mechanisms (e.g., savings clubs), transfers and existing practices (e.g., remittances). Challenges include poor coverage, trust and transparency.

Institutional and Sectoral Alignment

Improving rural populations' access to existing financial services is a high priority for the Ivorian Ministry of Agriculture (MINAGRI) and Ministry of Economy and Finance (MINEFI)[149]. The Ivorian's Five-Year Financial Inclusion Strategy[150] is already underway, and focuses on financial sector restructuration, diversification of services, strengthened regulation, consumer education and protection, more business-friendly environs, and expansion of financial services to marginalized populations.

[142] FAO et al., "Climate-Smart Agriculture in Côte d'Ivoire"; MINADER and FAO, "Stratégie Nationale Pour L'Agriculture Intelligente Face Au Climat (SNAIC) En Côte d'Ivoire."

[143] MINADER and FAO, "Stratégie Nationale Pour L'Agriculture Intelligente Face Au Climat (SNAIC) En Côte d'Ivoire."

[144] MINADER and FAO.

[145] World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[146] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[147] Palmer, "Making Climate Finance Work in Agriculture."

[148] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire; FAO et al., "Climate-Smart Agriculture in Côte d'Ivoire"; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[149] World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[150] Government of Côte d'Ivoire, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report."

This national priority aligns with the aims of multiple international alliances of which the Côte d'Ivoire is a part. Improving agricultural producers' access to financial services directly supports Côte d'Ivoire's commitments to Sustainable Development Goal 2: Zero Hunger; Goal 8: Economic Growth; Goal 10: Reduced Inequalities; Goal 13: Climate Action; and Goal 15: Life on Land[151]. It indirectly supports Goal 1: No Poverty; Goal 9: Innovation; Goal 11: Sustainable Communities; Goal 12: Responsible Production; and Goal 16: Peace and Justice[152]. The African Union has prioritized equitable economic growth alongside sustainable environmental management, as well as resource mobilization with an emphasis on funding[153]. The West African Economic and Monetary Union holds the goal of strengthening the economic and financial competitiveness of its member states, including Côte d'Ivoire[154].

Multiple international organizations have collaborated with Côte d'Ivoire in addressing this priority issue. The Global Agriculture and Food Security Program has invested about US$53 million in expanding finance services for agricultural producers in Côte d'Ivoire. Projects include risk-sharing agreements for up to 100,000 smallholder cocoa farmers, with an expected average income increase of 23% ; truck leasing for up to 100 cooperatives, enabling them to, among other things, build a credit history; and US$40 million in loans for women-owned agribusinesses via Société Ivoiriene de Banque[155]. Consultative Group for Assisting the Poor recently partnered with Olam in Côte d'Ivoire to facilitate the development of digital finance services in agricultural value chains[156]. Making Finance Work for Africa has 11 active or completed projects directly addressing agricultural grant, guarantee, equity and loan services in Côte d'Ivoire. The Egyptian Agriculture Bank sees significant opportunity in Côte d'Ivoire's agriculture sector and is planning to expand operations outside of Egypt for the first time[157].

Proposed Development Objective and Results

Proposed Development Objective: This project aims to increase agricultural producers' ability to manage climate-related risks and sustainably increase productivity by improving their access to and ability to successfully leverage financial products and services.

Beneficiaries: During the project, 980,000 agricultural workers will benefit, and with time, all agricultural producers in Côte d'Ivoire could directly or indirectly benefit from this project. The significant difference between the percentage of agricultural producers with a bank account and the percentage with a credit line (~23% or 2.8 million) in Côte d'Ivoire suggests that producers have interest in financial services and some degree of access, but are unable to fully leverage risk-reducing financial instruments. The initial phase of this project (five years) will focus on improving this segment of producers' access by promoting expansion of existing financial networks in underserved regions. Subsequent project phases will expand on a national scale. A well-designed financial service can directly benefit large numbers of people in a short amount of time with relatively low cost, particularly when ICTs are leveraged. For example, one million people had m-Pesa accounts within 8 months of

[151] Knoema, "Sustainable Development Goals of Côte d'Ivoire - Côte d'Ivoire Data Portal."

[152] Knoema.

[153] Department of Rural Economy and Agriculture, "Fostering the African Agenda on Agricultural Growth and Transformation and Sound Environmental Management."

[154] West African Economic and Monetary Union, "The Amended Treaty."

[155] Global Agriculture and Food Security Program, "Projects."

[156] Consultative Group for Assisting the Poor, "Focus Areas."

[157] Making Finance Work for Africa, "Côte d'Ivoire Financial Sector Profile."

the project launch; as of 2017 (its tenth year), m-Pesa had 30 million users, 19 million of whom are active monthly[158].

Project description: The goal of this project is to strengthen the foundations for a national CSA financial services system to provide savings, credit and insurance products for agricultural producers seeking to adopt CSA practices and manage climate-related risks. The initial phase would focus on capacity building (for producer associations), policy review and reform, and the identification and development, with private sector partners, of new savings, credit and insurance products for producers at all scales of operation.

Project Components

COMPONENT 1: Build Capacity with Technical Assistance
Key actors: NGOs, private sector financial institutions

This component will build the capacity of producers, cooperatives and finance professionals for financial services. Specific components will: (i) integrate technical assistance to improve agriculture cooperatives' performance and transparency into existing training programs such that they meet minimum requirements to participate in formal financial markets (e.g., banking)[159]; (ii) build capacity of finance staff to respond to the distinct and very diverse needs of farmers, such as segmenting farming populations, assessing their needs and constraints, and customizing financial products accordingly[160]; (iii) build potential borrowers' (i.e., producers) capacity to navigate and leverage financial services by integrating financial management skills capacity building into existing technical assistance programs[161]; (iv) strengthen microfinance-sector performance in rural areas via technical assistance[162]; and (v) bring additional finance for CSA into the agriculture sector by preparing fund managers who understand the sector to identify profitable and sustainable deals and develop innovative investment vehicles, such as layered capital structure[163].

COMPONENT 2: Foster an Enabling Policy Environment
Key actors: MINAGRI, MINEFI, BCEAO, Interbranch, DOPA

This component will foster a favorable policy environment for the provision of financial services to producers and agribusinesses. Specifically, this will involve: (i) establishing a federal agriculture disaster fund[164]; (ii) strengthening microfinance sector performance via greater regulation and presence and strength in rural areas via startup grants[165]; (iii) investigating impacts of removing or loosening the current 24% interest rate cap[166]; (iv) regulating banking agents to (a) improve the percentage of rural adults with access to formal financial service points (this is already underway via

[158] Harford, "Money via Mobile."

[159] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[160] Palmer, "Making Climate Finance Work in Agriculture."

[161] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire; Palmer, "Making Climate Finance Work in Agriculture."

[162] World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[163] Palmer, "Making Climate Finance Work in Agriculture."

[164] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire.

[165] World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[166] World Bank.

FISF)[167], (b) allow and encourage the use of crops, inventory or equipment as collateral[168], (c) mobilize deposits, which constitute one of the main funding costs for financiers[169], (d) establish agricultural refinancing line prediction and (e) secure a funding quota for agriculture[170]; (v) conducting awareness campaigns to recognize agriculture as a vibrant and dynamic economic sector with great potential to accelerate economic growth[171]; (vi) strengthening property rights and registries to recognize producer assets, improve access to long-term loans and increase producer willingness to invest in their land[172]; (vii) bolstering effectiveness of court systems such that banks are consistently able to enforce debts and recover collateral, thus decreasing their lending risk[173]; and (viii) bolstering customer protection laws to ensure transparency of contract conditions and pricing, avoidance of over-indebtedness, and client privacy[174].

COMPONENT 3: Reduce Risks with Financial Products and Services

Key actors: Private-sector financial institutions, MINAGRI, MINEFI, BCEAO, NGOs

This component will deploy financial tools that reduce producer and agribusiness risks, thus encouraging investment and growth. Specific steps will include: (i) establishing local partial guarantee funds under BCEAO[175], (ii) establishing warehouse receipt licensing authority and register under SRE 2015 ERRA[176], (iii) developing agriculture index-insurance via public-private partnerships[177], and (iv) establishing value chain finance (example: HDFC Bank, India[178]).

COMPONENT 4: Reduce Transaction Costs

Key actors: Private-sector financial institutions, MINAGRI, MINEFI, BCEAO, NGOs

This component will significantly reduce the transaction costs of payments and services for producers and agribusinesses. Subcomponents will include: (i) mobilizing liquid assets via savings pools (such as savings and credit cooperatives, savings clubs, and village and savings loan associations, particularly for longer-term loans (example: Village Savings and Loan, CARE, Niger[179]); (ii) establishing (a) a loan monitoring platform in which all buyers participate to decrease credit analysis and collection costs[180] and (b) rural credit bureaus or rating agencies to enable a producer-customized range of services, integration of CSA and risk mitigation into credit ratings, and timely sharing of credit ratings with financial institutions (example: SERVIR Project, Red Financiera Rural, Ecuador)[181]; (iii) digitizing payment

[167] World Bank.

[168] Palmer, "Making Climate Finance Work in Agriculture."

[168] Palmer.

[170] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire.

[171] Expert Panel Workshop; Palmer, "Making Climate Finance Work in Agriculture."

[172] Palmer, "Making Climate Finance Work in Agriculture."

[173] Palmer.

[174] Palmer.

[175] Palmer; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[176] Palmer, "Making Climate Finance Work in Agriculture"; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[177] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire; Palmer, "Making Climate Finance Work in Agriculture"; World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[178] Palmer, "Making Climate Finance Work in Agriculture."

[179] CARE International, "When Women Contribute to the Resilience of Communities in the Sahel through Savings and Community-Based Adaptation"; Palmer, "Making Climate Finance Work in Agriculture."

[180] World Bank, "Atelier de Restitution, Diagnostic de Finance Agricole et Plan d'Action."

[181] Palmer.

value chains, including scanning driver agricultural payments and historical data on producers[182]; (iv) using big data and data-science services to assess risk, determine creditworthiness and provide loans (examples: Gro Ventures, Farm Drive, Grameen Foundation, EFL, Arifu)[183]; and (v) leveraging ICTs to implement mobile, over-the-counter, and branchless banking in underserved areas where a brick-and-mortar location would not be feasible (examples: Branchless Banking, United Bank Ltd, Pakistan; M-Pesa and M-Kesho, Kenya[184]).

COMPONENT 5: Bolster Provision of CSA-Relevant Data
Key actors: Agrobusiness, MINAGRI, NGOs

This component will provide producers and agribusinesses the information they need to make informed financial decisions. Specifically, this will include: (i) strengthening or establishing a national climate information system185, (ii) strengthening or establishing a national soil information system186, and (iii) leveraging ICTs to provide timely, accurate climate information, soil information and other CSA-related data to producers to inform decision-making and reduce risk (example: Rice Crop Manager, IRRI, Philippines[187]).

F-3 Development of a national agrometeorological system for CSA

Weather is a primary risk for agricultural production, and climate change has made weather significantly more variable, extreme and difficult to predict. Resource-poor smallholder farmers, especially in sub-Saharan Africa[188], are particularly vulnerable to loss from extreme weather events. Without advance notice of near-term weather and impending hazards, or access to technologies (e.g., irrigation systems) to buffer crops and livestock against unfavorable conditions, climate fluctuations can cripple production and contribute to persistent poverty and food insecurity[189].

Timely, accurate, accessible agrometeorological information is foundational to CSA. Climate information services (CIS) communicate climate knowledge to farmers and other end users. Such information reduces the uncertainty surrounding erratic climactic patterns, allowing producers and agribusiness to anticipate and manage adverse weather conditions, take advantage of favorable ones and adapt to change[190]. CIS also support climate-informed policy, planning and extension agent recommendations[191].

Well-designed CIS translate data into practical advisories, transmit them over accessible communication channels and invest in the capacity of end users to understand and leverage

[182] World Bank.

[183] Palmer, "Making Climate Finance Work in Agriculture."

[184] Palmer.

[185] Expert Panel Workshop, Theorie du Changement Financier CSA Côte d'Ivoire.

[186] Africa Soils, "Africa Soil Information Service."

[187] Expert Panel Workshop; Palmer, "Making Climate Finance Work in Agriculture."

[188] Welle, "Extreme Weather."

[189] CCAFS, "Climate Services in Agriculture"; CCAFS, "Agricultural Advisory Services at a Global Scale"; CCAFS,"Putting Farmers at the Centre of Climate Information Services"; Tesfaye et al., "Estimating the Economic Benefits of Alternative Options for Investing in Agricultural Climate Services in Africa: A Review of Methodologies"; CCAFS, "Participatory Integrated Climate Services for Agriculture (PICSA)."

[190] CCAFS, "10 Best Bet Innovations for Adaptation in Agriculture: A Supplement to the UNFCCC NAP Technical Guidelines."

[191] CCAFS; CCAFS, "Building Climate Services Capacity in Rwanda."

the information[192]. Practical advisories are actionable and directly inform decision-making; examples include crop production forecasts and recommendations, pest and disease forecasts, extreme weather advisories, and information on new CSA practices and technologies[193]. In general, mass media and ICT are the most effective communication channels for short-term information, such as in-season forecasts and major weather events; structured in-person participatory processes are most effective for longer-term production strategizing and for building the capacity of end users to understand information and act effectively[194].

Socioeconomically and culturally informed design of CIS delivery processes help ensure access for the most vulnerable potential beneficiaries. Factors such as age, gender and socioeconomic status can affect an individual's ability to access advisories and join participatory and capacity building processes. For example, extension services are often biased toward male farmers, and women's household responsibilities often preclude them from listening to radio broadcasts or attending community gatherings. Communication strategies that leverage multiple channels have proven to be effective in this regard; another strategy that has been established as effective is making CIS available in places and processes that are already part of the most vulnerable populations' routines, such as health centers, boreholes and women's groups[195].

Country context for a national agrometeorological system for CSA

Côte d'Ivoire is experiencing extreme weather events due to climate change. The dry seasons have been marked by heat waves and drought that cripple crop production and exhaust water reservoirs. Weather extremes are being felt in cities too, with taps in Abdijan and Bouake having run dry for months in early 2018[196]. Rainy seasons have brought intense downpours and flash floods that destroyed infrastructure and human life; in June 2018 alone, flash flooding displaced hundreds of people, killed 18 and caused millions of dollars of property damage[197]. Without reliable CIS, Ivorians are caught unaware by such extreme weather events; impoverished individuals are more likely to live in vulnerable areas, and are less able to invest in recovery following loss[198].

The National Meteorological Service of Côte d'Ivoire (SODEXAM) faces significant obstacles in implementing effective CIS. SODEXAM is the primary provider of climate information in the country. SODEXAM offers general public weather warnings, rain gauge measurements and marine forecasting; warning services for drought and flood are not currently available[199]. The current climate

[192] Expert Panel Workshop, Agromet Theorie du Changement; CCAFS, "Participatory Integrated Climate Services for Agriculture (PICSA)"; CCAFS, "10 Best Bet Innovations for Adaptation in Agriculture: A Supplement to the UNFCCC NAP Technical Guidelines"; CCAFS, "Rwanda Establishes a National Framework for Climate Services"; CCAFS, "Climate Services for Farmers."

[193] CCAFS, "Agricultural Advisory Services at a Global Scale"; Tesfaye et al., "Estimating the Economic Benefits of Alternative Options for Investing in Agricultural Climate Services in Africa: A Review of Methodologies"; CCAFS, "Participatory Integrated Climate Services for Agriculture (PICSA)"; Expert Panel Workshop, Agromet Theorie du Changement; Huyer et al., "What We Know about Gender and Rural Climate Services"; CCAFS, "Rwanda Establishes a National Framework for Climate Services"; CCAFS, "Building Climate Services Capacity in Rwanda."

[194] CCAFS, "10 Best Bet Innovations for Adaptation in Agriculture: A Supplement to the UNFCCC NAP Technical Guidelines"; CCAFS, "Participatory Integrated Climate Services for Agriculture (PICSA)."

[195] Huyer et al., "What We Know about Gender and Rural Climate Services"; CCAFS, "Climate Services for Farmers."

[196] "'Water Is Life'"; "Farmers Fear for Ivory Coast's Drought-Hit Cocoa Crop."

[197] Al Jazeera, "Cleanup Follows Deadly Flooding in Ivory Coast's Abidjan."

[198] Welle, "Extreme Weather."

[199] World Meterological Organization, "Côte d'Ivoire."

observation network covers 6% of national territory[200]. SODEXAM has reported obsolete instruments, lack of operational infrastructure (such as radar and automatic weather stations) and absence of mechanisms for instrument calibration. The World Meteorological Organization identifies forecasting, climate services, agrometeorology, meteorological equipment and computer science as the areas of greatest need for staff training[201].

Ivorian smallholders are willing and able to leverage CIS but do not currently have good access. The World Meteorological Organization reports that SODEXAM offers tailored agrometeorological products, including data services (e.g., rain gauge information) and climate analysis and diagnostics[202]. Nevertheless, Ivorian farmers generally do not use agrometeorological information in making management decisions, often explaining that CIS are inaccessible to them and that local media do not offer weather data. Preliminary studies indicate that Ivorian farmers prefer to receive CIS via mobile SMS, and that providing farmers with basic CIS data increases yields by about 32%[203].

Institutional and sectoral alignment

Implementing CIS is a priority for the Ivorian government. The Ivorian government, including MINAGRI and the National Weather Service, identified agriculture as a high-priority beneficiary of its 2016–2020 action plan for the implementation of a national climate services framework[204]. In the 2017–2025 national agriculture investment plan, the government names climate data collection and information services as key components of the Sustainable Management of Environmental Resources and Climate Resilience program, as well as of the Strengthening Institutional Framework of Sector and Business Environment Governance program[205].

This priority aligns with the goals of international agreements of which Côte d'Ivoire is a part. The Climate for Development in Africa project was designed by the African Development Bank, Commission of the African Union and the United Nations to disseminate quality climate information and build capacity across the African Economic Communities of the Union, including the Economic Community of the West African States, of which Côte d'Ivoire is a member[206]. Implementing CIS will support several of Côte d'Ivoire's Sustainable Development Goals, including Goal 2: Zero Hunger; Goal 8: Economic Growth; and Goal 13: Climate Action. It also indirectly supports Goal 9: Innovation and Infrastructure; Goal 15: Life on Land; and Goal 16: Strong Institutions[207].

Multiple international organizations have collaborated with Côte d'Ivoire in addressing this priority issue. The UN has put forth the Global Framework for Climate Services; as part of this initiative, Norway funded climate services development and capacity building in 32 countries, including Côte d'Ivoire, from 2011–2016[208]. The Climate Research for Development in Africa program, which includes projects

[200] Kouassi, "National Meterological Service of Côte D'Ivoire."

[201] World Meterological Organization, "Côte d'Ivoire."

[202] World Meterological Organization.

[203] Tarchiani et al., "Smallholder Farmers Facing Climate Change in West Africa."

[204] Direction de la Météorologie Nationale, "Plan d'Actions de La Côte D'Ivoire 2016 – 2020 Pour La Mise En Place Du Cadre National Pour Les Services Climatiques"; Government of Côte d'Ivoire, "Program National D'Investissement Agricole de Deuxième Génération."

[205] Government of Côte d'Ivoire, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report."

[206] African Development Bank, "Climate for Development in Africa (ClimDev-Africa) Initiative."

[207] Knoema, "Sustainable Development Goals of Côte d'Ivoire - Côte d'Ivoire Data Portal."

[208] Global Framework for Climate Services, "Climate Services Adaptation and Disaster Risk Reduction in Africa."

such as WISER, the Regional Climate Research Partnerships and the Africa Climate Network, aims to mobilize climate expertise and resources through a multi-stakeholder collaborative platform[209]. The Enhancing National Climate Services program, which aims to produce reliable climate information to inform national and local decision-making, has been piloted in Uganda, Kenya, Ethiopia, Tanzania and Rwanda[210], and the CCAFS PICSA model has been successfully piloted and implemented in Tanzania, Kenya, Malawi, Ghana and Lesotho[211].

Proposed development objectives and results

Proposed project development objective: This project aims to increase farm productivity and mitigate climate-related risks by providing producers, extension agents and agribusiness with timely, accurate agrometeorological information.

Beneficiaries: The mobile-based advisories subcomponent of this project will directly benefit up to 312,000 rural agricultural workers ages 15 and up[212] and their households. Integration of CIS into radio station programs, health centers, women's groups, and/or extension agent advisory services would significantly increase the potential beneficiary population. For example, about 20% of the Ivorian population uses healthcare facilities[213]. Providing CIS at these facilities would directly benefit an additional 1 million non-mobile subscribers and their families, as well as offer a second access point for about 400,000 mobile subscribers. Indirect benefits via resulting climate-conscious policy and extension recommendations could feasibly reach all Ivorian agricultural producers.

Project description: This project is designed to provide agricultural producers, extension agents, agribusiness and policymakers with timely, accurate agrometeorological data. The project will address public sector systems and technical capacity to produce and convey agromet information, as well as producer technical ability to access and leverage agromet information. Activities will aim to develop (i) physical infrastructure, (ii) data aggregation, synthesis and dissemination systems, and (iii) capacity for maintaining and leveraging CIS. The project has been informed by outputs of an in-country expert convening, as well as the extensive institutional knowledge of Côte d'Ivoire's SMN and MINADER, CCAFS and other agricultural research and development organizations.

Project components

COMPONENT 1: Produce and Process Data

Key actors: SMN, CNRA, ANADER, MINADER, Weather-Morocco, Weather-France

This component will lay the foundation for an effective CIS by producing and storing accurate meteorological data at the appropriate spatial resolution. The public sector will (i) conduct a network

[209] Climate Research for Development in Africa, "CR4D Goal, Vision and Mission."

[210] "Enhancing National Climate Services (ENACTS)."

[211] CCAFS, "Participatory Integrated Climate Services for Agriculture (PICSA)."

[212] The population of Côte d'Ivoire is estimated at over 25 million, of which roughly 46%, or 11.5 million, live in rural areas and are primarily employed in agriculture . Of these, 63%, or 7.2 million, are ages 15 and up. As of 2016, mobile technology unique subscriber penetration was 83% of the adult Ivorian population; we can assume the rate is very similar for youth ages 15-17. Assuming unique subscriber penetration among urban individuals (54% of population) is 100%, then about 29% of rural individuals ages 15 and up, or 2.1 million, are current mobile subscribers. It can be assumed that extension agents and policy makers are included in the population of mobile subscribers.

[213] Cisse, "Analysis of Health Care Utilization in Côte d'Ivoire."

optimization study and acquire, install and maintain weather stations based on results and current financing, (ii) automate collection and processing of new weather data, (iii) clean and consolidate historical weather data, as well as agricultural and phenological data, on comparable scales as the monitored meteorological data, (iv) integrate these three datasets, and (v) analyze data for actual and predicted patterns[214].

COMPONENT 2: Translate Data into Practical Advisories
Key actors: MINADER, ANADER, SMN, Weather-Morocco, Weather-France

This project component will translate data into immediately applicable information and recommendations, such as: (i) revision of national agroclimatic measures, such as seasonal calendars and agroclimatic maps[215]; (ii) crop production forecasts[216] and recommendations per degree of risk and potential gain[217]; (iii) agroclimatic modeling of pests and disease risk[218]; (iv) an early warning system for unfavorable events such as dry spells, heat waves and storms[219]; and (v) information regarding new CSA practices and technologies, such as stress-tolerant seed varieties[220].

COMPONENT 3: Develop Products and Services to Communicate Advisories
Key actors: NMS, CNRA, ANADER, MINADER, universities, research centers, AGRHYMET

In this component, dissemination channels for the advisories developed in Component 2 are created that are socially, culturally and economically appropriate and inclusive[221]. Channels may include: (i) mobile (SMS, call) services, (ii) radio broadcasting, (ii) a web-GIS portal, (iii) periodic and special newsletters, (v) integration into places frequented by producers (e.g., boreholes, health offices and women's groups) and (v) integration into existing extension structures[222].

[214] Tesfaye et al., "Estimating the Economic Benefits of Alternative Options for Investing in Agricultural Climate Services in Africa: A Review of Methodologies"; CCAFS, "Rwanda Establishes a National Framework for Climate Services"; Expert Panel Workshop, Agromet Theorie du Changement.

[215] Expert Panel Workshop, Agromet Theorie du Changement.

[216] Tesfaye et al., "Estimating the Economic Benefits of Alternative Options for Investing in Agricultural Climate Services in Africa: A Review of Methodologies."

[217] CCAFS, "Participatory Integrated Climate Services for Agriculture (PICSA)."

[218] Expert Panel Workshop, Agromet Theorie du Changement; CCAFS, "Building Climate Services Capacity in Rwanda"; CCAFS, "Rwanda Establishes a National Framework for Climate Services."

[219] Expert Panel Workshop, Agromet Theorie du Changement; Huyer et al., "What We Know about Gender and Rural Climate Services"; CCAFS, "Rwanda Establishes a National Framework for Climate Services."

[220] CCAFS, "Agricultural Advisory Services at a Global Scale."

[221] Tesfaye et al., "Estimating the Economic Benefits of Alternative Options for Investing in Agricultural Climate Services in Africa: A Review of Methodologies"; CCAFS, "Rwanda Establishes a National Framework for Climate Services"; Huyer et al., "What We Know about Gender and Rural Climate Services."

[222] Expert Panel Workshop, Agromet Theorie du Changement; CCAFS, "Climate Services for Farmers"; CCAFS, "10 Best Bet Innovations for Adaptation in Agriculture: A Supplement to the UNFCCC NAP Technical Guidelines"; Tesfaye et al., "Estimating the Economic Benefits of Alternative Options for Investing in Agricultural Climate Services in Africa: A Review of Methodologies"; CCAFS, "Building Climate Services Capacity in Rwanda"; Huyer et al., "What We Know about Gender and Rural Climate Services"; CCAFS, "Climate Services for Farmers."

COMPONENT 4: Train Farmers on Using Data
Key actors: SMN, ANADER, MINADER, universities, INP-HB, CNRA

This component will focus on increasing capacity for CIS. This will consist of (i) instituting a train-the-trainer model for relevant staff in data collection applications and information dissemination processes (examples: PICSA, CCAFS, various African countries; Climate Services for Agriculture, CGIAR, RwandaI); (ii) training of relevant staff in equipment maintenance; (iii) integrating a weather and climate module into CSA technical assistance curricula; (iv) training extension staff on recognizing when age, gender or socioeconomic status may affect an individual's ability to access CIS; and (v) ongoing training on use of CIS for producers and agribusiness (example: PICSA, CCAFS, various African countries[223]).

COMPONENT 5: Enabling Policy Environment
Key actors: SMN, CNRA, ANADER, MINADER

This component will help ensure that the policy environment supports Components 1-4. This will include: (i) institutional arrangements to bring together climate information providers, agricultural research and extension, national policymakers and farmer representatives to complete Components 1-4 (example: National Framework for Climate Services, Rwanda); (ii) creation of a multidisciplinary working group to guide the project[224] (example: National Consultative Workshop, Rwanda); (iii) incorporation of climate information and prediction into planning and policy; and (iv) funding availability for the establishment and maintenance of a national agroclimatic network[225].

F-4 Development of a national Climate-Smart Agricultural extension system

Introduction and strategic context

High-quality extension services are foundational to CSA[226]. Climate information is at the heart of climate resilience. Nevertheless, climate information alone is not generally beneficial to agricultural producers. The translation of climate information into practical recommendations and decision support is crucial to enabling farmers to prepare for and adapt to change. Effective extension services are the outgrowth of substantial investment in the institutional capacity of national meteorological services, agricultural research organizations and farm advisory service providers[227].

The Ivorian Agricultural Extension Service (ANADER) faces challenges in providing effective farm advisory services. ANADER employs approximately 1,500[228] field extension staff to serve the approximately 7.2 million Ivorian agricultural workers ages 15 and up[229], or 1 farm advisor for every

[223] CCAFS, "Participatory Integrated Climate Services for Agriculture (PICSA)"; Expert Panel Workshop, Agromet Theorie du Changement; CCAFS, "Building Climate Services Capacity in Rwanda"; Huyer et al., "What We Know about Gender and Rural Climate Services"; CCAFS, "Rwanda Establishes a National Framework for Climate Services."

[224] Expert Panel Workshop, Agromet Theorie du Changement.

[225] Expert Panel Workshop; CCAFS, "Rwanda Establishes a National Framework for Climate Services"; Tesfaye et al., "Estimating the Economic Benefits of Alternative Options for Investing in Agricultural Climate Services in Africa: A Review of Methodologies."

[226] Sala et al. 2016.

[227] CCAFS, "10 Best Bet Innovations for Adaptation in Agriculture: A Supplement to the UNFCCC NAP Technical Guidelines."

[228] Global Forum for Rural Advisory Services, "Côte d'Ivoire."

[229] Index Mundi, "Côte d'Ivoire Demographics Profile 2018"; World Population Review, "Ivory Coast Population 2018 (Demographics, Maps, Graphs)."

4,800 agricultural workers. Even assuming family units of 4 adults, this amounts to a formidable 1,200 families per farm advisor. The World Bank standard ratio is 1 advisor to each 800 farmers[230]. Additionally, farm advisors come from a diverse educational background generally not exceeding the high school level. Approximately 80% of farm advisors have received some level of on-the-job training in agricultural extension[231]. There is currently no continuing education program in place to ensure their knowledge remains current with new technologies and practices.

Multiple other public and private institutions play important roles in providing advisory services to producers. Producers are expected to pay for services following ANADER's privatization in 1999. As a result, fewer farmers seek services from ANADER, and various other extension services have been established. Approximately 30 other public and private organizations, including research institutions, universities, non-governmental organizations, private sector companies and cooperatives now offer extension services[232].

Strengthening extension services is a priority for the Ivorian government. Increasing the production and dissemination of high-quality agricultural technologies through the research and extension systems is a key subcomponent of the National Plan for Agricultural Investments 2017–2025[233].

This project aligns with the goals of regional and international alliances of which Côte d'Ivoire is a part. The West Africa Agricultural Productivity Program, in coordination with the Economic Community of West African States and the African Union, works with researchers, extension agents and producers in Côte d'Ivoire to innovate, disseminate and adopt improved technologies, as well as build human and institutional capacity[234]. Improving extension services also directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 8: Economic Growth; Goal 9: Industry and Innovation; Goal 12: Responsible Consumption and Production; Goal 13: Climate Action; and Goal 15: Life on Land. It also indirectly addresses Goal 10: Reduced Inequalities; Goal 11: Sustainable Communities; and Goal 16: Peace, Justice, and Strong Institutions[235].

Proposed Development Objectives and Results

Proposed Project Development Objective: This project aims to increase farm productivity and minimize climate-related risks by improving the quality and quantity of CSA-informed recommendations made to producers by farm advisors.

Beneficiaries: The initial five-year project term will directly benefits the approximately 235,800 agricultural producers ages 15 and up who reside in Agropole 4. Across time, indirect benefits via improved services and greater climate resilience could feasibly reach all Ivorian agricultural producers.

Project Description: This project is designed to increase the capacity of the extension system to provide recommendations to producers that are informed by and promote CSA practices. The project will address demand-driven development of new CSA technologies and information, as well as timely, effective dissemination of the same to producers. Activities will aim to develop (i) capacity for

[230] http://documents.worldbank.org/curated/en/190121468140386154/pdf/wps3928.pdf

[231] Global Forum for Rural Advisory Services, "Côte d'Ivoire."

[232] Global Forum for Rural Advisory Services.

[233] Government of Côte d'Ivoire, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report."

[234] World Bank, "West Africa Agricultural Productivity Program."

[235] Knoema, "Sustainable Development Goals of Côte d'Ivoire - Côte d'Ivoire Data Portal."

multi-stakeholder CSA research, (ii) capacity of extension agents to effectively reach producers with high-quality CSA recommendations, and (iii) bolstering of infrastructure and equipment to support outreach. The project has been informed by outputs of an in-country expert convening, as well as the Ivorian National Agricultural Investment Plan for 2017–2025.

Project Components

COMPONENT 1: Increase Technical Capacity of Extension Agents in CSA
Key actors: ANADER, MINADER, NMS, CNRA, AGRHYMET, SMN, universities, INP-HB

This component will train farm advisors in cutting-edge CSA. Specific subcomponents will include: (i) integration of CSA module into all training centers' curricula, (ii) CSA-focused field trips for mid-level staff, (iii) establishment of a continuous training system for all extension agents, and (iv) training on use and maintenance of equipment specified in Component 3.

COMPONENT 2: Develop Dissemination Channels for CSA Recommendations
Key actors: ANADER, MINADER, SMN

This project component will bolster systems for dissemination of information to producers. Specifically, this will include: (i) development of new education tools and guides with a focus on field schools and functional literacy, (ii) technical capacitation of relay farmers to broaden reach, (iii) integration of data collection into extension activities in order to inform needs prioritization, (iv) development and implementation of multiple ICT dissemination channels, including radio and mobile, and (v) fostering decentralization of the advisory system through creation of additional satellite offices[236].

COMPONENT 3: Upgrade Infrastructure and Equipment to Support Extension
Key actors: ANADER, MINADER, SMN

This project component will improve the availability and quality of infrastructure and equipment that support extension. Priorities include: (i) research equipment and infrastructure in universities and research institutions, (ii) instructional equipment and infrastructure, (iii) maintenance kits for agrometeorological stations, (iv) vehicles for movement of extension and meteorological and (v) ICT communication tools for farm advisors and relay farmers.

COMPONENT 4: Bolster CSA Scientific Research
Key actors: MINADER, ANADER, universities, research institutions

This component will promote effective research conducted by highly skilled professionals. Specific steps will include: (i) rehabilitate the Bouake, Korhogo, Man and other research centers destroyed during recent national crises, (ii) promote researchers and research centers that produce meaningful results via a system of bonuses, awards, grants and media publications, (iii) institute research "incubators" in universities, (iv) establish research clusters in each Agropole and (v) create a national database of current skills that will enable identification of missing skill for prioritization in recruitment, training and organizational cooperative agreements[237].

[236] Government of Côte d'Ivoire, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report"; Expert Panel Workshop, Theorie du Changement Vulgarisation Côte d'Ivoire; Tarchiani et al., "Smallholder Farmers Facing Climate Change in West Africa."

[237] Government of Côte d'Ivoire, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report."

COMPONENT 5: Strengthen Extension-Research Communication Systems

Key actors: MINADER, ANADER, universities, research institutions

This component will foster multi-way communication between research organizations and extension services to support demand-driven research and results dissemination. Namely, this will include: (i) operationalize frameworks and networks between all public and private stakeholders through regional workshops, strategic plan development, scientific journal publications, evaluation of scientific results, etc.; (ii) fund multi-stakeholder and public-private research grants, financing contracts and research prizes; (iii) establish a permanent mechanism for timely dissemination of new technologies and information from researchers to farm advisors; (iv) establish a permanent mechanism for farm advisors' feedback to researchers and timely responses to the same; and (v) establish strong ties between research institutions and advisory services through shared staff, regular meetings, etc.[238]

Crop and livestock Climate-Smart Investments

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

[238] Government of Côte d'Ivoire.

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

F-5 Climate-Smart cassava production and processing program project concept

Introduction and Strategic Context

Cassava Interventions for Climate-Smart Agriculture

Cassava is a key source of nutritional security for African smallholder farmers. It is among the top five most important food crops in developing countries and the second-most important in the least-developed countries[239]. About 64% of the 218 megatons of cassava produced annually is grown in Africa, and over 90% of that is grown by smallholder famers[240]. The crop is a source of livelihood for about 300 million sub-Saharan Africans[241], but is primarily grown by smallholders for home consumption. Cassava's tubers and leaves are rich in carbohydrates (energy), fiber (digestion), calcium (bone formation), phosphorus (bone formation), magnesium (muscle function), manganese (bone formation), potassium (protein synthesis), zinc (immunity), iron (cell oxygenation) and vitamins C (antioxidant) and B (metabolism)[242]. Cassava is adaptive to biotic and abiotic stressors, such as low soil fertility, and, as a perennial species, is available year-round and can be left unharvested until needed.

Cassava will become even more crucial to the nutritional security of African smallholders in the face of climate change. Cassava has been identified as one of the staple crops most likely to be resilient to climate change in Africa, with predicted changes in suitable growing area ranging from minor losses to minor gains[243]. In contrast, the suitable growing areas in Africa for beans, maize, banana and finger millet are projected to shrink by 30%–50%[244]. Wild cassava strains have shown significant variability in terms of adaptation, nutritional content, toxins, resistance to pests and disease, and postharvest shelf life[245]; this implies a high potential for development of new varieties displaying beneficial characteristics.

Developing and refining CSA practices will help address the primary vulnerabilities of cassava crops. Cassava is sensitive to some pests and diseases—such as mosaic, brown streak and mites—and has a poor pre-processing shelf life[246]. Along with general CSA practices (such as intercropping, agroforestry and integrated pest management), innovation in varietal development and distribution[247], as well as in postharvest processing methodology and mechanization[248], have been shown to help overcome production, processing and marketing challenges.

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

[240] Research Program on Roots, Tubers, and Bananas; Spencer, "A Review of Cassava in Africa"; Vark, "Cassava Can Become Africa's New Cash Crop."

[241] Vark, "Cassava Can Become Africa's New Cash Crop."

[242] "Cassava Benefits"; lecturer et al., "AGRO-HUB – Nutritional Value of Cassava Leaves."

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

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

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

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

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

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

Country Context

Côte d'Ivoire is a significant and self-sufficient consumer of cassava. The approximately 2.5 megatons of cassava produced in Côte d'Ivoire annually[249] are almost entirely consumed by Ivorians, with approximately 5 tons/year exported over the last decade[250]. Approximately 85% of Ivorian cassava is produced by smallholders exclusively for household consumption[251]. The tuber is a mainstay of Ivorian cuisine, and, in particular, a foundational component of smallholders' diets. Ivorians process cassava into over 20 products[252], including attiéké, a fermented cassava pulp which accompanies most meals. Imports and exports are limited, and consist of cassava-based products rather than raw cassava[253].

Cassava holds potential as a national economic resource. Although widespread, cassava production and processing remains relatively rudimentary in Côte d'Ivoire[254], implying ample opportunity for technical improvements. Each of the over 20 cassava products consumed in Côte d'Ivoire offer multiple value-added opportunities (e.g., processing, transport, marketing) that, if scaled, could offer significant agribusiness growth and employment opportunity. A large percentage of Ivorian smallholders already produce cassava, suggesting that these product chains could be scaled with relative ease.

The potentially large number of agribusiness employment opportunities that could arise from scaled cassava processing are particularly relevant to rural Ivorian women and youth[255]. Cassava production and processing is typically done by women, and some women's groups and cooperatives already exist for this purpose. Rural youth are increasingly choosing to leave farming in favor of employee positions. A burgeoning agribusiness sector could offer them employment that effectively leverages their agricultural experience.

Nevertheless, cassava production in Côte d'Ivoire is facing significant challenges. Yields per hectare fell from 5 tons in 1985 to 4 tons in 2005; by 2015 it was just 2 tons[256]. The number of hectares dedicated to cassava is also falling as farmers switch to more lucrative rubber production[257]. The price of cassava products has steadily risen as a result[258]. Continued decreases in cassava production could threaten both national food security and the national cassava processing industry, triggering economic instability. Further threats to smallholder livelihoods and the national economy could conceivably stem from widespread rubber-crop loss due to climate change; the tree is relatively climate-sensitive, and its growing regions are expected to shift significantly as a result of climate change[259].

[249] FAOSTAT, "Ivory Coast."

[250] O Coulibaly et al., "Regional Cassava Value Chains Analysis in West Africa: Case Study of Côte-D'Ivoire."

[251] Vark, "Cassava Can Become Africa's New Cash Crop"; O Coulibaly et al., "Regional Cassava Value Chains Analysis in West Africa: Case Study of Côte -D'Ivoire."

[252] MINADER and FAO, "Stratégie Nationale Pour L'Agriculture Intelligente Face Au Climat (SNAIC) En Côte d'Ivoire."

[253] O Coulibaly et al., "Regional Cassava Value Chains Analysis in West Africa: Case Study of Côte d'Ivoire."

[254] O Coulibaly et al.

[255] Expert Panel Workshop, Theorie du Changement Manioc.

[256] ReSAKSS, "Cassava Production, Ivory Coast."

[257] IRIN, "Rubber Squeezing out Cassava around Abidjan."

[258] The Guardian, "Ivory Coast Farmers Abandon Cassava for More Lucrative Rubber."

[259] Liu et al., "Effects of future climate change on climatic suitability of rubber plantation in China."

Several existing varieties of cassava have proven to be well suited to Côte d'Ivoire. Bocou 1, Bocou 2 and Yavo are very productive, drought tolerant and disease resistant under Ivorian climactic conditions[260]. These traits, along with the generally adaptive characteristics of cassava, suggest that these varieties would demonstrate significant resiliency in the face of climate change. These varieties also yield about three times more per hectare than traditional varieties (8 vs. 25 metric tons), and are much more responsive to yield-increasing inputs (40% vs. 25%)[261].

Institutional and Sectoral Alignment

Improving production of cassava as both a food crop and a cash crop is of high priority for the Ivorian government. In part due to the recent decreases in cassava production, there is significant opportunity to catalyze agribusiness toward meeting the demands for cassava products and improving youth employment outlook. In collaboration with IFPRI, the Ivorian government has identified cassava as one of 14 priority crops for investment due to its potential for improving employment, income and food security of smallholders[262]. Based on this analysis, Agropoles 3-7 are of priority in terms of cassava as a food crop, and Agropole 4 is most promising for developing cassava as a cash crop. A recent convening of in-country experts identified cassava production improvements as the top national priority for CSA investing[263].

Multiple international organizations are heavily invested in developing the Ivorian cassava sector. Various cassava projects are already underway in Côte d'Ivoire. The Ivorian MINADER, FAO, the Swedish International Development Cooperation Agency and the European Union have collaborated on multiyear projects focused on improving root and tuber trade linkages, multi-stakeholder food systems and women's roles in agrofood value chains in Côte d'Ivoire[264]. The German government funded MINADER's work in providing technical assistance, improved varieties and business training from 2012 to 2016[265]. The World Bank and International Finance Corporation have invested US$2 billion in Côte d'Ivoire's economic development, with a focus on the agricultural sector; their West Africa Agricultural Productivity Program provided technical assistance to rural women to increase cassava yields and processing efficiency. The Swiss Development Cooperation also funded technical assistance for yield increases and value-added processing in Côte d'Ivoire. The CGIAR Roots, Tubers and Bananas Research Program is working to develop cassava varieties that will retain their most desirable characteristics under the stresses of climate change[266].

This investment aligns with the aims of several Ivorian international alliances. The project directly addresses Côte d'Ivoire's sustainable development goals, including Goal 2: Zero Hunger; Goal 5: Gender Equality; Goal 8: Economic Growth; Goal 12: Sustainable Production; Goal 13: Climate Action; and Goal 15: Life on Land[267]. It also indirectly addresses Goal 1: No Poverty; Goal 3: Good Health; Goal

[260] Expert Panel Workshop, Theorie du Changement Manioc.

[261] World Bank, "Overview."

[262] Government of Côte d'Ivoire, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report."

[263] Expert Panel Workshop, Theorie du Changement Manioc.

[264] FAO, "Les Acteurs Du Secteur Manioc s'engagent Pour Une Meilleure Coordination et Une Planification Efficace Des Interventions En Côte d'Ivoire."

[265] Federal German Ministry for Economic Cooperation and Development, "Adapting to Climate Change and Increasing the Resilience of the Population in South-West Côte d'Ivoire."

[266] CGIAR, "RTB Scientists at the Forefront of Developing Technologies to Help Farmers Cope with Climate Change."

[267] Knoema, "Sustainable Development Goals of Côte d'Ivoire - Côte d'Ivoire Data Portal."

10: Reduced Inequalities; and Goal 11: Sustainable Communities. The African Union is committed to on-the-ground cassava value-chain development[268], and the Economic Community of West African States has worked extensively with FAO and other international organizations to develop the cassava industry, with a focus on female entrepreneurs[269].

Proposed Development Objectives and Results

Proposed Project Development Objective: This project aims to increase the cassava sector's capacity to practice CSA by providing producers, processors and extension agents with technical assistance and increased access to improved varieties and up-to-date research outputs.

Beneficiaries: This project will directly benefit up to 90,000[270] producers and their households in the Iffou, Belier, Moronou and N'Zi districts of Agropole 4 during its five-year term[271]. Over time, nutritional security and economic outcomes of the project could indirectly benefit the 3.5 million Ivorians employed in agriculture in Agropoles 3-5, 7 and 9.

Project Description: This project is designed to provide cassava producers and processors with technical assistance to promote CSA practices in Côte d'Ivoire. The project will bolster national nutritional security and economic activity in the face of climate change. Project work will aim to develop (i) capacity for CSA in the cassava sector, (ii) commercialization of cassava-derived products and (iii) ongoing research to support the same.

Project Components

COMPONENT 1: Producer Technical Assistance

Key actors: MINADER, ANADER

This component will increase capacity for CSA in cassava production by offering the following technical assistance to production groups: (i) information on improved varieties and for what circumstances they are recommended; (ii) best CSA practices for cassava, including zero/reduced tillage, mulching, cover cropping, hedgerows (e.g., of rubber trees), legume intercropping and integrated pest management (e.g., using Ocimum grattisumum); (iii) appropriate mechanization technologies for processing (e.g., boiling, pressing, drying); and (iv) appropriate post-harvest storage techniques[272].

[268] African Union, "Cassava Value Chain Development Beyond Policy Making: African Union Commission in the Field to Get Grounding in Agro-Allied Industries' Daily Real World."

[269] ECOWAS, "Potential of Cassava processing in West Africa."

[270] The population of the rural districts of Agropole 4--Iffou, N'Zi, Belier, and Moronou--is approximately 1.66 million. Of these, we can assume that about 75%, or 1.24 million, are dedicated to agriculture. About 397,000 of these are women and female youth ages 15 and up, and another 335,000 are male youth ages 15-20. This project will focus on these 732,000 women and youth as primary beneficiaries. Index Mundi, "Côte d'Ivoire Demographics Profile 2018"; Statoids, "Côte d'Ivoire Regions"; FAOSTAT, "Ivory Coast"; World Population Review, "Ivory Coast Population 2018 (Demographics, Maps, Graphs)."

[271] Expert Panel Workshop, Theorie du Changement Manioc.

[272] Howeler, Lutaladio, and Thomas, Save and Grow; Expert Panel Workshop, Theorie du Changement Manioc; Gnahoua et al., "Assessment of Low-Input Technologies to Improve Productivity of Early Harvested Cassava in Côte d'Ivoire"; Ayemou et al., "Innovations in Cassava Production for Food Security and Forest Conservation in Western Côte D'ivoire"; Chapuis et al., "Pneumatic Drying of Cassava Starch."

COMPONENT 2: Extension Agent Capacitation

Key actors: ANADER

This component will promote the integration of CSA into extension agent's cassava recommendations. Extension agents will receive training in: (i) general recommended CSA practices for cassava, as detailed in Component 1; (ii) recommended cassava varieties by factor (i.e., climactic region, end use, biotic and abiotic stressors, etc.); (iii) appropriate production and propagation techniques for each variety; (iv) cassava-based product processing techniques and equipment; and v) approaches for supporting producers in transitioning to new varieties[273].

COMPONENT 3: Support Research

Key actors: MINAGRI, CNRA, universities, C. Suisse

This component will leverage existing links with the CGIAR Root and Tuber program[274] to support continued research on improved varieties and new CSA practices for cassava. Specifically, this will include: (i) ensuring ongoing funding availability for cassava research and innovations; (ii) breeding focused on adaptation to specific agroecological zones, end-uses, cropping systems and adverse climactic conditions with minimal need for inputs such as agrochemicals and irrigation; (iii) prioritizing genome-wide characterization of genetic diversity, filling gaps in landrace collections and creating natural reserves; (iv) routine propagation and distribution of disease-free planting material; and (v) bolstering multi-way communication and feedback between research institutions, extension agents and cassava producers[275].

COMPONENT 4: High Quality Planting Material System Development

Key actors: CNRA, universities, C. Suisse, MINADER, ANADER

This component will help ensure that CSA-recommended varieties, including Bocou 1, Bocou 2 and Yavo, as well as newly developed varieties, are readily available to Ivorian producers: (i) new varieties will be released by research institutions as an outgrowth of Component 3, (ii) varieties will be made available for commercial propagation, (iii) community nursery operators will be trained in correct propagation of these varieties, and (iv) public awareness campaigns will increase producer knowledge of the benefits of these varieties[276].

COMPONENT 5: Bolster Commercialization Organizations

Key actors: MINADER, ANADER, private sector

This component will strengthen the commercial processing of cassava products by offering technical assistance and formalized relationships with private industry partners to women's groups and youth. Specifically, this will include: (i) improved access to appropriate mechanization tools, (ii) training in new processing techniques to diversify product options, (iii) technical assistance in improved processing efficiency (i.e., mechanization)[277], (iv) systemization of the creation of working agreements with private sector business partners (e.g., store fronts, packaging producers, etc.), and (v) entrepreneurship training and mentorship programs (e.g., with private industry business partners)[278].

[273] Expert Panel Workshop, Theorie du Changement Manioc; Howeler, Lutaladio, and Thomas, Save and Grow.

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

[275] Expert Panel Workshop, Theorie du Changement Manioc; Howeler, Lutaladio, and Thomas, Save and Grow.

[276] Expert Panel Workshop, Theorie du Changement Manioc.

[277] Chapuis et al., "Pneumatic Drying of Cassava Starch."

[278] Expert Panel Workshop, Theorie du Changement Manioc.

F-6 Climate-Smart High-Value vegetable and livestock for Abidjan market

Introduction and Strategic Context

Climate-smart agriculture is crucial to sustaining Africa's rapidly burgeoning urban populations without exhausting natural resources or becoming dependent on international imports. As agricultural land becomes degraded, productivity declines. Rural populations, particularly youth, move to urban areas in search of economic viability. The combination of degraded resources and a reduced workforce undermines the capacity of rural populations to meet national food demands. This instigates a greater reliance on expensive international imports and a subsequent rise in food prices that exacerbates poverty and nutritional insecurity. Climate-smart agriculture offers the opportunity to break this cycle by sustainably increasing agricultural productivity, minimizing environmental impact and fostering the resilience of food systems in the face of climate variability.

Abidjan is now the fourth largest city in Africa and is expected to grow by 38% to 6.5 million inhabitants over the next 7 years[279]. This accounts for approximately 20% of the population of Côte d'Ivoire. The rapid urbanization of Abidjan has been accompanied by the challenges of meeting food demands and also managing waste to minimize environmental impact. For instance, trash collection services are limited to portions of the city with adequately wide streets[280]. The result is that solid waste has heavily polluted the nearby lagoon, making it unsuitable for fishing and thus undermining food production[281].

Côte d'Ivoire's rapid urbanization rate, particularly among youth, is challenging the country to sustain economic growth while simultaneously reducing poverty rates and protecting natural resources. Côte d'Ivoire is a net importer of many foodstuffs, and Abidjan is at the heart of that demand. The massive exodus of rural youth to urban areas has resulted in an aging rural population reliant on traditional farming systems. Weak infrastructure and increasingly degraded natural resources have reduced the capacity of the region to meet the nutritional demands of its urban residents[282]. Innovative agricultural planning offers the opportunity to promote economic and nutritional self-sufficiency in the region through improved agricultural productivity.

Women and youth play crucial roles in this work. Women are the primary salespeople in urban food markets[283] and play a significant role in vegetable and small livestock production. They are also engaged in important aspects of value-added processing, such as meat smoking, and starch and flour production. In addition, there are numerous opportunities for youth engagement in value-added processing, logistical transport and commercialization as markets develop, both in rural areas and peri-urban Abidjan.

The Ivorian government has prioritized development of the agricultural regions surrounding Abidjan to meet the demands of this growing market and reduce reliance on expensive imports. Specifically, the National Investment Plan targets increasing production and value-added processing in Agropoles 3 and 5 to fully supply the Abidjan market, and bolster exports to neighboring countries.

[279] Hoornweg 2016.

[280] World Bank 2016

[281] UNEP 2015.

[282] World Bank 2015.

[283] ADB 2015

Vegetables, poultry and pork value chains were prioritized for this work given their high market demands and good income potential[284]. The primary risks associated with agricultural production in this zone are flooding, water pollution, long dry seasons and insect pests targeting vegetable crops. This work also directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 5: Gender Equality; Goal 8: Economic Growth; Goal 9: Innovation; Goal 12: Responsible Production; Goal 13: Climate Action; and indirectly addresses Goal 10: Reduced Inequalities; Goal 11: Sustainable Communities; Goal 15: Life on Land; and Goal 16: Strong Institutions.

Proposed Development Objectives and Results

Proposed Project Development Objective: This project will foster improved economic and nutritional self-sufficiency through climate-smart agricultural practices in the regions supplying Abidjan.

Beneficiaries: The project will directly benefit up to 66,000[285] peri-urban agricultural workers in Grand Ponts region of Agropole 5 during the initial five-year term. Subsequent project terms will expand the project to La Me region of Agropole 3. Across time, indirect benefit resulting from improved economic stability and nutritional self-sufficiency could feasibly reach all agricultural producers.

Project Description: This project aims to: (i) expand year-round production of vegetables, poultry and pork products to meet the growing food demand of the Abidjan metropolis, while (ii) fostering economic opportunities for producers, especially women and youth, in the surrounding peri-urban and adjacent rural areas and (iii) minimizing environmental impact and fostering climate resilience.

Project Components

COMPONENT 1: Vegetable Producer Technical Assistance
Key actors: MINADER, ANADER, private industry

This component will build vegetable producer capacity to integrate climate-smart practices into their agricultural management decisions. Specific subcomponents will include: (i) identification of sites and producers with high potential for intensive, market oriented production with an explicit focus on gender and age inclusivity, (ii) training in nursery production of vegetable seedlings, (iii) training in production and use of compost, (iv) training in biopesticide use, and (v) training in water management for dry season production.

COMPONENT 2: Livestock Producer Technical Assistance
Key actors: MIRAH, IPRAVI, ANADER, private industry

This component will build livestock producer capacity to integrate climate-smart practices into their management decisions. Specific subcomponents will include: (i) identification of sites and producers with high potential for intensive, market-oriented production with an explicit focus on gender and age inclusivity, (ii) animal health and disease management, (iii) water and waste management, (iv) animal nutrition optimization, and (iv) improved value-added processing technologies (e.g., smoking).

[284] PNIA 2017.

[285] Approximately 469,500 people reside in Grands Ponts region, with 63% over the age of 14. Given that 46% of the Ivorian population is employed by agriculture, we assume 75% of rural populations work in agriculture.

COMPONENT 3: Build Extension Agent Capacity
Key actors: MINADER, MIRAH, IPRAVI, ANADER

This component will prepare farm advisors to integrate CSA practices into their recommendations, with a specific eye on market engagement. Subcomponents will include: (i) improved poultry and pig livestock breeds, and best management practices of the same, (ii) water management for dry-season production, (ii) integrated soil fertility management, (iii) access and use of start-up support and input subsidies for producers, (v) meeting product quality and safety standards, and (v) approaches to market participation.

COMPONENT 4: Strengthen Research & Development
Key actors: MINADER, CNRA, universities, NGOs

This component will focus on supporting producer's priorities through applied research and development. Namely, this will consist of (i) improving the quality and accessibility of infrastructure, equipment and training at CNRA and other national research institutions; (ii) vegetable research, including: (a) development of improved seed varieties offering disease resistance and climate resilience, (b) development of best management practice recommendations for vegetable storage and preservation techniques, and (c) development of best management practice recommendations for use of crop residues; and (iii) livestock research, including (a) research and development of improved breeds, (b) development of best management practice recommendations regarding nutrition and health, and (c) best management practice recommendations regarding waste management.

COMPONENT 5: Bolster Infrastructure Networks
Key actors: MINADER, MIRAH

This component will develop infrastructure to support an expanding and sustainable food market. Namely, this will include: (i) constructing storage facilities in wholesale markets designed to minimize post-harvest losses, (ii) establishing small-scale irrigation technologies to facilitate dry-season vegetable production, (iii) building poultry hatcheries, (iv) installing modernized meat-smoking equipment, and (v) identifying and training cooperatives and professional organizations to use, manage and maintain this infrastructure.

Risks: The main risks, their probability, and potential impact on the investment are:

RISKS	PROBABILITY	IMPACT
Sociopolitical crisis	Low	High
Access to land/water	Medium	Medium
Plant and animal pests and diseases	High	Medium

F-7 Sustainable cocoa production

Introduction and Strategic Context

West Africa produces 70% of the world's cocoa. The International Cocoa Organization foresees an increase of 10% in world cocoa production and a sharp increase in cocoa prices in the next decade. This represents a significant economic opportunity for West African cocoa producers. Nevertheless, the industry faces pressing environmental and economic challenges despite reliable global demand.

Projected increases in mean temperatures and increased temperature variability as a result of climate change will reduce suitability of the current cocoa-growing regions over the coming decades[286]. Pests and disease (such as swollen shoot), aging plantations, land degradation and high tree mortality also pose increasing risks to cocoa farmers' livelihoods[287], resulting in migration to urban areas, particularly among rural youth.

CSA practices have delivered significant improvements in West African cocoa plantations. For example, association of banana trees with young cacao plants has been shown to improve soil fertility, minimize erosion, increase soil organic matter content and improve soil carbon stock[288]. The banana trees also shelter cocoa plants during the early stages of development, long dry spells and extreme temperatures[289], thus reducing tree mortality and aging. These improvements in soil quality and micro-climate have increased cocoa yields and overall income by 25%–50% in Ghana, Cameroon and Côte d'Ivoire[290] and extended the productive life of trees to as much as 40 years[291].

The cocoa sector is crucial to Côte d'Ivoire's economy. The country produces about 1.5 million tons annually, or 33% of total global supply, making it the world's largest cocoa producer[292]. Cocoa accounts for 44% of the Côte d'Ivoire's exports and 5% of the national GDP. Approximately 3.6 million people are employed by the Ivorian cocoa industry[293]. The majority (66%) of Ivorian cocoa is currently exported unprocessed; this represents an important opportunity for economic development through vertical value-chain integration[294].

Climate is posing various challenges to the Ivorian cocoa sector. The current tree stock is more than 25 years old and is suffering decreased yields per hectare and higher incidences of pest and disease outbreaks, including mirids, black pod disease and swollen shoot virus[295]. Poor access to capital for investment in new trees prevents many producers from renovating their stock; this results in significant decreases in profit that have driven many young people to seek work in urban areas. Some CSA practices are already well known in the country; approximately 2 million smallholders already practice banana-cocoa association on 13% of total production area. Further scaling and expanding proven CSA practices offers the opportunity to continue revitalizing the Ivorian cocoa industry.

Women are an integral part of the cocoa value chain and represent approximately 68% of the labor force296. Particularly relevant to CSA practices is that women are traditionally responsible for planting shade trees in cocoa plantations. Nevertheless, inequalities exist: women own approximately 25% of cocoa plantations, earn around 15% of the total revenue (US$1.5 billion annually) and are underrepresented in cooperatives[297]. Fully engaging women in this work is thus crucial to the national economy, to climate resilience and to improving gender equality.

[286] SNAIC 2018, Wessel 2015, Laderach 2011

[287] Wessel 2015

[288] CIAT 2018, Jagoret 2012

[289] CIAT 2018

[290] CIAT 2018

[291] Jagoret 2012

[292] Van den Broek 2016

[293] CIAT 2018

[294] ADB 2015

[295] N'Guessan 2013

[296] ADB 2015

[297] Marston 2016

The Ivorian government has prioritized revitalization of the cocoa industry. Reforming the cocoa sector is prominent in the 2017–2025 National Agricultural Investment Plan strategies. An important component of this work will be developing the domestic cocoa processing market. This work also directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 5: Gender Equality; Goal 8: Economic Growth; Goal 9: Innovation; Goal 12: Responsible Production; Goal 13: Climate Action; and indirectly addresses Goal 10: Reduced Inequalities; Goal 11: Sustainable Communities; Goal 15: Life on Land; and Goal 16: Strong Institutions. In addition, the Cocoa and Forest Initiative prohibits deforestation activities and promotes sustainable intensification that improves production per hectare[298].

Proposed Development Objectives and Results

Proposed Project Development Objective: This project aims to increase cocoa farm climate resilience in order to augment productivity and generate new income opportunities, particularly for women and youth.

Beneficiaries: The project will directly benefit up to 88,000[299] rural agricultural workers ages 15 and up in the Moronou region of Agropole 4 during the initial five-year project term. The subsequent project term will expand the project to the Indénié-Djuablin region of Agropole 3. Across time, indirect benefit via improved economic outcomes could feasibly reach all Ivorian cocoa producers.

Project Description: This project is designed to increase cocoa producer's capacity to leverage CSA practices to achieve improved economic outcomes and adapt to climate change. The project will address (i) extension services, (ii) research and development, (iii) policy and (iv) technical assistance programs.

Project Components

COMPONENT 1: Producer Technical Assistance
Key actors: MINADER, ANADER, Ministry of Water and Forests

This component will increase the capacity of producers to integrate climate-smart practices into management decision processes. Specifically, this will include training in: (i) integrated systems, including agroforestry, livestock, mushroom and vegetable systems, (ii) grafting techniques to rehabilitate old plantations, (iii) improved varieties and their recommended best management practices, (iv) best management practices for pest and disease control, (iv) production and use of organic fertilizers, and (v) organization and management of producer groups and cooperatives.

COMPONENT 2: Building Capacity of Extension Agents
Key actors: MINADER, Ministry of Water and Forests

This project component will increase the capacity of farm advisors to integrate CSA practices into their recommendations to cocoa farmers. Specifically, training will include: (i) integrated systems, including agroforestry, livestock, mushroom and vegetable systems, (ii) grafting techniques to rehabilitate old plantations, (iii) improved varieties and their recommended best management practices, (iv) best management practices for pest and disease control, (iv) production and use of organic fertilizers, and (v) organization and management of producer groups and cooperatives.

[298] Joint Framework for Action 2017

[299] Moronou has approximately 463,700 inhabitants. 63% of them are above the age of 14. Given that 46% of all Ivorians work in agriculture, we assume that 75% or rural residents are employed by agriculture.

COMPONENT 3: Bolster Research and Development
Key actors: CNRA, Centre Suisse, NGOs, universities

This component will promote research and development to support to cocoa industry. Subcomponents will include: (i) building the capacity of research institutions to conduct cutting-edge cocoa research, (ii) improving the quality and accessibility of infrastructure and equipment for conducting cocoa research, (iii) developing improved varieties and best management practice recommendations for each, (iv) conducting an extensive cocoa pest and disease research program, and (v) systematizing the timely transfer of research outputs to producers and of producer issues and priorities for research to researchers.

COMPONENT 4: Foster and Enabling Policy Environment
Key actors: MINADER

This component will focus on creating a policy environment that enables the cocoa sector to grow and develop. Specific subcomponents could include: (i) governmental promotion, regulation and monitoring of the rehabilitation of old plantations through grafting techniques, (ii) subsidized construction and management of irrigation structures such as small dams, (iii) government program to promote introduction of forest species into cocoa plantations at a rate of 18 tree/ha, (iv) support of cooperatives in meeting minimum requirements to access financial services, and (v) prioritization of agrometeorological and other information services to support producer decision processes.

Risks: The main risks, probability and potential impact identified for this cocoa investment are:

RISKS	PROBABILITY	IMPACT
Access to land/land tenure	Low	Low
Shortage of qualified farmers	Low	Low
Limited access to information	Low	Low

F-8 Development of a Climate-Smart livestock sector in northern Côte d'Ivoire

Introduction and Strategic Context

Smallholder livestock production in sub-Saharan Africa has direct impacts on climate change. The livestock sector contributes up to 18% of global greenhouse gas emissions. These emissions are attributable to land change associated with pastoralism, manure and slurry, and ruminant digestion. The developing world accounts for about 67% of this figure, or 12% of global emissions[300]. Sub-Saharan Africa is a hotspot of emissions intensity due to low animal productivity, poor animal health and low-quality feed.

Climate change threatens the nutritional security of smallholder livestock farmers. Precipitation variability makes the availability of forage and water unpredictable, affecting livestock productivity and pushing pastoralists to travel longer distances and exploit more land to sustain their flocks. Drought, flood and extreme heat bring livestock mortality and destabilize markets[301]. Poor market

[300] Amole & Ayantunde 2016.

[301] Doumbia 2017.

access to inputs and financing, recurrent animal disease, and weak policy and infrastructure further challenge the livelihoods of livestock farmers.

Climate-smart agriculture reduces the impacts of livestock systems on climate, and makes livestock systems more resilience in the face of climate change. Climate-smart approaches in livestock systems improve productivity through breeding, diseases prevention, pasture and forage management, and improved water supply and shade resources. Animal waste is leveraged to produce energy via biogas and improve soil fertility in agricultural systems through organic composting[302]. The opportunities for improving livestock production are particularly relevant to women's livelihood diversification. Women are traditionally charged with milk production and sale within the cattle subsector. Also, small ruminants, such as sheep and goats, and fowl, such as chickens and ducks, are typically owned and managed by women farmers.

Côte d'Ivoire has a long tradition of livestock production. Fifty-eight percent of the rural Ivorian population is engaged in the livestock sector. As of 2014 Côte d'Ivoire had an estimated 1.6 million cattle (85% of which are found in the north of the country), 1.7 million poultry and 3 million goats and sheep[303]. This represents a 50% increase from 1990[304]. Cattle are primarily of the N'Dama, Baoule and Zebus breeds[305]. The approximately 800,000 pastoralists in the country account for 70%–90% of cattle and 30%–40% of small ruminant production[306], with the rest coming from sedentary systems. The country offers over 11 million hectares of pastoral land and abundant water sources.

The Ivorian livestock sector is challenged by increasing climate variability and degrading natural resources. Drought, floods, extreme heat and degrading natural resources have increasingly pushed the country's 800,000 pastoralists onto farmland, resulting in violent conflict[307]. Poor accessibility to inputs and financing, recurrent disease and weak infrastructure have further challenged livestock smallholders. The country currently produces approximately 35,000 tons of meat annually[308], which supplies 30% of national demand[309]. This consumption gap, and livestock trade balance, are the highest in ECOWAS.

Development of the livestock sector is a priority for the Ivorian government and its allies. The National Strategic Plan for Livestock Development, Fisheries and Aquaculture aims to increase national meat production to 60% of national demand by 2020. Bolstering food security and market opportunities features prominently in the strategic objectives of the Côte d'Ivoire National Agriculture Investment Plan, the African Union Strategic Agriculture and Rural Development Agenda, the West African Economic and Monetary Union Treaty, and the Economic Community of West African States' Vision. This work also directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 5: Gender Equality; Goal 8: Economic Growth; Goal 9: Innovation; Goal 12: Responsible Production; Goal 13: Climate Action; and indirectly addresses Goal 10: Reduced Inequalities; Goal 11: Sustainable Communities; Goal 15: Life on Land; and Goal 16: Strong Institutions.

[302] FAO 2017.

[303] Salla 2017.

[304] PRIDEC 2016.

[305] Salla 2017.

[306] PRIDEC 2016

[307] PRIDEC 2016

[308] Salla 2017,

[309] PSDEPA 2014.

Proposed Development Objectives and Results

Proposed Project Development Objective: This project aims to increase the productivity and climate resilience of the livestock sector through climate-smart practices, infrastructure development and scientific research.

Beneficiaries: This project will directly benefit the approximately 80,100 smallholders ages 15 and up residing in the Hambol region of Agropole 1 during the initial five-year project term. Subsequent project terms will expand to benefit the remainder of Agropole 1. Across time, all livestock smallholders could feasibly benefit indirectly from the improved productivity, marketability and resilience resulting from the project.

Project Description: This project is designed to support nutritional and economic security by building capacity for climate-smart livestock production. The project will address (i) research and development, (ii) extension services, (iii) infrastructure development, and (iv) producer technical assistance.

Project Components

COMPONENT 1: Technically Assist Producers
Key actors: ANADER

This component will increase livestock producers' technical capacity by offering training in: (i) benefits of CSA in livestock production; (ii) use of manure in agropastoral systems; (iii) use and benefits of silvopastoral systems, including (a) forage production for nutrition optimization, (b) microclimate control and (c) shading; (iv) meat quality and hygiene standards; and (v) disease prevention and treatments.

COMPONENT 2: Build Capacity of Extension Agents and Veterinarians
Key actors: MIRAH, ANADER, universities, CNRA

This component will increase farm advisors' capacity to integrate CSA best practices into their recommendations for livestock systems. Specifically, this will include training in: (i) benefits of CSA in livestock production; (ii) improved breeds of cattle and small ruminants; (iii) use and benefits of silvopastoral systems, including (a) forage production for nutrition optimization, (b) micro-climate control and (c) shading; (iv) meat quality and hygiene standards; and (v) disease prevention and treatments.

COMPONENT 3: Support Research
Key actors: MIRAH, CNRA, universities, NGOs

This component will bolster livestock research initiatives. Specific components will include: (i) research and development of improved breeds; (ii) best management recommends for the improved breeds, as well as other popular varieties; (iii) research and development of improved forage crop varieties; (iv) health and disease prevention studies and recommendations (e.g., seasonal dynamics and distribution of tsetse fly populations, incidence of disease per agropole); and (v) operationalization of a system for transferring newly developed technology to producers and communicating producer priorities to researchers in a timely manner.

COMPONENT 4: Support Infrastructure Development

Key actors: MIRAH

This component will improve the quality and accessibility of livestock-related infrastructure. Specific subcomponents could include: (i) defining transhumant pastoralist corridors, (ii) creating night facilities, (iii) developing new points of safe water access, (iv) constructing new vaccination facilities, and (v) establishing quarantine zones.

Risks: The main risks, their probability, and potential impact on the livestock sector investment are summarized below:

RISKS	PROBABILITY	IMPACT
Sociopolitical crisis	Low	High
Climate change (drought)	Medium	High
Land rights and conflict	Low	Medium
Animal diseases	Low	Medium

F-9 Climate-Smart development of the mango value chain

Introduction and strategic context

Fruits are the main source of vitamins for much of the rural poor of West Africa[310]. The region has a particularly good climate for growing mangoes[311]. Nevertheless, mango fruits are very perishable and particularly vulnerable to disease[312]. Mango's susceptibility to environmental stressors means it is heavily affected by climate; crop yield and quality fluctuate considerably from year to year, and even within a season should any unexpected weather events occur. Inefficient, costly transport as a result of poor infrastructure further exacerbates crop loss. Consequently, crop losses consume up to one-third of total annual production[313]. In recent years the export market has grown significantly, bringing with it both economic gain and significant challenges in terms of quality. A single pest found in a container destined for export will result in destruction of the entire lot, implying significant loss for producers[314]. Pest outbreaks can truncate the entire export season[315].

Climate-smart agricultural practices can significantly improve mango production and reduce post-harvest loss. Fruit flies and anthracnose are the two primary pest issues associated with mango production in West Africa[316]. Additionally, farmers grapple with outdated production techniques, limited access to inputs, limited access to timely information and techniques to support decision-making, and a heavy dependence on intermediary traders to bring their products to market. Climate-smart management practices such as integrated soil management, integrated pest management, mulching and intercropping have been shown to improve mango yields by up to 300% in African systems[317]. Climate information services enable smallholders to anticipate impending weather events and plan accordingly.

Côte d'Ivoire is the largest exporter of mangoes in West Africa[318]. While mangos have historically been grown for domestic consumption, the export market has flourished in recent years. Côte d'Ivoire now produces approximately 100,000 million tons per year, of which 25% is exported to Europe, 50% is consumed domestically, and the remainder is lost post-harvest[319]. Production is concentrated in the northern region of Poro[320]. There are approximately 5,000 mango producers, 90% of whom are smallholders with orchards less than 5 hectares in size producing less than 10 tons per hectare[321]. Many mango producers are members of associations or cooperatives. The most popular export varieties are Amelie, Kent and Keith.

[310] Sangare 2009

[311] CBI 2014

[312] Ban Koffi 2017

[313] Toure 2012

[314] Toure 2012

[315] van den Broek 2016

[316] Toure 2012

[317] Recha 2017

[318] van den Broek 2016

[319] van den Broek 2016, Ban Koffi 2017

[320] Toure 2012

[321] Toure 2012

Côte d'Ivoire is the third largest supplier of mangoes to the European market. Côte d'Ivoire's proximity to Europe allows for later harvesting compared with more distant South American producers, thus improving fruit flavor. Additionally, Ivorian fruit maturation occurs at a significantly different time from that of producers in the southern hemisphere[322]. The cost of West African mangoes remains comparatively lower than South American imports[323].

Mango processing offers an important value-added opportunity in the Ivorian market. Mango products, such as dried mango, have a high market value and significantly lower perishability compared to processed mango. Importantly, the quality criteria for mangos bound for processing is lower than that of mangos for fresh consumption. As such, mango processing creates jobs and diversifies the market, and also significantly reduces post-harvest losses by creating a high-value use for second-grade mangos that would otherwise be discarded. There are currently three functioning drying facilities in Côte d'Ivoire[324].

Fostering the competitiveness of the mango sector for international export is a priority for the Ivorian government. Specifically, the 2017–2025 National Agricultural Investment Plan prioritizes supporting agribusiness in meeting European export market standards and creating a fund to support improved competitiveness of Ivorian mangos. The Ministry of Agriculture estimates that expanding trade in the fruit and nut sector could increase producer household revenue by nearly 50%—by far the most of any agricultural product category[325]. This work also directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 8: Economic Growth; Goal 9: Innovation; Goal 12: Responsible Production; Goal 13: Climate Action; and indirectly addresses Goal 10: Reduced Inequalities; Goal 11: Sustainable Communities; Goal 15: Life on Land; and Goal 16: Strong Institutions. The Economic Community of West African States and the African Union (Côte d'Ivoire is a member of both) have prioritized improving the competitiveness of Côte d'Ivoire's fruit export market.

Proposed Development Objectives and Results

Proposed Project Development Objective: This project aims to increase incomes in the Ivorian mango sector via (i) greater productivity through CSA practices and (ii) reduced post-production losses through value-added processing.

Beneficiaries: The project will directly benefit up to 5,000 mango producers ages 15 and up in the Poro region of Agropole 1, as well as additional employees of value-added, transport and other post-harvest processes, during the five-year project term.

Project Description: This project is designed to bolster mango productivity and postharvest processing. Project activities will address: (i) extension services, (ii) research and development, (iii) postharvest value-added processing, (iv) producer technical assistance and (v) climate information services.

[322] van den Broek 2016

[323] CBI 2014

[324] van den Broek 2016

[325] NAIP 2017

Project Components

COMPONENT 1: Producer Technical Assistance
Key actors: MINADER, ANADER

This component will increase mango producers' capacity to integrate climate-smart practices into their farm management decisions. Specifically, this will include training in: (i) opportunities for CSA in mango production and the potential benefits, (ii) integrated pest management and bio-pesticide use, (iii) integrated soil fertility management, (iv) improved varieties and best management practice recommendations for each, and (v) processes and benefits of certification.

COMPONENT 2: Building Extension Agent Capacity
Key actors: MINADER, ANADER

This project component will develop farm advisors' capacity to integrate CSA management practices into their recommendations for mango production. Specifically, this will include training in: (i) opportunities for CSA in mango production and the potential benefits, (ii) integrated pest management and bio-pesticide use, (iii) integrated soil fertility management, (iv) improved varieties and best management practice recommendations for each, and (v) processes and benefits of certification.

COMPONENT 3: Bolster Research and Development
Key actors: MINADER, CNRA, Centre Suisse, universities, NGOs

This component will support research and development of CSA technologies for the mango sector. Subcomponents will include development of: (i) improved varieties suited to local conditions and demand, (ii) recommended best practices for each new variety, (iii) optimized integrated pest management recommendations, (iv) an operational system for timely transfer of new technology to producers, and (v) an operational system for timely communication of producer priorities for research to researchers.

COMPONENT 4: Foster Processed Mango Market
Key actors: MINADER, Interbranch, cooperatives, associations

This component will focus on developing the processed mango market in order to reduce post-harvest losses and generate additional economic opportunities. Namely, this will consist of: (i) installation of three small processing units in Agropole 1, (ii) training mango producer associations and cooperatives in constructing and managing small processing units, (iii) promoting diversification of mango-based product processing, (iv) providing technical assistance to exporters in processes and benefits of meeting quality standards for certification, and (v) funding a grant program for start-up mango processing organizations that will offer products not currently on the market.

COMPONENT 5: Develop Climate Information Services
Key actors: SMN, CNRA, ANADER, MINADER, Weather-Morocco, Weather-France

This component will support the development of climate information services to equip farmers with both seasonal and short-term weather information to inform their management decisions. Specifically, this component will: (i) establish weather station infrastructure to produce weather data, (ii) process and integrate weather data with agronomic and geographic data, (iii) translate data

into practical agricultural advisories, (iv) develop products and services to effectively communicate advisories to farmers through a variety of channels as part of their everyday routines, and (v) raise farmer awareness of the service and train them on accessing and effectively utilizing the advisories.

Risks: The main risks, their probability, and potential impact on the mango investment are:

RISKS	PROBABILITY	IMPACT
Sociopolitical crisis	Low	High
Drought	Medium	High
Community conflict	Medium	Medium

F-10 Climate-Smart Maize Development

Introduction and Strategic Context

Smallholders throughout sub-Saharan Africa rely heavily on maize for both income and nutritional security. Nevertheless, maize production remains relatively unimproved across much of the continent. At an average of 1.4 metric tons/ha[326], yields are the lowest of any continent and well below the international benchmark of 7.25 metric tons[327]. This is primarily due to the crop's high sensitivity to temperature and precipitation variability; in many regions of sub-Saharan Africa, climate variability accounts for over 50% of the variation in maize production from year to year[328]. Although varieties have been bred to tolerate such variability, they remain inaccessible to most African farmers. Smallholders thus continue to rely largely on landrace varieties or outdated hybrids. The predicted changes in temperature and precipitation as a result of climate change will exacerbate these issues, further increasing the vulnerability of smallholders.

Integrating maize into agroforestry systems significantly improves climate resiliency. Trees help reduce variability in temperature and soil moisture in maize's microclimate. Species that improve soil fertility through organic matter or nitrogen fixation have been shown to significantly increase maize yields[329]. Trees also serve as a fire break to help minimize the risk of losing entire maize plantations to bushfire. Species with economic value, such as teak, acacia and fuelwood[330], offer diversified income to offset poor maize harvests. Similarly, fruit trees diversify smallholder's nutritional options when the maize harvest is insufficient.

Ivorians grow maize in rotation with other annual crops. In the cotton basin, maize is primarily grown as part of a cotton-legume or rice-legume rotation; in the central forest zone, it is more frequently produced in association with legumes and yams or cassava. Average yields in Côte d'Ivoire are 2 metric tons/ha[331] (versus the international benchmark of about 7.25 metric tons/ha[332]). Women in Côte d'Ivoire play a major role in producing, processing and selling maize, particularly in the northern zone[333].

[326] "Cereal Yield (Kg per Hectare) | Data."

[327] Langemeier and Lunik, "International Benchmarks for Corn Production."

[328] Cairns and Prasanna, "Developing and Deploying Climate-Resilient Maize Varieties in the Developing World."

[329] Mkonda and He, "The Potentials of Agroforestry Systems in East Africa."

[330] RICAU, "Diagnostic de la Filiere Mais en Côte d'Ivoire."

[331] FAOSTAT, "Maize Yields in Ivory Coast."

[332] Langemeier and Lunik, "International Benchmarks for Corn Production."

[333] RICAU, "Diagnostic de la Filiere Mais en Côte d'Ivoire."

Increasing the productivity and resilience of maize systems is a priority for the Ivorian government and its allies. The self-sufficiency rate for maize is a target indicator for the strategic objective of developing agricultural production systems in the 2017–2025 National Agricultural Investment Plan[334]. This work also directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 5: Gender Equality; Goal 8: Economic Growth; Goal 9: Innovation; Goal 12: Responsible Production; Goal 13: Climate Action; and indirectly addresses Goal 10: Reduced Inequalities; Goal 11: Sustainable Communities; Goal 15: Life on Land; and Goal 16: Strong Institutions. The Economic Community of West African States, of which Côte d'Ivoire is a member, promotes food self-sufficiency and security, including through improved maize post-harvest processes.

Proposed Development Objectives and Results

Proposed Project Development Objective: This project aims to increase farm productivity and minimize climate-related risks by increasing the capacity of producers, cooperatives, extension agents and researchers in climate-smart maize research, production, processing and marketing.

Beneficiaries: The project will directly benefit the 138,000 female agriculturalists[335] residing in the Poro region of Agropole 1 during the five-year project term. Subsequent project terms will expand to Agropoles 6 and 7. Across time, the improved productivity and climate resilience resulting from this project could indirectly benefit all Ivorian agricultural producers.

Project Description: This project is designed to increase producers' capacity for CSA in maize and their access to relevant inputs. Project activities address (i) research, development and distribution of climate-smart maize technologies, (iii) capacity of extension agents to use and recommend these technologies, (iv) cooperative and professional organization capacity to facilitate access to these technologies, (iv) public awareness of the benefits of these technologies, and (v) financial services to facilitate access to these technologies.

Project Components

COMPONENT 1: Research and Develop Improved Varieties
Key actors: CNRA, universities, private industry

This project component will focus on the development of improved maize varieties and relevant products, including agroforestry seed. Subcomponents include research and development of: (i) three short-cycle improved maize varieties, (ii) three long-cycle improved maize varieties, (ii) optimized seed bases for each variety, (iii) CSA best management practice recommendations for each variety, (iv) improved tree seed for recommended agroforestry practices, and (v) recommended best management practices for tree varieties[336].

[334] Côte d'Ivoire Ministry of Agriculture and Rural Development, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report."

[335] The population of Poro is approximately 1 million. Given that 46% of the total Ivorian population is employed by agriculture, we assume that 75% of rural populations are employed by agriculture. Women over the age of 14 account for 32% of the population. World Population Review, "Ivory Coast Population 2018 (Demographics, Maps, Graphs)"; Statoids, "Côte d'Ivoire Regions."

[336] Expert Panel Workshop, Theorie du Changement Mais.

[337] Expert Panel Workshop.

COMPONENT 2: Build Capacity of Farm Advisors

Key actors: MINADER, ANADER, CNRA, universities, private industry

This project component will develop the capacity of extension agents to integrate CSA concepts and practices into their recommendations. Specifically, this will include training on: (i) general CSA benefits and practices in maize; (ii) characteristics and optimum conditions for each improved variety from Component 1; (iii) agroforestry in maize systems, including benefits, economic activities, ownership of trees and best management practices; (iv) formation, management and benefits of farmer cooperatives; and (v) processing, packaging and storage of maize and agroforestry products[337].

COMPONENT 3: Raise Awareness and Technical Capacity of Producers

Key actors: ANADER, MINADER, Ministry of the Environment

This component will build awareness of the opportunities for improved productivity and resilience among producers and provide technical assistance in employing CSA technologies. Specifically, this will include: (i) integration of CSA techniques and practices into existing capacity-building programs; (ii) technical assistance in agroforestry; (iii) general awareness campaigns on environmental issues, improved consumer technologies (e.g., biodegradable products) and the benefits of CSA; (iv) targeted campaigns for maize producers contrasting obsolete practices (e.g., highly polluting pesticides, outdated hybrid seed varieties) to improved CSA practices and technologies; and (v) technical assistance in establishing and managing cooperatives and accessing financial services[338].

COMPONENT 4: Operationalize a System for Dissemination of Improved Varieties

Key actors: MINADER, Department of Water and Forests, cooperatives, private sector

This component will focus on implementing a system for producing and distributing the improved maize and tree varieties developed in Component 3. Namely, this will consist of: (i) supporting the establishment of local nursery groups; (ii) provision (by the ministry) of seed, facilities and land intended for this purpose; (iii) field school and parcel demonstration training of trainers for production and management of improved maize varieties; (iv) field school and parcel demonstration training of trainers for production and management of recommended agroforestry varieties; and (v) establishment of multi-stakeholder agricultural boards, including all supply chain actors, in order to facilitate exchange regarding, e.g., organizational structure, market pricing and quality standards.

COMPONENT 5: Improve Access to Inputs

Key actors: MINADER, private industry, cooperatives

This component will help improve producer access to the recommended inputs and technologies. Subcomponents include: (i) distributing the improved seed varieties and fertilizer (at rates of 150kg/ha for average-fertility soils and 200–250kg/ha for poor soils) in the first season they are available to raise awareness; (ii) promoting the establishment of professional agricultural organizations and cooperatives through start-up grants, technical capacity building and conducive policy; (iii) strengthening the capacity of agricultural organizations and cooperatives through management and finance training, facilitated common markets for bulk sale, and assistance in accessing financial services; (iv) bolstering producer access to financial services through subsidies, credit and lending based on agricultural seasons, and equity; and (v) operationalization of an input monitoring program to evaluate and determine opportunities for improvement of producer access to inputs.

[337] Expert Panel Workshop.

[338] Expert Panel Workshop.

Risks: The main risks, their probability and potential impact on the maize investment are as follows:

RISKS	PROBABILITY	IMPACT
Locust invasion	Medium	High
Sociopolitical problems	Low	High
Farmer-herder conflict	High	High

F-11 Irrigated and Rainfed Rice Development

Introduction and Strategic Context

Rice is foundational to the diets and livelihoods of smallholders across sub-Saharan Africa. The popularity of rice among African consumers has skyrocketed over the past three decades, particularly in urban areas[339]. About 100 million African depend directly on rice farming for their livelihoods. Nevertheless, Asian rice continues to dominate African markets. This is attributable primarily to poor technology access, because the improved varieties and best management practices developed in Asia during the Green Revolution do not translate well to African climates. As a result, African rice systems remain costly and highly sensitive to climate variability, and yields and profit remain low. At 1.4 tons/ha, average rice yields on the subcontinent are the lowest in the world; Asia's average is 4 tons/ha[340].

CSA practices have been shown to significantly improve African rice productivity. Significant research in the rice sector has produced climate-resilient varieties, revised production calendars to account for climate change, and low-cost soil erosion control practices[341]. The System of Rice Intensification has shown increased yields of as much as 67% in some regions[342]. Integrated rice-fish systems offer nutritional and economic diversification as well as enhanced soil fertility.

Rice is a staple food crop in Côte d'Ivoire. It accounts for 65% of total cereal production[343] and is the single largest calorie source in the country[344]. National rice consumption is expected to steadily rise as the grain grows in popularity[345]. Lowland rice systems account for 10% of the planted land area in Côte d'Ivoire. Rainfed and upland systems, which generate the lowest yields (0.5–1.5 tons/ha), represent 85% of land area[346]. The remaining 5% of planted land area is irrigated and generates 20% of national yield[347]. An estimated 20% of Ivorian rice farmers use integrated rice-fish systems[348].

Ivorian rice systems are challenged by international competitors and high costs. Current national production satisfies approximately 50% of the national demand; the remaining 50% of rice consumed in Côte d'Ivoire is imported. Given this strong presence of inexpensive international products on the

[339] WARDA 2005

[340] Nwanze et al. 2006

[341] Doumbia 2017

[342] Doumbia 2017

[343] Sylla 2017; NRDS 2012

[344] CIAT 2018

[345] NRDS 2012

[346] CIA 2018

[347] Archibald 2018

[348] Doumbia 2017.

market, rice prices are highly volatile[349]. Limited access to inputs, minimal finance options and high collection and transportation costs have further undermined the profitability of rice production[350]. Climate change threatens to further decrease Ivorian rice yield by 5%–25%.

Women play a crucial role in the Ivorian rice sector. Women typically are responsible for transplantation, harvest, threshing and transport in irrigated rice systems. Rainfed rice production is generally done solely by women. The National Office for Rice Development has proposed value-added product delivery services operated by women and youth, as well as measure to support the creation of a market exclusively for women farmers to facilitate knowledge sharing and enhance business opportunities[351].

The Ivorian government and its allies have prioritized improved rice production and market reforms. Rice self-sufficiency is of strategic importance across sub-Saharan Africa[352].The African Rice Center and the Economic Community of West African States, both of which have Côte d'Ivoire as a member, are working to reform the African rice sector to attain self-sufficiency, alleviate poverty and improve nutritional and economic outcomes. The Ivorian Revised National Rice Development Strategy (2012) also aims for national self-sufficiency by 2020. In addition, the Ivorian government seeks to stabilize revenues for producers[353] augment its milling capacity, and become a leading player in the West Africa rice market[354]. This work directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 5: Gender Equality; Goal 8: Economic Growth; Goal 9: Innovation; Goal 12: Responsible Production; Goal 13: Climate Action; and indirectly addresses Goal 10: Reduced Inequalities; Goal 11: Sustainable Communities; Goal 15: Life on Land; and Goal 16: Strong Institutions.

Proposed Development Objectives and Results

Proposed Project Development Objective: This project aims to increase rice productivity and stabilize producer revenues by scaling climate-smart practices applicable to the African context in order to achieve national rice self-sufficiency.

Beneficiaries: The project will directly benefit up to 68,640[355] rainfed rice producers over the age of 14 in the Cavally region of Agropole 7 during the initial five-year term. Subsequent project terms will expand the project to the Guemon region. Across time, improved national nutritional self-sufficiency and economic outcomes could indirectly benefit all rice producers.

Project Description: This project is designed to provide Ivorian rice producers with climate-smart technologies suited to their climate and situation. The project will address (i) research and development, (ii) extension services, (iii) infrastructure and (iv) producer technical assistance.

[349] Dimova 2012

[350] Archibald 2018; NRDS 2012; CIAT 2018

[351] PNIA II 2017

[352] WARDA 2005

[353] NRDS 2012

[354] Archibald 2018

[355] The population of Cavally is approximately 604,850. Since 63% of the Ivorian population is over the age of 14, and 46% of the Ivorian population is employed by agriculture, we assume that 75% of rural populations work in agriculture.

Project Components

COMPONENT 1: Producer Organization and Technical Assistance
Key actors: ANADER, MINADER, Ministry of Environment, ADERIZ

This component will raise awareness among rainfed rice producers of the options and benefits of CSA, and technically assist them in implementing these practices. Specifically, this will include: (i) targeted awareness campaigns regarding potential yields and climate resilience, (ii) field school training on CSA best management practices, (iii) formation and capacity building of producer associations, (iv) technical assistance to producer associations in organizational management and meeting minimum requirements for financial services, and (v) training in accessing and using services, e.g., input subsidies, bulk purchasing and sales, credit and loan, etc.

COMPONENT 2: Extension Agent Capacitation
Key actors: ANADER, MINADER, Livestock and Fisheries, ADERIZ

This project component will increase the capacity of farm advisors to integrate CSA practices into their recommendations for rice producers. Specifically, this will include training in: (i) climate change and benefits of CSA in rice systems, (ii) improved rice varieties, their advantages and recommended best management practices, (iii) general CSA practices for both rainfed and irrigated rice systems, including rice-fish systems, and (iv) production of training manuals, reference guides and modules for integration into general training curricula.

COMPONENT 3: Production and Dissemination of High-Quality Inputs
Key actors: CNRA, Centre Suisse, universities, NGOs, cooperatives, producer associations

This component will ensure the dissemination of climate-smart best management practices and technologies for Ivorian rice systems. Specific subcomponents will include: (i) transfer of technologies developed in Component 5 to producers, (ii) training of community-based seed producers, (iii) supporting access to seed production facilities and improved seed for seed production cooperatives, (iv) technically assisting new cooperatives and organizations in management and meeting minimum requirements for accessing financial services, (v) technically assisting new cooperatives in leveraging available services such as bulk purchasing and sales, financial services, governmental assistance programs, etc., and (vi) a general public awareness campaign of new improved varieties and their benefits.

COMPONENT 4: Streamline Infrastructure Development
Key actors: MINADER, private industry

This component will focus on ensuring that the infrastructure to support a thriving national rice sector is in place. Namely, this will consist of (i) the development of irrigated rice infrastructure where feasible, (ii) rehabilitation of aquaculture infrastructure to augment the supply of recommended breeds for rice-fish integrated systems, (iii) rehabilitation of irrigated perimeters, (iv) rehabilitation and construction of rice processing and storage facilities, and (v) subsidization of on-farm technology to mechanize production processes.

COMPONENT 5: Bolster Rice Research and Development

Key actors: CNRA, Centre Suisse, universities, NGOs, producer associations, cooperatives

This component will bolster research and development efforts in the rice sector. Specifically, this will include: (i) development of improved rice varieties for rainfed, lowland and irrigated rice systems, (ii) development of improved breeds of fish for integrated rice-fish systems, (iii) development of best management practice recommendations for each improved rice variety, (iv) development of best management practice recommendations for each improve breed of fish, and (v) operationalization of a system for timely transfer of new technologies to producers and timely reception of feedback from producers on priorities for research.

Risks: The main risks, their probability and potential impact on the rice investment are as follows:

RISKS	PROBABILITY	IMPACT
Political crisis (that disrupts implementation and monitoring)	Low	High
Insufficient community engagement (undermining sustainability) and poor uptake of CSA practices	Medium	Medium
Land problems (tenure, rent) in irrigated perimeters	Medium	High
Financial and technical capacity of enterprises in infrastructure sector	Low	High
Community conflict, esp. in Agropole 1 (e.g., farmer-herder)	High	High

F-12 Development of Climate Smart Production and Processing of Yam

Introduction and Strategic Context

Yams play a crucial role in the diet, economy and culture of West Africa. Smallholders in the region grow 94% of the world's approximately 50 megatons annually[356]. The significant cultural value of yams[357] creates strong, reliable demand and good profits despite high production costs. Nevertheless, yields average about 10 tons/ha, compared to potential yields of approximately 50 tons/ha[358]. Most of the over 600 yam species in the world are native to this region. To date, only about 20 of these species are under production. This implies significant opportunity for research and development of improved varieties highly suited to West African soils and climate.

Yam production in West Africa is costly and challenging. Planting and harvesting are labor-intensive. The crop has a long crop cycle and poor seed multiplication ratio[359]. Nutritional value, yield, texture and postharvest durability vary significantly with soil quality and climactic factors. It is susceptible to nematodes, viruses, anthracnose and scale[360] and heavily degrades the soil[361]. Due to its high soil nutrient demands, many farmers slash and burn directly prior to planting. Decreasing soil quality and mounting pest pressures have pushed many traditional production zones to switch to other crops[362].

[356] Root Tuber Banana Research, "Yam."

[357] Southworld, "Ivory Coast – The Yam Festival."

[358] ETH Zurich, "Sustainable Yam Systems in West Africa."

[359] Adebola, "Enhancing Yam Breeding for Increased Productivity and Improved Quality in West Africa."

[360] Doumbia, "Changements Climatiques et Agriculture Intelligente En Côte d'Ivoire: Diagnostic Du Contexte National et Recueil Des Résultats de La Recherche Sur Les Facteurs Socio-Économiques Favorisant l'adaptation et Les Technologies Appropriées de l'AIC Chez Les Petits Agriculteurs."

[361] ETH Zurich, "Sustainable Yam Systems in West Africa."

[362] International Institute of Tropical Agriculture, "Yam."

The predicted changes in temperature and precipitation as a result of climate change will exacerbate these issues, further increasing the vulnerability of smallholders. Innovations to improve productivity and reduce labor are needed in order to sustain this long-standing market.

Yams are widely grown in Côte d'Ivoire, particularly in the northern and central regions. The landrace varieties Kponon, Krengle and Djate are in high demand, as are the improved varieties TDA, Mao and C20. The latter have demonstrated good productivity, disease resistance and drought tolerance. Value-added yam products currently on the market are limited to chips and flour[363]. Yam production is traditionally the work of men, while women are primarily involved in processing and marketing[364].

Increasing the productivity, resilience and marketability of yam systems is a priority for the Ivorian government and its allies. Bolstering food security and market opportunities feature prominently in the strategic objectives of the Côte d'Ivoire National Agriculture Investment Plan[365], the African Union Strategic Agriculture and Rural Development Agenda[366], the West African Economic and Monetary Union Treaty[367], and the Economic Community of West African States' Vision[368]. This work also directly addresses Côte d'Ivoire's Sustainable Development Goal 2: Zero Hunger; Goal 5: Gender Equality;, Goal 8: Economic Growth; Goal 9: Innovation; Goal 12: Responsible Production; Goal 13: Climate Action; and indirectly addresses Goal 10: Reduced Inequalities; Goal 11: Sustainable Communities; Goal 15: Life on Land; and Goal 16: Strong Institutions.

Multiple international organizations have prioritized innovation in yam systems in Côte d'Ivoire. The International Institute for Tropical Agriculture[369] and YamAfrica[370] are breeding new varieties that address production and propagation challenges. ETH Zurich's YAMSYS project is working to improve seed quality and soil fertility[371].

Proposed Development Objectives and Results

Proposed Project Development Objective: This project aims to (i) increase farm productivity and minimize climate-related risks by increasing capacity for climate-smart yam production and (ii) strengthen yam markets for improved economic and nutritional resilience.

Beneficiaries: The project will directly benefit the approximately 70,000[372] rural agricultural workers ages 15 and up in the Gbeke region of Agropole 4 over the five-year project term. Future terms will

[363] Expert Panel Workshop, Theorie du Changement Igname.

[364] Doumbia, "Changements Climatiques et Agriculture Intelligente En Côte d'Ivoire: Diagnostic Du Contexte National et Recueil Des Résultats de La Recherche Sur Les Facteurs Socio-Économiques Favorisant l'adaptation et Les Technologies Appropriées de l'AIC Chez Les Petits Agriculteurs."

[365] Côte d'Ivoire Ministry of Agriculture and Rural Development, "Program National D'Investissement Agricole de Deuxième Génération, 2017-2025, Final Report."

[366] Department of Rural Economy and Agriculture, "Fostering the African Agenda on Agricultural Growth and Transformation and Sound Environmental Management."

[367] West African Economic and Monetary Union, "The Amended Treaty."

[368] Economic Community of West African States, "Vision 2020."

[369] International Institute of Tropical Agriculture, "Yam Crop Improvement."

[370] Adebola, "Enhancing Yam Breeding for Increased Productivity and Improved Quality in West Africa."

[371] ETH Zurich, "Sustainable Yam Systems in West Africa."

[372] Approximately 1.33 million people reside in this region, of which approximately 580,000 are urban residents. We assume 75% of the rural population works in agriculture. 63% of the population is ages 15 and up. World Population Review, "Ivory Coast Population 2018 (Demographics, Maps, Graphs)"; Statoids, "Côte d'Ivoire Regions."

expand the project to the remaining regions of Agropole 4. Across time, indirect benefit via improved nutritional and market outcomes could feasibly reach all Ivorian agricultural producers.

Project Description: This project is designed to support nutritional and economic security by building capacity for climate-smart yam production and optimized processing. The project will address (i) research and development, (ii) extension services and market development, including (a) propagation, (b) production and (c) processing.

Project Components

COMPONENT 1: Bolster Research
Key actors: MINADER, universities, CNRA, private industry

This component will establish and strengthen research and development of new technologies in yam production and processing. Specifically, this will include: (i) improving the quality and accessibility of laboratory equipment, (ii) building capacity of researchers to employ new laboratory equipment and techniques, (iii) development of improved varieties to increase productivity and resilience to stressors, (iv) development of optimized propagation and processing techniques for each improved variety and other widely produced varieties, and (v) operationalizing a multi-way communication system between researchers, extensionists and producers, in order to systematize timely transfer of newly developed technologies, as well as prioritize research most relevant to current producer issues[373].

COMPONENT 2: Produce and Distribute Improved Varieties
Key actors: CNRA, universities, MINADER, ANADER

This project component will systematize propagation and distribution of the improved varieties developed in Component 1. Specific subcomponents will include: (i) supporting establishment and development of propagation cooperatives through (a) start-up grants, (b) management capacity building and advising, and (c) access to land, facilities, and equipment; (ii) assisting cooperatives in meeting standards to access financial services; (iii) building technical capacity of cooperatives to effectively propagate the improved varieties per recommendations developed in Component 1; (iv) raising producer awareness of the improved varieties and their benefits; and (v) brokering cooperative-private industry alliances to establish and strengthen value chains[374].

COMPONENT 3: Build Extension Agent Capacity
Key actors: MINADER, ANADER

This component will strengthen farm advisors' capacity to integrate CSA best practices into their recommendations regarding yam production and processing. Namely, this will include training on: (i) the varieties developed in Component 1 and the relevant best management practices for each, (ii) the optimized processing techniques developed in Component 1, (iii) the optimized propagation techniques developed in Component 1, and (iv) effective use of the communication system implemented in Component 1[375].

[375] Expert Panel Workshop.

COMPONENT 4: Build Producer Capacity

Key actors: ANADER, private industry, NGOs

This component will integrate climate-smart yam production into existing capacity building programs. Specifically, training will address: (i) general CSA practices, e.g., organic fertilizers and pest control, composting, diversification, crop rotation; (ii) access to and use of the improved varieties and relevant best management practices developed in Component 1, including the conditions under which each is recommended; (iii) access to and use of appropriate mechanization technologies; (iv) legume, agropastoral and agroforestry associations to improve yam production; and (v) leveraging the markets developed in Component 5.

COMPONENT 5: Strengthen Value-Added Processing Systems

Key actors: MINADER, private industry, cooperatives, NGOs

This component will improve yam processing to reduce postharvest losses, increase product quality and expand marketability. Specific subcomponents will include: (i) supporting establishment and development of processing cooperatives through (a) start-up grants, (b) management capacity building and (c) access to facilities and equipment; (ii) assisting cooperatives in meeting standards to access financial services; (iii) building technical capacity of cooperatives in optimal processing techniques and the mechanization, thereof per research in Component 1; (iv) establishing a digital market information platform to facilitate sales and inform stakeholders of current market conditions; and (v) brokering cooperative-private sector alliances to establish and strengthen market opportunities[376].

Risks: The main risks, their probability, and potential impact on the yam investment are as follows:

RISKS	PROBABILITY	IMPACT
Political crisis	Low	High
Donor unwillingness to support	Medium	High
Lack of community acceptance	Low	High
Drought	Medium	Medium
Community conflict (e.g., farmer-herder)	Medium	Medium

[376] Expert Panel Workshop.

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