Info Note

Climate Smart Cocoa in Ghana

Towards climate resilient production at scale

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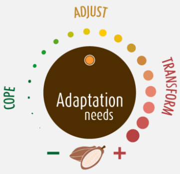
Key messages

- The expected cost of inaction on adaptation of cocoa production by the 2050s was estimated at 410m USD per year or about 1% of current real GDP.
- Recommendation domains with different degree of projected impact can guide interventions to scale out adaptation.
- Climate Smart Practices for Cocoa simultaneously improve productivity and help to adapt to future climate risk.
- Current, low adoption rates of improved farming practices are a reflection of significant barriers.
- We recommend cocoa value chain actors mainstream interventions tailored to projected climate gradients in different regions of Ghana.

Three degrees of adaptation **effort**



1. **Incremental** adaptation where climate is most likely to remain suitable and adaption will be achieved by a change of practices and ideally improved strategies and enablers
2. **Systemic** adaptation where climate is most likely to remain suitable but with substantial stress, adaptation will be achieved through a comprehensive change of practices, but also requires a change of strategy and adequate enablers
3. **Transformational** adaptation where climate is likely to make cocoa production unfeasible, this will require a focus on a change of strategy and adequate enablers as practices alone may be uneconomical

Climate Smart Cocoa (CSC) is not only about avoiding future losses but also about mitigating greenhouse gas (GHG) emissions and improving the livelihoods of farmers by increasing the productivity and resilience of their farms. The current state of cocoa production in Ghana has significant leeway to become more forward-looking and productive.

Cocoa farms in Ghana are vulnerable to an array of climate-related risks: the Harmattan wind, droughts, storms, flooding. Climate change is projected to increase the occurrence of such extreme events, as well as induce more gradual changes to cocoa farming suitability via higher average temperatures and more erratic rainfall. Whether sudden or gradual, production needs to be resilient to these changes.

> This info note gives an overview of research to guide the implementation of CSC practices in Ghana.

To achieve adaptation at scale, stakeholders should consider impact gradient maps as well as the costs and benefits of potential CSC practices.

Practices	*Strategies*	*Enablers*
implemented on-farm to adapt to current climate variability (and to a lesser extent, prepare for climate change)	implemented on- and off-farm, within the cooperative, community or supply chain, that adapt to current climate	supported by actors on- and off-farm to establish the conditions needed to implement CSA strategies and to adopt CSA practices
Cover crops Shade management Distancing Trenches	Diversification Choosing resilient varieties Changing processing methods	Financing Weather insurance Weather stations

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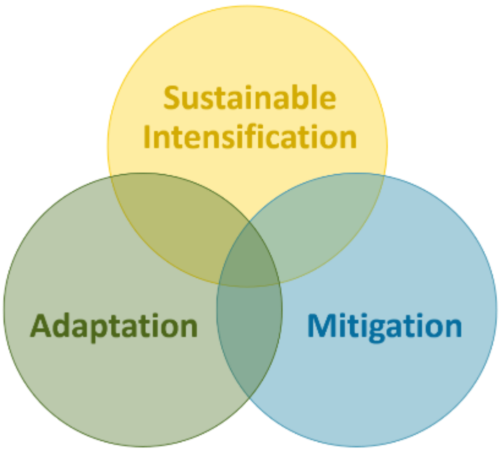
IITA Transforming African Agriculture
CGIAR
RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security
CCAFS

Climate-Smart Cocoa

Uncertain precipitation patterns and increasing temperatures are projected to pose a challenge to Cocoa production in Ghana. Cocoa is produced all over the southern part of Ghana, whereas in the Northern Savanna the lack of suitable precipitation prohibits its production. Cocoa production is an integral part of the rural economy in Ghana. An estimated 800,000 families cultivate and market cocoa on 1.69 million ha in plots that average 2 to 3 hectares. It has been estimated that 25 to 30% of the population of Ghana depends on the cocoa sector for their livelihood. Gross Domestic Product (GDP) generated from cocoa accounts for 1.6% of the total GDP and 6.8% of primary sector GDP.

> The negative impacts of climate change on cocoa would have repercussions for the Ghanaian economy and especially for rural development.

Without adaptive action, a geographical shift of cocoa production in Ghana caused by climate change appears likely and stakeholders increasingly demand decision support to direct adaptation. Climate smart cocoa (CSC) production sustainably increases productivity, enhances resilience to climate risk, and reduces or removes greenhouse gas emissions (GHGs). Many of the interventions that make up CSC already exist worldwide and are used by farmers to cope with various production risks. Interventions can take place at different technological, organizational, institutional and political levels.



Climate Smart Cocoa requires by definition a more nuanced approach to determining what constitutes a “good” agricultural practice by accounting for site- and time-specific variability such as climate, vulnerability and capacities of producers to identify and adopt climate smart responses when needed. Traditional guidance such as national sustainability curriculums and GAP manuals may be insufficiently tailored to local variability, particularly under conditions of future climate uncertainty and volatility.

Resilient production at scale

Training, enabling, and monitoring are not trivial tasks at any scale. Therefore, the importance of selecting no-regret adaptation practices and understanding barriers to implementation becomes crucial. To take a further step toward increasing the resiliency of production in the face of climate change, scaling must account not only for the current climate but also for the projected developments of the coming decades. Recommendation domains of future impacts, as displayed in the following pages, and the division of practices into incremental, systemic, and transformational are a touchstone of CSC for improving the resiliency of cocoa production in Ghana.

Resiliency at the farm-level equates sustained productivity despite gradual climate change and a rapid and thorough recovery after extreme climate events. Resilient production at the national scale implies that the supply of cocoa beans from Ghanaian farmers is far more secure and sector incomes are more stable.

> Scaling CSC practices provides a path to greater resilience and improved productivity, adaptation, and mitigation of GHG emissions in the production of Ghanaian cocoa.

Adaptation to climate change is often understood as a change of production practices at farm level. Because of the high climate uncertainty for Ghana, we recommend no-regret CSC practices, i.e. practices that improve economic and social benefits regardless of the actual future climate. We were able to identify these suggested farm level practices with the input from farmers and experts. This aims to make the adoption of these practices feasible for resource-constrained smallholders. With increasing degree of climate impacts, the importance of systems approaches to adaptation and the enabling environment increases. Value chain inclusive systems approaches to adaptation, therefore, include a wider range of actors or crops to manage risk from cocoa. Such systemic or transformational adaptation may require changes to the framework conditions, or enabling environment for CSC. This enabling environment includes policies, institutional arrangements, stakeholder involvement, gender considerations, infrastructure, credit, insurance schemes, as well as access to weather information and advisory services.

The implementation of strategies and enablers by value chain actors beyond the farm gate is needed to help farmers adapt specific CSC practices. Climate change is a threat not only to cocoa production but to the entire cocoa value chain. Effective solutions require shared investments and greater collaboration among diverse value chain actors both private and public.

Observed and projected climate change

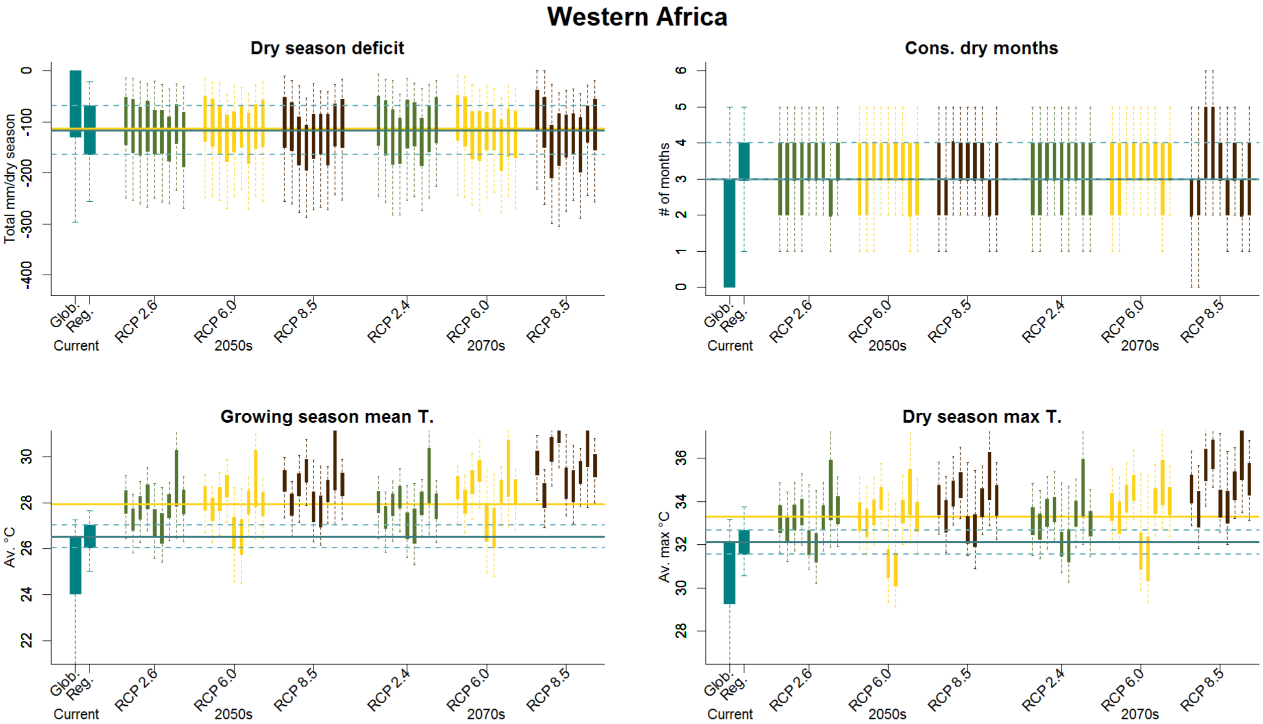


Figure 2. Comparison of observed and simulated climate at cocoa occurrence locations in West Africa; teal colored bars show current climate conditions at global occurrence locations and only the locations in West Africa; green, yellow, and brown bars show the projections in the emission scenarios RCP's 2.6, 6.0, and 8.5 for the 2050ies and 2070ies. Bars represent the 1st and 3rd interquartile range, whiskers 5% and 95% percentiles. The yellow horizontal line represents median conditions at occurrence locations in the 2050s in the RCP 6.0 emissions scenario.

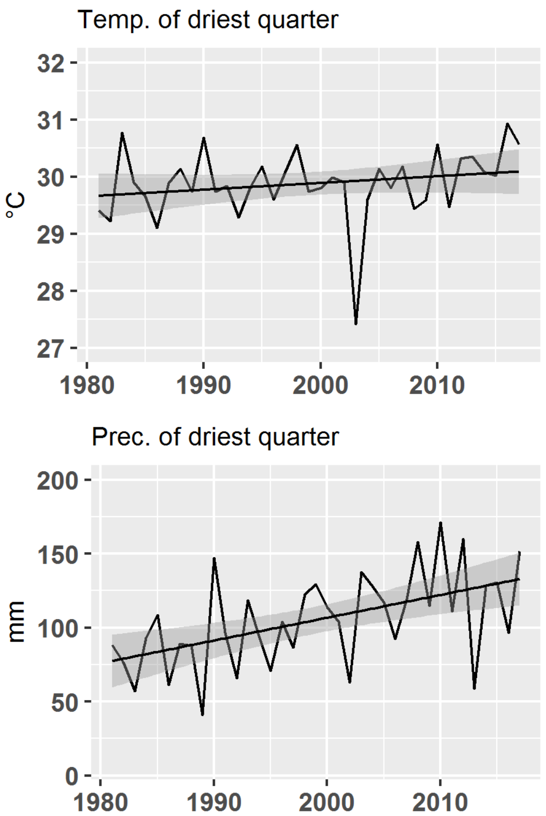


Figure 1. Mean temperature and precipitation during the driest quarter of the year in Ghana from 1981 to 2017.

Cocoa experts and stakeholders report a wide range of perceived climatic changes to date. Irregular or intermittent rainfall are among the most voiced complaints, yet others state that heat and drought are increasingly concerning.

Observed climate data from interpolated weather observations confirmed some of these perceptions but not all. Across the cocoa zone in Ghana, temperatures have risen in all seasons: For example, the driest quarter has become hotter everywhere by about 0.7°C over the last three decades. However, precipitation during the dry season has also increased on average between 1981 and 2017 with high variability between years (Figure 1). Increases in evapotranspiration are similar to the rise in temperatures but the precipitation increase is outpacing this so that the driest quarter is overall more humid. Precipitation of the wettest quarter has not changed. The data is inconclusive about the perceived irregularity of rainfalls.

> In an intermediate emissions scenario the median temperatures in the 2050s would be hotter than at 98% of global locations under current conditions.

Observed trends should not be extrapolated over several decades. Therefore, we used data from global climate models (GCMs) for long term projections. West African growing areas were found to have pronounced dry seasons both in length and in deficit compared to other global locations (Figure 2). Under current conditions, growing and dry season temperatures were above most other global locations. Precipitation projections in the climate change simulations were uncertain. In the RCP 6.0 and 8.5 emission scenarios, slightly more GCMs projected increasingly severe dry seasons but overall the humid conditions were projected to prevail.

Recommendation domains for adaptation

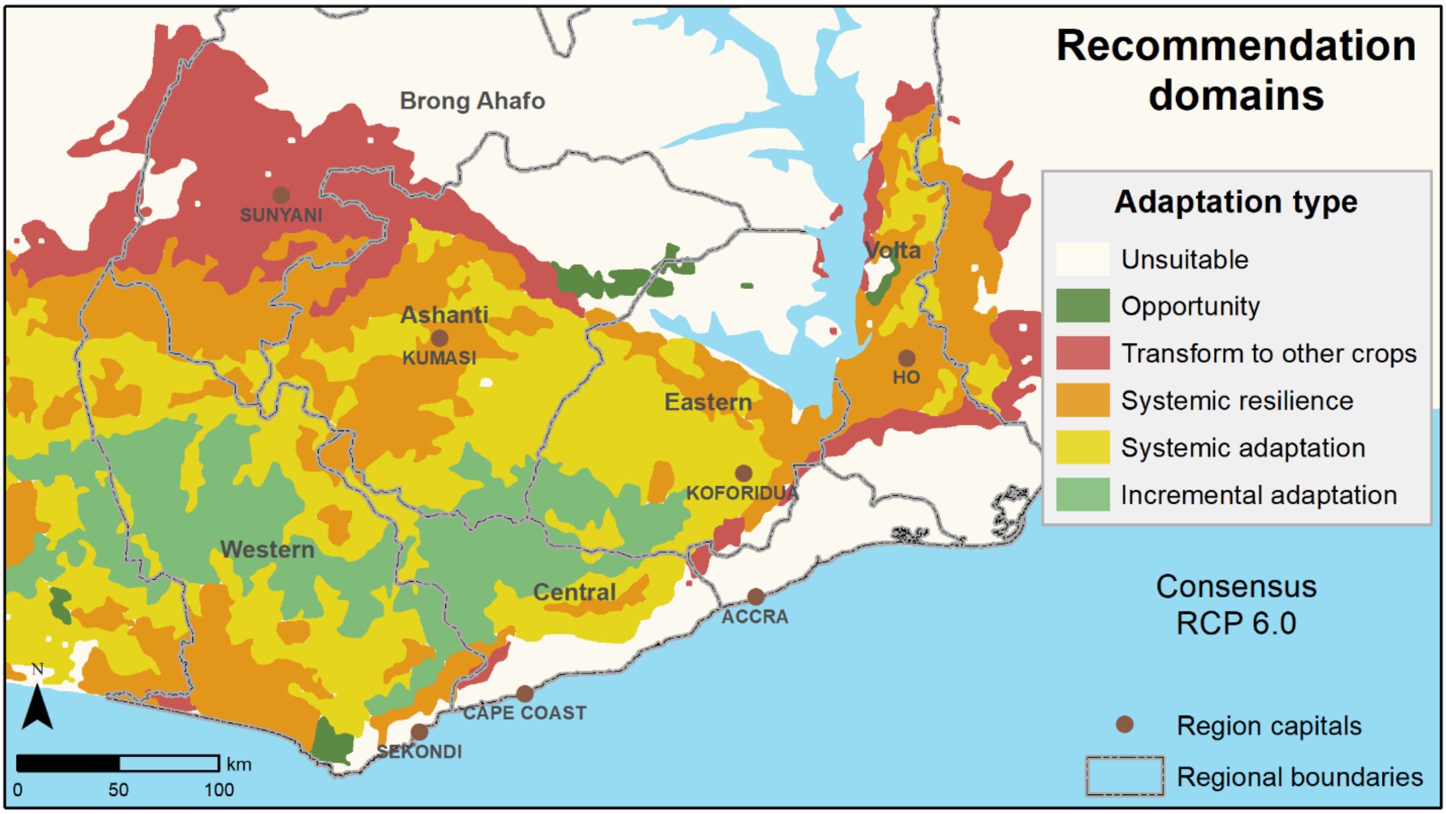
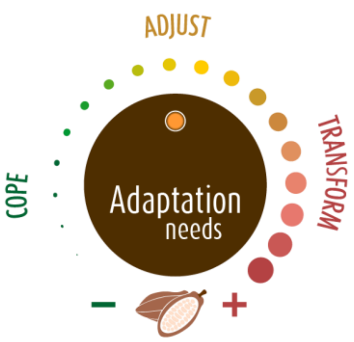


Figure 3 Recommendation domains to scale adaptation strategies by degree of impact in the consensus across 19 GCMs in the RCP 6.0 scenario.



To support efficient adaptation, we developed a gradient of climate change impacts. The gradient is a cocoa specific evaluation of the projected climatic changes described above. Otherwise identical climatic changes may result in severe or irrelevant impacts depending on the historic climate conditions. For example, a reduction of 50mm precipitation may be critical to the cocoa crop at locations with low water availability but would be irrelevant where rainfalls are abundant throughout the year.

> The gradient shows the most likely degree of necessary adaptation effort across several potential future climate developments.

Our method used an RF classification model to evaluate the degree of climate change impacts in Ghana by comparing future (2040-69) to present (1950-2000) bioclimatic suitability for cocoa. We considered 19 climate projections from GCMs in a moderate emissions scenario. For each climate scenario, we distinguished four impact zones: Cocoa production can either be sustained under low or high adaptation effort (incremental or systemic adaptation) or will become unprofitable such that it should be substituted or radically transformed (transformation). In previously unsuitable regions (opportunity) cocoa may become a new option for farmers.

The gradient showed that southern Brong Ahafo, northern Ashanti, and the North and South of Volta will become transformation zones. Such transformation may include the development of alternative value chains or novel cocoa systems that are viable under conditions that would in the past be considered hostile for cocoa

The Northern half of the central cocoa production zone (northern Ashanti, northern Western region and most of the Volta region) was classified as a zone with little certainty of climate projections. For this zone, global climate models don't exhibit the necessary degree of agreement to support specific technological packages and emphasis should be put on increasing the resilience of producers.

Southern Ashanti, the Eastern region, and the southern margin will require systemic change because a change of one climate zone to another was projected (Figure 3).

For other parts of the country, the climate change signal was found to be less significant. The southern stretch of the current production zone was projected to remain in the same climate zone so that no fundamental changes in agronomic practice are needed. Incremental adaptation is the dominant strategy. Only a few sites were projected to become suitable because of climate change. Some locations at the margins of the currently suitable area may become suitable, but with strong limitations.

Cost of inaction

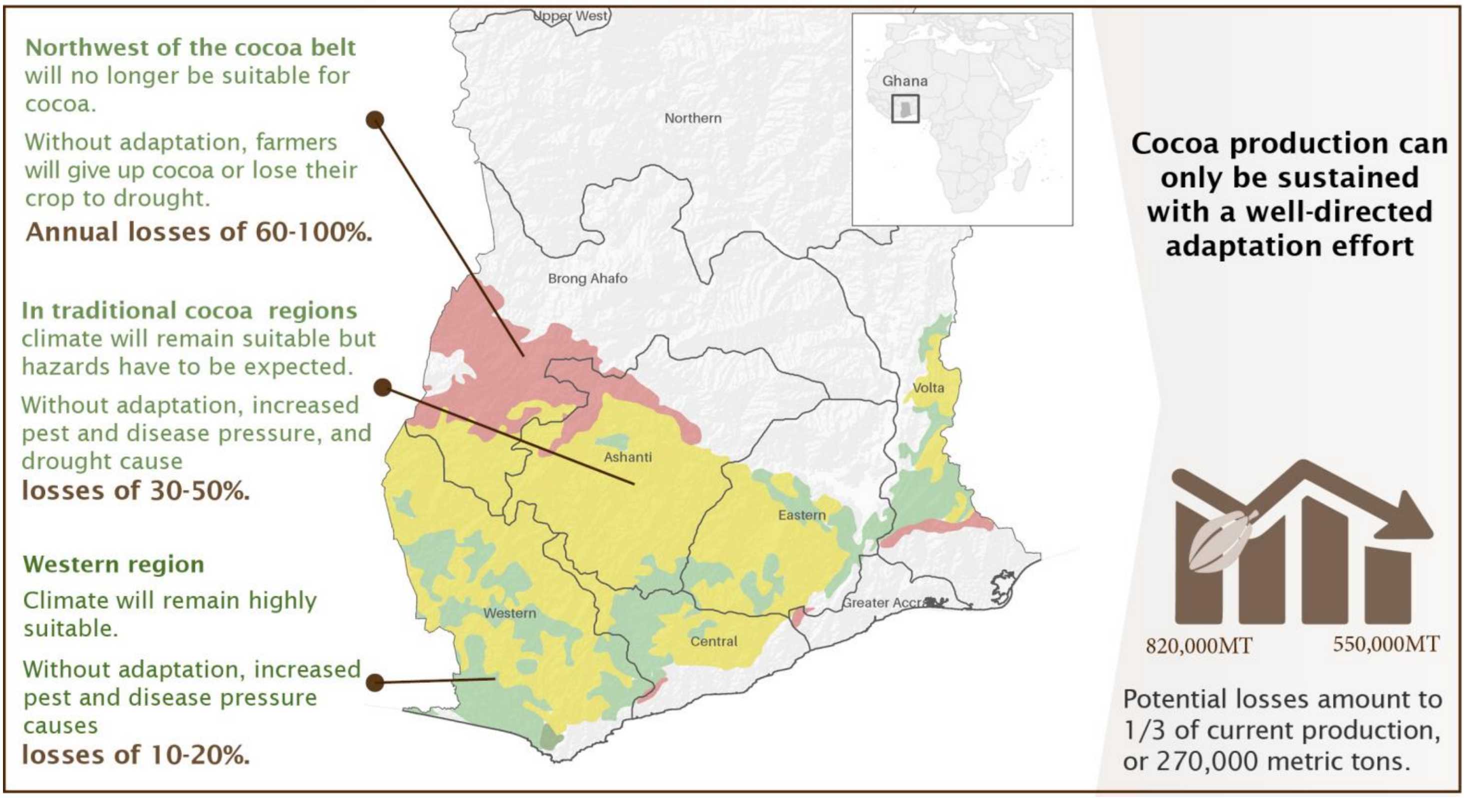


Figure 4. Cost of inaction estimates in the different impact zones.

Stakeholders along the cocoa value chain, on the one hand, acknowledge the reality of climatic change and the need for action. On the other hand, many of them downplay the cost of inaction and proceed with 'business as usual'.

> Stakeholders avoid investments that anticipate future climate change because the action would not have had positive returns with current (or past) climate conditions.

We demonstrate that adaptive action needs to be valued against a hypothetical future in which no action is taken to contain negative impacts and conditions for cocoa degenerate. By providing a benchmark for this cost of inaction we aim to make it easier for cocoa stakeholders to argue in favor of investments in climate change adaptation.

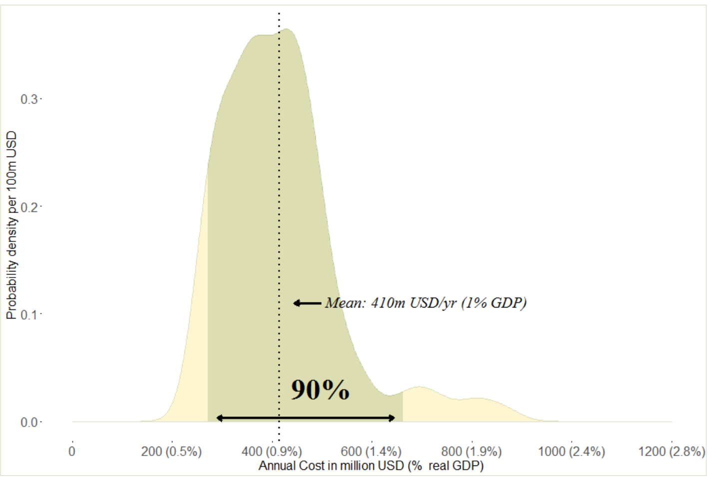


Figure 5. Distribution of scenario results of the expected cost of inaction on adaptation by the 2050s.

In our analysis, we asked how cocoa producers in West Africa would be affected if the projected conditions of the 2050s hit today. We evaluated the loss of production under 171 impact scenarios that reflect potential climate change trajectories and empirically founded production losses.

> The expected cost of inaction on adaptation by the 2050s was estimated at 410m USD per year which is about 1% of current real GDP.

However, there is considerable uncertainty about future climate conditions and climate damages to unadjusted cocoa. We estimated a 90%-probability range of 270m-660m USD per year (or 0.7-1.6% of GDP).

The probability distribution was not symmetric and indicated that the risk of extreme values, i.e. very low cost (e.g. less than 250m USD) are rather unlikely, while very high cost (higher than 570m USD correspondingly) are relatively more likely. Our cost of inaction must, therefore, be understood as an estimate of the degree of potential cost based on reasonable assumptions.

A full assessment of the benefits of adaptation by the 2050s would require knowledge of future cocoa production and prices. Demand will likely grow in the future and Ghana announced an effort to expand future production. Under these conditions, the true cost of inaction could, therefore, be even higher. Decisive climate action is a smart investment.

> Download the report here:
> https://hdl.handle.net/10568/97167

Potential CSC practices

Climate Smart Cocoa recommends a series of agricultural practices that fulfill one or more of the key objectives of Climate Smart Agriculture. Because of the urgent need for high adoption, an obvious approach to CSC development is to promote the scaling of strategies that some farmers already use to cope with climate risks within suitable recommendation domains.

Such practices are usually no-regret options because they exhibit positive economic returns despite uncertainty about the future climate.

The following list consists of expert validated practices. They can serve as a starting point to develop portfolios for each of the risk zones.

> These CSC practices are already used in the region and may increase the resilience of farmers.

> See an example of practical implementation for training here: https://hdl.handle.net/10568/93360

Intervention	Incremental adaptation	Systemic adaptation	Transformation
Plant	Improved planting material and propagation Spacing Pruning	Improved planting material and propagation Spacing Pruning	Improved planting material and propagation Spacing Pruning
Plot	Diverse shade Flood tolerant shade species	Diverse shade Buffer strips	Diverse shade High % of shade cover
Diversification	Mushroom cultivation, Snails production Optimize shade	Food crop diversification	Intercropping with cola nut/African plum/cashew/timber
Soil	Mulch Cover crops Manual weeding	Biochar Irrigation Zero burn and tillage	Soil organic carbon enhancement Irrigation Zero burn and tillage
Pest and Disease	Integrated pest management Phytosanitary measures Resistant varieties	Integrated pest management Phytosanitary measures Resistant varieties	Integrated pest management Phytosanitary measures Resistant varieties
Household	Join a farmer group. Form credit unions Provide financial management training and access to financial information to farmer groups Enhance farmer access to input/credits Provide financial/ credit support to farmers for the acquisition of basic farm assets and technologies (such as radio sets, mobile phones, tricycles, and solar systems for lighting and home appliances) which when these are needed for facilitation the adoption of CSA among farmers		
Landscape and enabling environment	Watershed protection Riparian buffers Forest and wildlife protection Farmer groups for reforestation Protection of off-reserve forests The Forestry Commission, the Minerals Commission, the Water Resources Commission and other relevant agencies should be well resourced to enable them to live to their mandate. Farmer field school approach and mass media campaigns should be adopted to raise awareness about the threat of climate change and preventive measures against forest fires Roads, bridges, and other construction activities should be planned away from riparian areas, wetlands and aquifers.		

Cost-Benefit Analysis of CSC

Farmers are resource constrained, i.e. they lack the financial capacity and knowledge of expected returns to adopt new practices. Making an economic argument for investments in climate smart practices and the present value of future benefits can be a determining factor in increasing adoption rates of the practices and for obtaining the necessary credit to finance them. Although cost-benefit analyses (CBAs) are ex-ante assessments and involve some uncertainty, the comparison of incremental costs and benefits can aid farmers and extension agents in prioritizing the adoption of certain CSC practices over overs. From the above set of climate smart practices, we chose a few that are widely debated to be potential “Best bet” options for scaling out. We compared the costs and benefits of these practices to a conventional – well managed – reference system with some shade and intercropping.

The following overview of costs, benefits, and barriers to adoption may help design interventions to support the adoption of these practices. From our analysis, the barriers to adoption are high for each of these practices.

The Net Present Value NPV) is calculated as the sum of benefits minus costs of each year at discounted at a specified rate (14% in our case) to find their equivalent value in the present period in the following way and it can be used to prioritize one investment over another, as a higher NPV is generally preferred. The Internal Rate of Return (IRR) is calculated in the following way and is a measure of the discount rate at which the NPV is zero, the higher the IRR the better the investment. BAU refers to results according to continued current production practices with no adaptation or Business As Usual.

Current state of cocoa farming	Climate Smart Practice	Cost	IRR/NPV Compared to BAU	Barriers to adoption
		Fertilizer application		
Insufficient quantity Wrong timing Wrong composition Not adequate to soil	Correct fertilizer application increases land productivity, avoids soil depletion and offsets land use changes. 130% higher yields	Higher fertilizer cost Soils analysis Training More labor	+50% +100%	Inadequate public fertilizer schemes Lack of weather services to support the timing of application
		Planting material		
Inadequate varieties Old material Random planting	Hybrid varieties from verified sources in ordered plantation offer higher yields and better resilience	Cost of obtaining seedlings doubled	+2% +25%	Lack of access to verified seeds Lack of varieties that are ready for the future climate
		Shade cover		
Low shade cover Natural shade trees Low density	Long term sustainability of the system increases by adding more trees, with a functional structure	Lower yields in the first years More labor	-10% -10%	Fear of higher disease incidence Uncertain land and tree tenure results in a preference for short term benefits
		Irrigation		
No irrigation No drainage	Better water management by drip irrigation can increase yields substantially (+75%) and trenches reduce soil erosion and flooding during intensive rainfall	USD 2500 for irrigation equipment and installation	-30% -25%	High upfront investment for irrigation Trenches and low-tech irrigation with plastic bottles require substantial labor but are more profitable Such systems require training
		Pest and disease management		
Pests control is insufficient and fungicides are not applied	Changes in climate increase pest pressure. Integrated pest management raises yields by 25%	15 labor days per ha, Pesticides, and fungicides	+3% +30%	Misuse and mishandling of pesticides threaten health, environment, and effectiveness of agents Very high training deficit in the region

Diversification options

Cocoa producers at locations that are severely affected by climate change will seek alternative income sources. Diversifying production can be a measure to reduce climate shock risk to household income. However, field crops often don't offer the same income and ecosystem services benefits provided by cocoa. Other tree crops are therefore preferential. The development of alternative or complementary value chains that can replace lost cocoa income will require multi-stakeholder approaches that include public and private actors.

We evaluated the climatic suitability of frequently named companion crops for cocoa under current and future climate conditions. For the cocoa zone, we evaluated whether these companion crops can be considered resilient to climate change so that they can be recommended for on-farm diversification if a market for the produce exists locally.

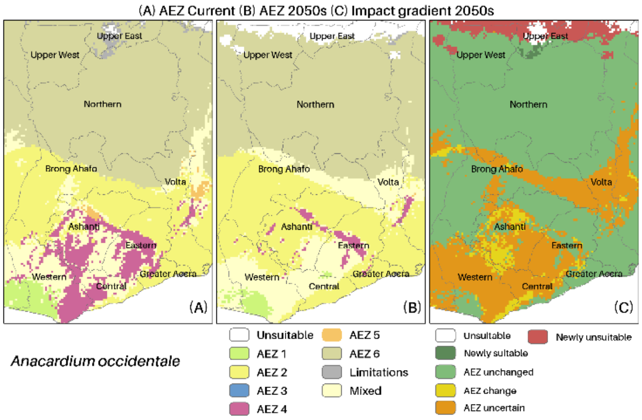
The methodology used was similar to the approach to evaluate climate impacts on cocoa. First, we evaluated the degree of climate change impacts in Ghana by comparing future (2040-69) to present (1950-2000) bioclimatic suitability for these crops. We then identified what the most likely future suitability in a certain region will be. A crop is recommended if cultivation can continue with only incremental adaptation. Results maps are shown on the following page.

Companion tree cropsfor cocoa and adaptation needs

Crop	Scientific	Brong Ahafo	Volta	Ashanti	Eastern	Western	Central
Cashew	*Anacardium Occidentale*	Recommended	Requires adaptation	Requires adaptation	Requires adaptation	Requires adaptation	Requires adaptation
Peanut	*Arachis hypogaea*	Recommended	Requires adaptation	Mixed	Not recommended	Not recommended	Mixed
Papaya (Paw paw)	*Carica papaya*	Recommended	Recommended	Requires adaptation	Requires adaptation	Requires adaptation	Recommended
Coffee	*Coffea arabica*	Not recommended	Not recommended	Not recommended	Not recommended	Mixed	Mixed
Citrics	*Citrus*	Recommended	Recommended	Recommended	Recommended	Recommended	Recommended
African Walnut	*Coula edulis*	Not recommended	Not recommended	Not recommended	Not recommended	Mixed	Not recommended
Water yam	*Dioscorea alata*	Recommended	Recommended	Requires adaptation	Requires adaptation	Recommended	Requires adaptation
African oil palm	*Elaeis guineensis*	Requires adaptation	Requires adaptation	Requires adaptation	Requires adaptation	Requires adaptation	Requires adaptation
Mango	*Mangifera indica*	Requires adaptation	Mixed	Requires adaptation	Requires adaptation	Requires adaptation	Recommended
Banana	*Musa paradisiaca*	Recommended	Mixed	Recommended	Recommended	Recommended	Recommended
Guava	*Psidium guajava*	Mixed	Mixed	Mixed	Not recommended	Recommended	Recommended
Njangsa (Wama)	*Ricinodendron heudelotii*	Requires adaptation	Recommended	Mixed	Recommended	Recommended	Requires adaptation
Sugar cane	*Saccharum officinarum*	Recommended	Recommended	Mixed	Requires adaptation	Recommended	Recommended
Elephant ear	*Colocasia esculenta*	Recommended	Recommended	Recommended	Recommended	Mixed	Mixed

Cashew

(A) AEZ Current (B) AEZ 2050s (C) Impact gradient 2050s



Anacardium occidentale

African oil palm

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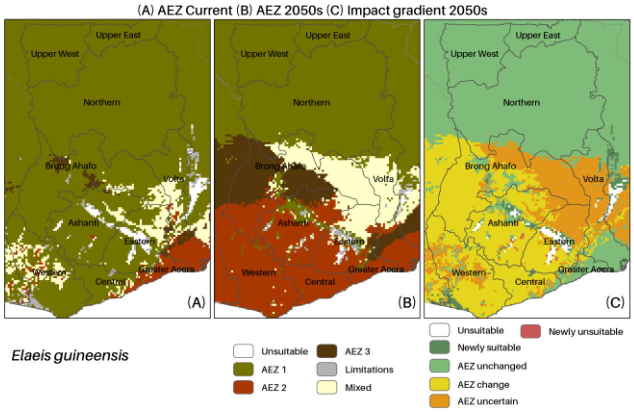

Elaeis guineensis

Peanut

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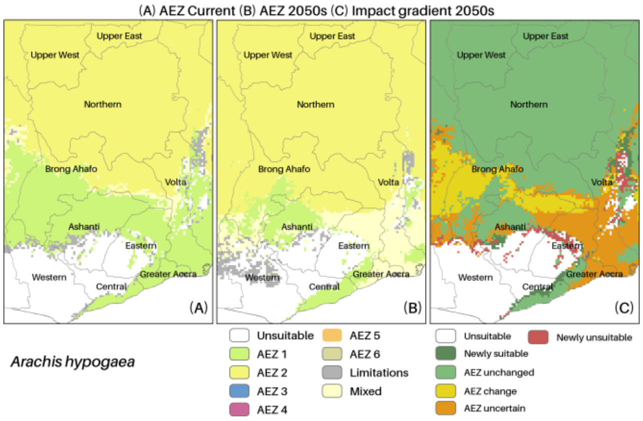

Arachis hypogaea

Orange

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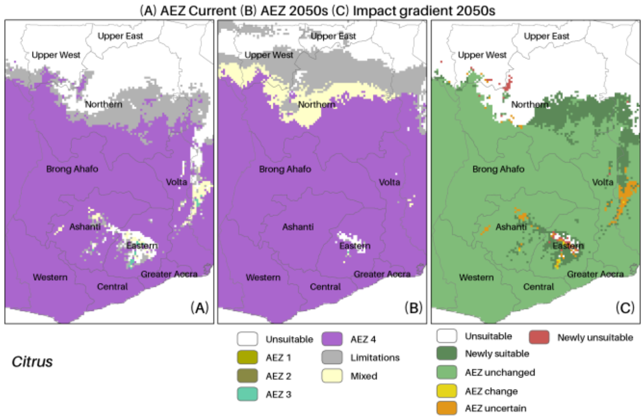
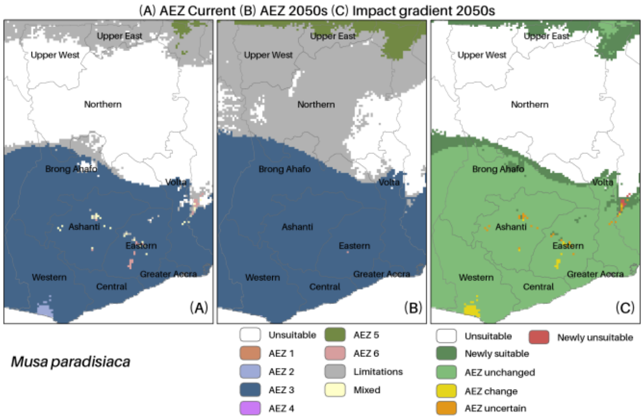


Citrus

Banana

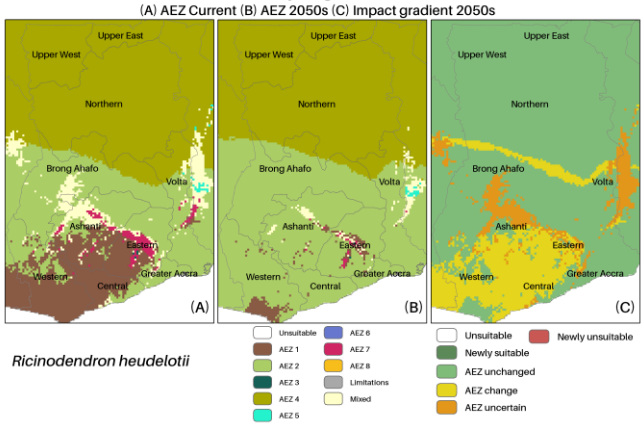
(A) AEZ Current (B) AEZ 2050s (C) Impact gradient 2050s



Musa paradisiaca

Njangsa

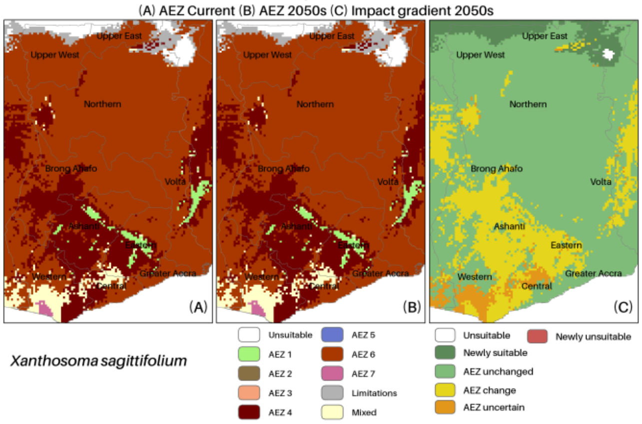
(A) AEZ Current (B) AEZ 2050s (C) Impact gradient 2050s



Ricinodendron heudelotii

Elephant ear

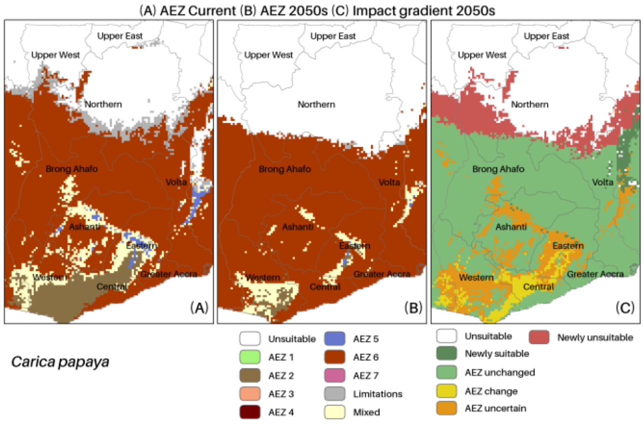
(A) AEZ Current (B) AEZ 2050s (C) Impact gradient 2050s



Xanthosoma sagittifolium

Pawpaw

(A) AEZ Current (B) AEZ 2050s (C) Impact gradient 2050s



Carica papaya

Scaling strategies and enabling interventions

With an increasing degree of climate impacts, the importance of systems approaches to adaptation and the enabling environment increases. In this case, a change in the livelihood strategy may be necessary. Value chain inclusive systems approaches to adaptation, therefore, include a wider range of actors or crops to manage risk from cocoa. The chain itself may be made risk-proof or more efficient, for example at the processing and transport stages, or where farmers and exporters choose to diversify into alternative crops. Such systemic or transformational adaptation may require changes to the framework conditions, or enabling environment for CSC.

> Practice focused adaptation reaches a limit when the climate changes to a degree that makes alternative systems more attractive.

Changes in the enabling environment can reorient current practices toward climate-smart cocoa in a sustainable and efficient way. It promotes institutional capacity and facilitates access and risk-reduction to the adoption of new technologies and practices. Comprehensive enabling environments have already been proven effective for climate-smart agriculture implementation.

> The enabling environment for climate-smart cocoa constitutes a set of framework conditions that encourage the adoption of climate-smart practices.

The following presents the vision for a climate smart cocao sector, and the roles of sector participants. For each degree of impact, it presents a set of priority actions that should be developed towards 2030 with the objective of increasing the resilience of cocoa in Ghana. This vision was co-developed with high-level representatives of each sector group.

	Transform	Systemic adaptation	Incremental adaptation
Research	• List of diversification options • Improved crop production systems • New varieties • Improved predictions • Strong extension	• Shade levels • Soil nutrition and water management and retention • Resilient livelihood structures: the importance of different cash and food crops, profitability, and diversification • Make cocoa attractive for young people. Pension scheme tied to the farmer and/or plot. Insurance • Consistent data gathering and communication • Pest and disease control • Technology beyond providing shade trees • Financial models for rehabilitation • Process research with effective and smart communication of research including effective extension	• Introduction of optimal number of shade trees • Research findings need to be accessible to farmers (e.g. soil nutrition) • Research and extension should be linked
Policy	• Incentive packages for transformation • Environmental social responsibility • Education on policies • Engagement framework • Local by-laws • Support private sector leadership in policy implementation	• Preparation of the youth, in terms of education, training, and coaching • Laws that are enforced to protect livelihoods and landscapes • Tie in policies with local by-laws • Empowering communities by decentralization in management	• Pricing structure • Incentives and subsidies management • Land/tree tenure • Additional premiums for ecosystem management • Enforcement of laws e.g. illegal mining

Business and Consumers	• Alternative value chains • Public Private Partnership to define profitable transition crops • Strategy alignment between private and public sector • Improved value addition to non-cocoa crops in rural areas • Pricing mechanisms • Transparency and accountability	• Access to land • Access to input and services • Litigation free land • Commitment and support at the community level • Understand the attractiveness of youth in cocoa • Intergenerational discussions about land tenure and farm ownership • Investment in systems – social, infrastructure (roads, ICT, etc.) • Collaborations of private and public sector	• Innovation in terms of provision of social capital (education, health…), subsidies • Private sector engagement to develop opportunities • Cutting the cost of production • Government partner input companies to provide fertilizers and other agro-inputs at the right time and quantities • Consumer awareness: Being a major producer of cocoa, production should be done sustainably by meeting labor and ethical standards
Ecosystems	• Afforestation • Rehabilitation • Conservation of soils and water • By-laws and education • Land use planning • Bush fire prevention • Land reclamation	• Orientation and awareness about environment and consciousness about the impact of the farm on the ecosystem • Understand the benefit of ecosystem services for thriving cocoa • Capacity to adapt to agroforestry and other adjustment strategies • Farm plans and planning for diversification and for enhancing ecosystem services • Enabling environment that allows farmers to have an option for adaptive capacity	• Tree and land tenure: provision of a proper system for integration of shade/ economic trees in the cocoa landscape • Encourage Agroforestry • Sustainable intensification and diversification in the landscape: reduce/ eliminate encroachment of forest lands. IPM and other activities to improve biodiversity
Livelihoods	• Diversification • Value chain development • Resilience • Training • On-farm and off-farm income • Entrepreneurship • Strengthening social and traditional systems	• Early involvement of young entrepreneurs • Profitable cocoa with higher household income share • Focus on off-farm income – Role of women in particular • Youth involvement in support services and value chain activities • Targeting on-and off-farm • Access to startup capital • Incentive private sector • Enabling environment that ensures land tenure and cocoa profitability and attractiveness • Promotion of diverse trees and crops	• Population increase, pressure on protected areas, diversification, productivity increase (intensification) & diversification (oil palm, food crops) to address food security • Additional/Alternative livelihoods, bee keeping-pollination, animal rearing-using their feces-by product • Land use change: Tenure • Sustainable production increase through cocoa intensification and provision of additional livelihoods (cash and food crops) to improve food security: improved income levels. • Provision of social amenities such as daycare centers, water, and electricity – encourage women and youth

Conclusions

Over many decades, cocoa production has been shaping the landscapes of Ghana. Forest cover is lost at a rate of 3%, among the highest in Africa. In the coming decades, however, the changing climate will come to shape cocoa production more deeply. Some areas will become unsuitable, yet most will require some form of adaptation. The analyses presented here should be useful to achieve the goals of policy directed toward increasing the resilience of cocoa at scale in Ghana.

There is an urgent need to shift from current cocoa farming practices to CSC practices adapted to the requirements of each climate impact zones. Crop diversification helps stabilize farmer incomes and increase food security. Furthermore, cost-benefit analyses of these practices may be helpful in convincing farmers and lenders of potential increases in profits. Interventions at different technological, organizational, institutional and political levels should consider barriers to the current adoption, such as access to inputs, lack of training, and high costs. No-regret adaptive practices, such as adequate fertilizer application and planting of improved seeds, are a stepping stone toward increasing the resilience at scale of cocoa farming in Ghana and achieving CSC objectives.

Further Reading

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The Feed the Future Learning Community for Private Investment in Climate Resilient Agriculture is a consortium of non-governmental organizations and research institutions working at the intersection of climate change and cocoa production. Our vision is to improve the livelihoods and resiliency of cocoa farmers and promote better environmental stewardship by having the private sector fully support and allocate resources to the implementation of climate-smart agriculture in cocoa landscapes globally.

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