



Annual Report 2021 & Workplan 2022



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Acronyms and Abbreviations

APNI	African Plant Nutrition Institute
AEZ	Agroecological zone
ARTCI	Autorité de régulation de télécommunication de Côte d'Ivoire
AMS	Agroproduce Management Services
BMP	Best Management Practices
CASE2	Cocoa Crop Model
CIAT	International Centre for Tropical Agriculture
CMIP6	Coupled Model Intercomparison Project Phase 6
CNRA	Centre National de Recherche Agronomique
CRIG	Cocoa Research Institute of Ghana
CRIN	Cocoa Research Institute of Nigeria
CSA	Climate-smart agriculture
CSC	Climate-smart cocoa
CT	Core trials
CT	Current Farmer Practice
EA	Extension agent
GAPs	Good Agricultural Practices
GCM	Global climate model
ETG	Export Trading Group
FC	Forestry Commission
ICRAF	World Agroforestry Centre
IDH	The Sustainable Trade Initiative
IITA	International Institute of Tropical Agriculture
IRAD	<i>Institut de recherche agricole pour le développement</i>
ISFM	Integrated Soil Fertility Management
IVR	Interactive Voice Response
KABP	Knowledge, Attitude, Behavior, and Practices
MEL	Monitoring, Evaluation, and Learning
NARS	National agricultural research systems

NO	No Fertilizer
NGO	Nongovernmental organization
NORAD	Norwegian Agency for Development Cooperation
ODK	Open Data Kit
OF	Offtake Model
P4D	Partnership for Delivery
R4D	Research for Development
SMS	Short messaging services
SQM	<i>Sociedad Quimica y Minera de Chile S. A.</i>
ST	Satellite Trials
ToR	Terms of reference
ToT	Training of trainers
UNEP-WCMC	United Nations Environmental Program—World Conservation Monitoring Centre
UN-REDD	United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation
WCF	World Cocoa Foundation
WENR	Wageningen Environmental Research
WUR	Wageningen University and Research

1 Key messages and challenges

In the context of its research for development (R4D) component, an extra cocoa trial (CT) was added in Ghana, increasing the number from eight to nine in West Africa. The STs had additional 98 sites in Côte d'Ivoire and Nigeria to increase the total number to 389. The database infrastructure has been developed to make data accessible to partners in Cameroon, Côte d'Ivoire, Ghana, and Nigeria. Poor internet connectivity in the areas where the experiments are located made sending data to the server challenging for the technicians. There were delays in the assessment of the interactions between potassium nutrition and drought stress in cocoa in Q1, A2, and Q3 due to the maintenance of field materials and the return of apparatus to the company for repair. These delays have been resolved and all field experiments were implemented in Q4 of 2021. The extension manuals and farmer handbooks were developed, validated, printed, and presented to policymakers and private companies under the P4D component.

With a current database of over 180,000 farmers available through our partner dissemination networks and the engagement with digital dissemination partners, the project is delivering recommended options on Integrated Soil Fertility Management (ISFM) to smallholder farmers in West and Central Africa through extension agent (EA)-led farmer training sessions organized in all the four countries. In this summary, highlights of the progress on the R4D, P4D, and project management for 2021 are described and further detailed in the main body of the report.

Progress on R4D Outputs

With regards to generating ISFM options, an additional CT has been established by Mondelez in Ghana, adding to the existing eight CTs in West and Central Africa. This trial is in the south-western part of Ghana and is being managed by the Cocoa Research Institute of Ghana (CRIG).

The protocol for data collection for the evaluation of the CTs has been finalized. The protocol is divided into Early-Stage Evaluation, Advanced Stage Evaluation, and Mature Stage Evaluation. Data for Early Evaluation have been collected in Côte d'Ivoire (CNRA, Nestlé, and Barry Callebaut), Nigeria (IITA), Cameroon (IITA), and Indonesia (Mondelez). Advanced Stage Evaluation data has been collected in Nigeria (IITA and CRIN) and Cameroon (IITA).

For the Satellite Trials (STs), there are seven partners (Olam, Mondelez, Cargill, Kuapa Kooko, Sucden, Olatunde International, and Tulip Cocoa) hosting a total of 389 ST sites representing a 34% increase in the number of ST sites from 2020. The current distribution of the ST sites is as follows: 132 in Côte d'Ivoire; 64 in Cameroon; 127 in Ghana and 66 in Nigeria.

A cocoa-specific ontology report has been finalized. A data curation workflow that allows exchange of cocoa-related datasets has been developed. In addition, data analytics, interfaces, and visualizations of cocoa dataset for the public, policy making, and research domains have been created.

The second draft of the decision-support app (STEPWISE) has been developed to include a segmentation module to understand farm diversity and a best management practices (BMP) module.

Draft maps of land-use patterns and ecosystem services in target countries have been developed and are being validated with different stakeholders. The International Centre for Tropical Agriculture (CIAT) and the United Nations World Conservation Monitoring Centre (WCMC) have developed guiding principles to enable integrated decision-making aimed at sustainable intensification of cocoa, increased farmer resilience, biodiversity support, and forest protection.

A draft of a decision-tree and guidance document to support spatially explicit and integrated decision-making to increase productivity and farmer resilience, support biodiversity, and protect forests has been finalized.

A report on mapping potential areas to implement cocoa agroforestry in Côte d'Ivoire has been published.

The four PhD students are in the process of publishing their works and getting to the completion of their PhD studies. At the time of reporting, three peer reviewed articles have been published: (1) 'Unravelling drivers of high variability of on-farm cocoa yields across environmental gradients in Ghana' in Agricultural Systems Journal; (2) 'How nutrients rich are decaying cocoa pod husks?' in Plant and Soil Journal; and (3) Farmers' Perception as a Driver of Agricultural Practices: Understanding Soil Fertility Management Practices in Cocoa Agroforestry Systems in Cameroon'

Challenges with the R4D Outputs

Fertilizer application in the CTs was delayed in some countries due to varying mortality rates of cocoa plants. Poor internet connectivity in the areas where the experiments are located made sending data to the server sometimes challenging for the technicians. There is a need for a new PostgreSQL database (curated data storage) with user management. The non-privacy sensitive data will be available for download and this may delay the developments on the Knowledge Portal for data publication till 2022.

Progress with P4D Outputs

Two partners, Sucden and Tulip Cocoa, have signed a dissemination agreement and a participation agreement, respectively. A total of 11 partners have signed agreements either through the joint Consortium Agreement or Participation Agreement. In addition, 10 dissemination agreements have been signed by seven scaling partners.

Two service providers (Viamo and ANADER) contracted to undertake digital dissemination in Cameroon, Côte d'Ivoire, Ghana, and Nigeria completed their pilot work in July with 30782 farmers (19% female) trained with content in the training manual. Also, a radio station contracted in Gagnoa, Côte d'Ivoire reached more than 2,000,000 listeners through its broadcast of content from the CocoaSoils Training Manual.

The training manual which has been validated and approved by the P4D committee members (comprising both public and private sectors) in the four countries has been finalized and printed. Copies of the training manual have been handed over to the government of Cameroon. Copies were also submitted to private partners and are being used for training of trainer (ToT) sessions, farmers training, and digital dissemination. A total of 535 EAs (7% female) were trained through 20 training sessions. The total number of EAs trained represents 107 percent of the 2021 target of EAs to be trained (500 EAs). The total number of training sessions conducted also represents 100 percent of the target for 2021 (20 training sessions).

A total of 32 472 farmers (29% female) were trained by partners' EAs on ISFM recommendations and good agricultural practices using the CocoaSoils manual. In addition, 30 782 farmers (19% female) were trained through Viamo and ANADER's digital dissemination programs. This gives a total of 63254 farmers (25% female) trained with the existing ISFM content. This represents 70 percent of the 2021 target of 90 000 farmers to be reached.

The documentation of cocoa-related policies has been validated and finalized in all the four countries.

P4D component—challenges

The training of EAs was delayed by COVID-19 restrictions on travel, movement, and gatherings, and the reluctance of some partners to release their EAs for training due to the yearly compulsory audit of their

field. Discussions held with two partners (AMS and ETG) to increase dissemination in Cameroon have not progressed as anticipated due to concerns about data confidentiality.

Facilitation of feedback sessions with dissemination partners on the extension tools have not been organized, although initial feedback on content has been received through the EAs training. The low pick-up rates of the digital dissemination programs in the beginning were a challenge and were attributed to low sensitization. Version 2 of the training manual will be developed when new recommendations from research activities are available.

The collection and documentation of cocoa-related policies in the four countries were delayed due to the establishment of the partnership committees, the COVID-19 pandemic, and the validation of training manuals.

Progress with project coordination

The project shared insights and learnings with the wider public through its Annual Forum held virtually in 2021. This edition was attended by over 150 global participants. At the forum, a stronger alignment between CocoaSoils and national initiatives aiming to end cocoa-related deforestation (e.g., Cocoa & Forests Initiative) was laid out. A linkage between CocoaSoils and the living income of smallholder cocoa farmers was also explored.

Under MEL, a new Open Data Kit (ODK) tool for capturing data at farmer and EA levels after digital dissemination of ISFM content was developed. An endline tool was also developed to capture the knowledge and practices of EAs and farmers after the digital dissemination.

With regards to communication, social media platforms were used to reach project partners online. The number of followers and engagement across LinkedIn, Twitter, and Facebook increased from (0, 68, and 9) to 104, 261, and 241), respectively. Tweets about the program's activities were seen 16 877 times by Twitter users between January 2021 and December 2021. Three newsletters were published and the use of MailChimp email services helped to deliver monthly updates to partners. A new Communications Officer was recruited in August 2021 in Ghana.

Project coordination—challenges

The timelines for MEL training were pushed back due to a delay in the partner extension network training because of the COVID-19 pandemic. The training timelines will be extended to Q4 2021 to cover the refresher training based on the to-be-identified MEL framework gaps.

2 Progress narrative

2.1 Introduction

The CocoaSoils Annual Report 2021 presents the workplan for 2022, as well as the project's progress on the 2021 workplan. Results and progress were evaluated against the 2021 targets for outcomes and outputs, as well as the set milestones for coordination-related activities, and the R4D, and P4D components. Delays experienced were explained and mitigation plans were presented with timelines. Progress against specific outcomes and outputs is presented in APPENDIX 1—Status of Project Results with Mitigation Plans. The milestones are evaluated under the respective outputs in the report itself.

2.2 Project coordination

2.2.1 Project coordination team established

Achievement of the following milestones is expected at the time of reporting: (1) interviews based on specific terms of reference (ToR) organized; (2) negotiations and signing of contracts completed; (3) list

of required capital items assembled; and (4) capital items procured and delivered. Table 1 and the following information provide details on progress in the milestones for 2020.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 1. Status of milestones under project coordination team established

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Coordination-related																				
Project coordination team established																				
Recruitment of project staff																				
Milestone: Interviews based on specific terms of reference organized									X	X										
Milestone: Negotiations and signing of contracts completed									X	X										
Procurement of capital equipment																				
Milestone: List of required capital items assembled																				
Milestone: Capital items procured and delivered																				

Progress on milestones: A Communication Officer was recruited to join the project implementation unit in Ghana due to the departure of the colleague who previously held the position.

2.2.2 Project management and administration functional

Achievement of the following milestones is expected at the time of reporting: (1) timely reports by the applicants and its partners submitted; (2) annual planning and evaluation meetings organized; (3) effective communication using various tools facilitated; and (4) three quarterly newsletters produced. Table 2 and the subsequent information provide details on the progress of the milestones for 2021.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 2. Status of milestones under project management and administration functional

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Coordination-related																				
Project management and administration functional																				
Agreement on a reporting framework																				
Milestone: A reporting framework established																				
Milestone: Timely reports by the application and its partners submitted																				
Agreement on a meeting and communication strategy																				
Milestone: Annual planning and evaluation meetings organized																				
Milestone: Effective communication using various tools facilitated																				
Milestone: 3-monthly newsletter produced																				

Progress on milestones: All contractual reports (progress on financial and technical reports for 2020 and workplan for 2021) were submitted on the agreed dates. See [here](#) for the final approved annual report by NORAD for 2020. All contractual reports have been submitted by partners for the current progress report. The reporting framework for 2021 was used for this report. See [here](#) for a sample.

The project shared annual insights, learnings, and updates with the wider public including the research committee members, other participants from the larger research community, private sector companies across the globe, and the general public through its 3rd Annual Forum held online on 28 January 2021. under the theme ‘Produce more on less land: how increased productivity contributes to a sustainable cocoa sector’. During this edition, which was attended by over 150 participants, global stakeholders convened virtually to discuss the progress and recommendations in relation to the CocoaSoils program. See [here](#) for the agenda for the 2020 Annual Forum. See [here](#) for the report on the forum.

As part of the Annual Forum Week, the R4D committee met on 26 January 2021 under the theme ‘Transformative interventions (mineral nutrition and BMPs) to enhance productivity (ecosystem services) in cocoa production: consolidating evidence’. The P4D committee meeting was held on 27 January 2021 under the theme ‘Creating an inclusive partnership and improved dissemination processes for successful yield intensification by CocoaSoils’. See [here](#) for the programs of PD4 and R4D meetings.

Despite the downsides of not meeting physically, the forum was positively received by multiple stakeholders who don’t usually attend the forum since it involves intercontinental travelling. However, the dynamics of exchanges and networking that are present in a physical meeting was missing. Therefore, a physical meeting in the next edition is desired. The planning activities for the forum in 2022 have begun

with the creation of a Coordinating Committee among the Consortium members led by the Sustainable Trade Initiative (IDH).

Various tools and platforms were developed and implemented to support both internal and external communication. The project's [website](#) is updated regularly with information on various activities under the project. A [page](#) has been created to publish and make accessible to partners and the public videos from the core trials (CTs). Between January and December 2021, the website was used by a total of 2289 users, 2264 of which were new users. The website held a total of 3064 sessions. The top countries for users were the USA, Ghana, Netherlands, Cameroon, the United Kingdom, Finland, and Côte d'Ivoire. Seventy-four percent of users are English-speaking. Other users are French-speaking (8%) and German-speaking (3%). See [here](#) for detailed analytics on the website turnout overview in terms of audience, location of users, and language.

Three newsletters were published between January and December 2021. The three newsletters had a combined readership of total of 369. See [here](#) for detailed analytics on readership for 2021. With the use of MailChimp email services, monthly updates were sent to all partners, including the national agricultural research systems (NARS) and private sector companies. A total of 163 successful deliveries were made with a 42 percent readership. See [here](#) for detailed analytics on readership for monthly newsletter for March, August, and September 2021. The project's [Twitter page](#) has 261 followers. Tweets from CocoaSoils Twitter account were seen 16 877 times by Twitter users between January 2021 and December 2021. See [here](#) for detailed analytics of the Twitter account. A [LinkedIn page](#) was created in August to interact with partners and the general public. The page has 104 followers. The project's [Facebook](#) account has been revamped and now has 241 followers.

Challenges and proposed changes in milestone timelines: The organization of the forum in January happens close to December when most colleagues are unavailable. This affects the number of people that can participate in the Annual Forum. Thus, consideration should be given to organizing the next edition of the forum at a later stage of the year when most colleagues are likely to be available.

The number of followers and engagements on social media could be more. The platforms are being updated regularly with relevant and engaging content to grow followers and engagements. These efforts are yielding results. The numbers of followers and engagements have increased across Twitter, Facebook, and LinkedIn by 100 percent. Information on activities on both R4D and P4D components, as well as new publications by PhD students and their supervisors, are being received under the project. The publication of this content on the project's website is expected to drive more users to the site. The social media pages are also being used to refer visitors to the website.

Workplan for 2022

Activity: Agreement on meetings and communication strategy

- Milestone: Organize annual planning and evaluation meetings by Q1, 2022.
- Milestone: Facilitate effective communication using various tools by Q2, 2022.
 - Milestone: Produce three monthly newsletters by Q2, 2022.

2.2.3 Convening mechanisms in place

At the time of reporting, the milestone “regular meetings with industry partners facilitated” should have been realized. Table 3 and the subsequent information provide details on the progress towards the milestones for 2021.

Columns with an ‘X’ indicate new timelines for the milestone. Columns in grey indicate the original timeline according to the implementation plan in the proposal.

Table 3. Status of milestones under convening mechanisms in place

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Coordination-related																				
Convening mechanisms in place																				
Organization of regular meetings with the industry																				
Milestone: Meeting schedules agreed upon																				
Milestone: Regular meetings with industry partners facilitated																				

Progress on milestones: IDH continued facilitating monthly meetings (online) with the private sector partners that are part of the CocoaSoils consortium. In 2020, these meetings were always structured around sharing updates by the different partners. To increase the value of the meetings, the structure of the meetings was changed. Since the beginning of 2021, each meeting has included a thematic deep dive on a specific topic or output related to the CocoaSoils program. This drew positive reactions from the various participants. The positive reactions were reflected in the high attendance rate at these meetings. As a result, this structure continued throughout the year. Deep-dive topics to date were:

- March: STs—Progress and updates by companies (Kuapa Kokoo, Mondelez, Olam).
- April: no deep dive.
- May: CTs—Progress and updates by companies (Barry Callebaut, Mars, Nestlé)
- June: CTs + STs—Progress and updates by companies (Mars, Cargill).
- July: no deep dive.
- August: PhD publications—Presentation by CocoaSoils PhD student Paulina Asante.
- September: Digital dissemination—Insights in alternative dissemination tools by Viamo.
- October: Updates by partners on progress.
- November: Value proposition for second phase by IDH and IITA.
- December: no meeting organized.

In addition, the 2021 target was to organize two P4D committee meetings in each country. Côte d'Ivoire, Cameroon, Ghana, and Nigeria held the first meetings between January and August 2021. All the four countries held their second P4D meetings in the last quarter of 2021.

Challenges and proposed changes in milestone timelines: P4D committee meetings took place later than the planned dates due to conflict schedules of the P4D chairpersons and committee members.

Workplan for 2022

Activity: Organization of regular meetings with the industry

- Milestone: Facilitate regular meetings with the industry partners by Q2 2022.

2.2.4 Appropriate MEL tools and processes

Achievement of the following milestones is expected at the time of reporting: (1) users of the MEL framework trained, (2) MEL framework continuously updated, and (3) learning from the MEL framework fed back into other activities (refer to [APPENDIX 1—Status of Project Results with Mitigation Plans for milestone-specific details](#)). Table 4 and the subsequent information provide details on the progress of the milestones for 2021.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal

Table 4. Status of milestones under appropriate ME &L tools and processes

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Coordination-related																				
Appropriate ME&L tools and processes																				
Development of a participatory ME&L framework																				
Milestone: Key outcome and impact indicators identified																				
Milestone: ME&L tools and processes agreed upon																				
Facilitation of the use of the ME&L framework by all project partners																				
Milestone: Users of the ME&L framework trained						X	X	X	X	X	X	X	X	X	X	X				
Milestone: ME&L framework continuously updated																				
Milestone: Learning from the ME&L framework fed back into other activities																				
Implementation of baseline and end-line studies																				
Milestone: Baseline study documented for the four target countries							X	X												
Milestone: End-line study documented for the four target countries																				

Progress on milestones: The project continues to develop MEL tools and processes as it engages new partners (digital partners). A new ODK tool for capturing data at farmer and EA levels after digital dissemination of ISFM content has been developed. In addition, an endline tool was developed to capture the knowledge and practices of EAs and farmers after digital dissemination. This is to ensure that data from the project's two digital partners (Viamo and ANADER) are adequately captured.

The digital dissemination tools and the earlier in-person training tools developed in 2020 are being used for data collection during and after dissemination activities. The baseline and follow-up surveys of EA Knowledge, Attitude, Behavior and Practice (KABP) of ISFM have been conducted and all data submitted to the CocoaSoils ODK server. Refer to Outcome 2 for the analyzed data.

The project trained 466 EAs between Q1 and Q3 of 2021. An additional 69 EAs were trained in Q4, increasing the number of EAs trained on the CocoaSoils MEL framework and dissemination data collection tools in the four countries in 2021 to 535 (7% female). The number of EAs trained in each country are as follows: (230 Côte d'Ivoire, 57 Cameroon, 119 Ghana, and 129 Nigeria). The 535 EAs trained represents 107 percent of the target for 2021 (500) to be trained, which is 7% above the expected EAs to be trained in 2021. The MEL framework is continuously updated using data from project interventions. The farmer and EA baselines established the reference point for impact and most outcome indicators. Data from EA and farmer engagements (dissemination of ISFM knowledge through various events) have been captured and used in updating selected outputs under P4D. Follow-up surveys through the digital platforms on knowledge and practices of EAs and farmers have been used to update the outcome results in terms of the use of the recommendations.

The updated results framework provides learning for the project cycle, serving as a basis for appraisal and renewed planning. Recommendations from the evaluations of the initial EA training were used to improve content and methodology of subsequent trainings. EA learning areas have been made more practical as compared to initial trainings. The events registration tool also provides information on the content of farmer training. This helps the project to know areas farmers are being trained, the anticipated feedback, and benefits thereafter.

Updating the results framework has also provided opportunities for adaptive management of the project. New strategies were developed with partners where gaps were identified in achieving specific output targets (e.g., some partners are engaging cooperative leaders to reach out to more farmers in the dissemination of ISFM).

Challenges and proposed changes in milestone timelines: The COVID-19 restrictions caused delays in EA training in all countries. It also limited the time to be spent during face-to-face training of EAs and the number of participants. Some partners were also reluctant to release their EAs for training due to the yearly compulsory audit of their field work. Limited knowledge in the use of ICT platforms among most of the EAs resulted in delays in data upload. To resolve these challenges, multiple EA trainings were organized in the different countries to ensure COVID-19 protocols were observed. Other follow up mechanisms (i.e., common P4D WhatsApp groups and individual follow ups) were established for each partner EA for backstopping.

Workplan 2022

Activity: Facilitation of the use of the MEL framework by all project partners

Milestone: Refresher training based on good agricultural practices (GAPS) will be organized through to Q2 2022.

- Milestone: MEL framework continuously updated in Q2, 2022.
- Milestone: Learning from the MEL framework fed back into other activities by Q2, 2022.

Activity: Implementation of baseline and end-line studies

- Milestone: End-line study documented for the four target countries by Q2, 2022.

2.3 Key impacts and outcomes of CocoaSoils

The project has three main outcomes: (1) New cocoa ISFM-related research products are used by private and public stakeholder partners; (2) Recommendations generated through research products are used by target households; and (3) Decision-makers (public and private) are using tools and knowledge to avoid increased deforestation and child labor while promoting cocoa intensification.

The achievement of these outcomes will ultimately impact cocoa production through increased productivity and incomes of smallholder cocoa farmers and help to reduce pressure on forests. The impact indicators will be measured through the project endline to ascertain the changes against the baseline figures. The status of the outcomes is presented below. Refer to [APPENDIX 1—Status of Project Results with Mitigation Plans](#) for current status of indicator targets under impact, outcomes, and outputs.

I. Outcome 1: New cocoa ISFM-related research products are used by private and public stakeholder partners

This Outcome is related to the development of the research products and their ultimate use by the extension networks of both private and public organizations. The targets for this reporting period are: (1) at least four research products validated and used by private and/or public stakeholders and (2) at least 350 EAs using the new research products.

The following outputs contribute to the achievement of this Outcome: (1.1.) a set of ISFM options generated; (1.2.) documented evidence for understanding the physiological basis of cocoa nutrient uptake and use; (1.3.) decision-support system developed for intensifying cocoa production; (1.4) recommendation domains and forest dynamics; (1.5) sustainability assessment tools; (1.6.) operational open knowledge and data sharing portal for the storage, management, and dissemination of cocoa intensification research results; and (1.7) a new cadre of cocoa scientists having PhD/MSc with knowledge on new cocoa intensification. See Section 2.4 for updates on these outputs.

Existing research products assembled into a production manual and farmer handbook have been validated by private companies and public sector partners through the P4D committees. These manuals have been used to train partner EAs and content is also being used currently for farmer training at partner level. Refer to report on details of EA activities.

Regarding knowledge gained and its use, 535 EAs (7% female) have been trained across the project's partner organizations in the four countries using the content of the manual. The use of the knowledge gained by EAs has been documented through the KABP survey.

The analysis of this data shows knowledge gained in areas such as recommended periods of fertilizer application. Results show that most EAs across the four countries subscribed to fertilizer application between March and May, which differs from the recommendations assembled in the manual. In Côte d'Ivoire, for example, 75 percent of EAs stated in the baseline that fertilizer is applied between March and April, which is contrary to the recommendation that it is best applied between March/April and July/August. The KABP survey after the training shows that 90 percent of EAs now accept the recommended timings. A follow up endline survey by Viamo indicates that between 54 and 72 percent of EAs gained knowledge on how to improve soil fertility using organic and chemical fertilizers through the SMS and IVR messages. See endline reports [here](#).

In terms of EA attitude towards the use of ISFM content, the baseline shows that 33 percent of EAs were aware of the ISFM content but had limited access to content and materials. Analysis of farmers' training data from EAs shows that all the 212 EAs who have uploaded such data (40 percent of the EAs trained) have integrated the new knowledge they have gained. These include productivity without deforestation,

soil fertility management, pruning to enhance soil fertility, weeding, mulch and compost, inorganic fertilizers, pest and disease management, shade management, and seedling management. See here for the EA KABP survey [report](#).

II. Outcome 2: Recommendations generated through research products are used by target households

Under this Outcome, smallholder farmers are expected to acquire knowledge and use the intensification recommendations for cocoa production. The targets for this reporting period are: (i) at least 10 000 cocoa farmers using the new recommendations/new knowledge; (ii) at least 30 000 cocoa farmers using the existing recommendations/new knowledge; (iii) at least two new recommendations are being used; and (iv) at least five existing (old) recommendations are being used.

The outputs of this Outcome include the following: (2.1) agreements with private and/or governmental scaling partners; (2.2) appropriate extension tools for integration in partner-led scaling; (2.3) appropriate ToT manuals for use in the training sessions for EAs; and (2.4) engagement in policy action in support of cocoa intensification. Outputs 1.4 and 1.5 under R4D also contribute to the achievement of this Outcome, directly linked to output 2.3. See Section 2.5 for updates on the outputs.

A total of 59596 farmers were trained physically and through digital platforms (Viamo and ANADER) between Q1 and Q3. An additional 3658 farmers were trained in Q4 to increase the number of farmers trained to 63254. An endline survey was conducted to assess knowledge and practices after farmer training through the digital platforms. The analysis of the survey shows that farmers have gained knowledge and have started using such knowledge. For example, in Nigeria, out of a sample of 250 farmers, between 52 and 64 percent of farmers had already weeded and pruned their farms according to the recommendations. In addition, most farmers applied chemical fertilizers and implemented GAPs (e.g., most farmers pruned their farms twice by the end of August 2021) as against the baseline, where most farmers opted to clear forest lands to plant more cocoa to increase productivity. There is appreciation of good farm maintenance such as timely and yearly pruning of cocoa trees and weeding of farms. See [here](#) for endline reports. A follow-up survey to assess knowledge, practices, and benefits (yield) of farmers who participated in physical trainings by EAs will be conducted by the end of Q2, 2022.

III. Outcome 3: Decision-makers (public and private) are using tools and knowledge to avoid increased deforestation and child labor while promoting cocoa intensification

Under this Outcome, policymakers, and other organizations (including the private sector) are expected to integrate intensification recommendations in (country) policies and support the use of feedback from applying tools developed for sustainability assessment and deforestation monitoring. This outcome is related to the “sustainability” dimension of the project’s impact through reducing the risk of deforestation.

The target for this reporting period is the production of draft maps of land use patterns and ecosystem services in target countries. The main output related to this Outcome is (2.4) engagement in policy action in support of cocoa intensification. However, outputs 1.4 and 1.5 also contribute to the achievement of this outcome. See sections 2.4.4 and 2.4.5 for updates on these outputs.

2.4 R4D-related outputs

2.4.1 Output 1.1. A set of integrated soil fertility management options generated

The target for this output in 2021 is to generate a first set of ISFM recommendations ready for integration in scaling. Achievement of the following milestones is expected at the time of reporting. Table 5 and the subsequent information provide details on the progress to the milestones for 2021. Refer to [APPENDIX 1—Status of Project Results with Mitigation Plans](#) for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 5. Status of milestones for Output 1.1

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
R4D (Research-for-Development)-related																				
Output 1.1. A set of integrated soil fertility management options																				
Activity 1.1.1. Agreement on the design of the Core and STs																				
Milestone 1.1.1.1. Literature on cocoa agronomy reviewed																				
Milestone 1.1.1.2. The design of the Core and STs finalized				X	X	X	X	X	X											
Activity 1.1.2. Implementation of the Core and STs																				
Milestone 1.1.2.1. Sites selected, pending contributions from the industry				X	X	X	X	X	X	X										
Milestone 1.1.2.2. Trials installed following the approved protocols					X	X	X	X	X	X	X	X	X	X	X	X				
Milestone 1.1.2.3. Trials managed following agreed practices																				
Activity 1.1.3. Data collection and analysis on the trial data																				
Milestone 1.1.3.1. Data collection protocols finalized				X	X	X	X	X	X											
Milestone 1.1.3.2. Trial data collected																				
Milestone 1.1.3.3. Collected data analyzed																				
Activity 1.1.4. Development of a set of site-specific ISFM recommendations																				
Milestone 1.1.4.1. A prototype ISFM decision-support tool developed																				
Milestone 1.1.4.2. Version 1 of an ISFM																				

Progress on milestones All the eight CTs, with the additional two in Ecuador and Indonesia (Table 6), are running and data is being collected. At the new CT established by Mondelez, planting materials are ready for transplanting. This trial is in the southwestern part of Ghana and managed by CRIG. Fertilizer treatments were developed and executed in six core trials: Nigeria (IITA), Ghana (GRIG), Côte d'Ivoire (CNRA, Nestle, Barry Callebaut), and Indonesia (Mondelez) based on maize data and soil analyses information (Table 6). A methodological pipeline was developed that allows the streamlined generation of trial-specific treatment plans and associated tools for implementation. A tailor-made protocol was developed for each fertilizer and blocking design per trial. Information about fertilizer availability per country is used for the design.

[illegible]

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cherelles or pods). Advanced evaluation was conducted in Nigeria (IITA and CRIN) between the Q1 and Q3. In Q4, the evaluation was conducted for the CT in Cameroon established and managed by IITA.



Figure 1. Pod production in a Core Trial one-year-old in Ecuador



Figure 2. Fertilizer application in a Core Trial in Côte d'Ivoire

Data collection tools were constantly monitored based on technician's performance and feedback. Data tools were constantly updated based on requirements.

For the STs, activities and data collection were conducted through 2021 based on protocols and calendar activities per country (Fig. 3). Plot delineation was completed in all the countries. There is now a total of 389 ST sites, representing a 34 percent increase in the number of ST sites from 2020. The current distribution of the ST sites is as follows: 64 in Cameroon; 132 in Côte d'Ivoire; 127 in Ghana; and 66 in Nigeria. Four sites in Ghana and one site Côte d'Ivoire had to be dropped due to non-conformity of farmers to required protocols. Additional ST sites in Nigeria and Côte d'Ivoire were because of Olatunde International, Tulip Cocoa, Sucden, Mondelez, and Cargill joining in both countries.

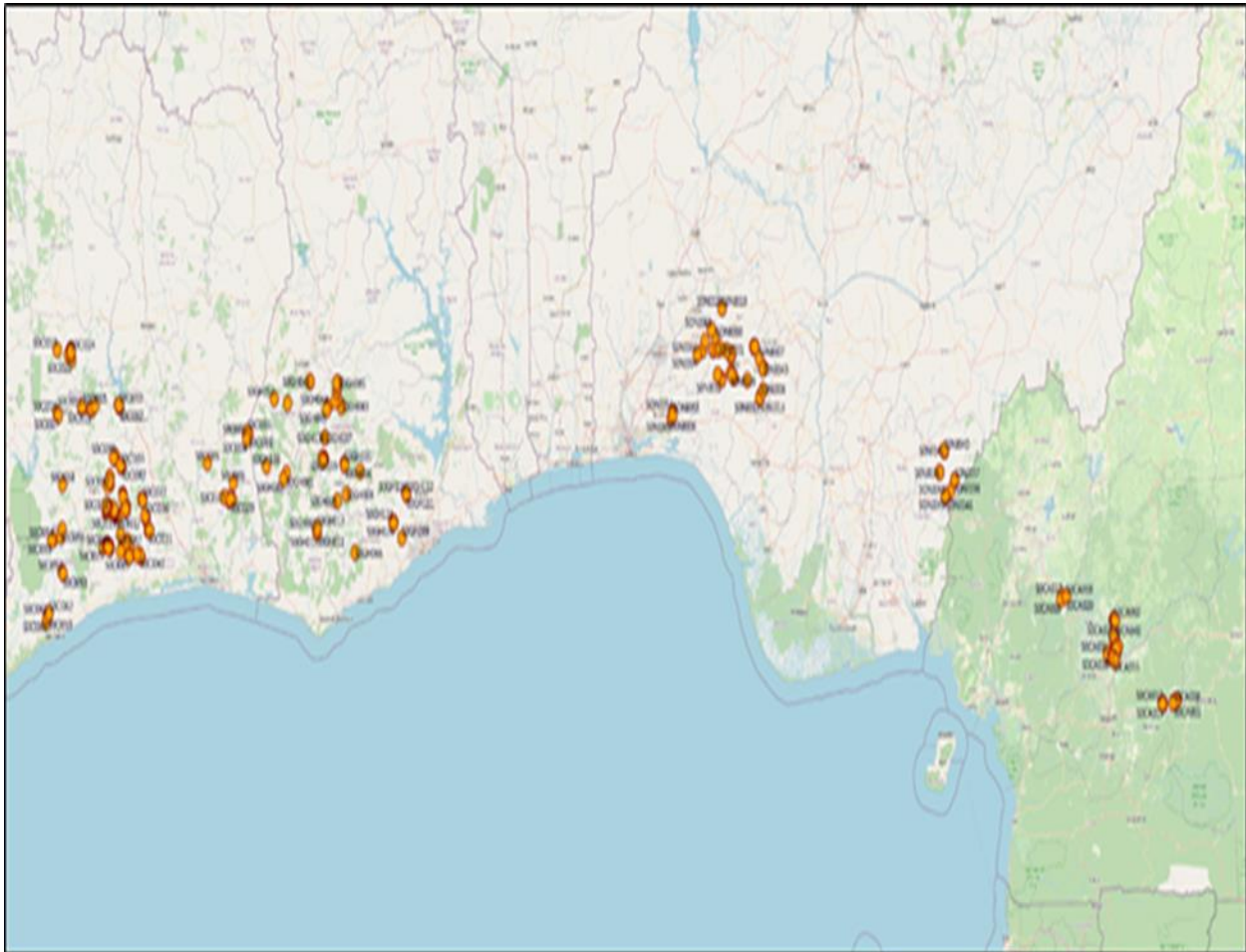


Figure 3. Distribution of ST sites in Cameroon, Côte d'Ivoire, Ghana, Nigeria



Figure 4. Pruning activities at an ST site in Ghana



Figure 5. Harvested pod measurement activities at an ST site in Ghana



Figure 6. Harvesting of cocoa at ST sites in Côte d'Ivoire

Based on data collected on ST sites, yield data has been processed and some preliminary results were presented to the Science Committee. Yields (kg dry beans/ha) differed significantly among countries and seasons (Fig. 7). Yields in Nigeria were substantially lower than yields in the other countries. The light season saw substantially lower yields in all countries compared to the main season. Response to the application of fertilizer was substantial and significant in all countries but Nigeria, and treatments with fertilizer were the only ones to outfield the control. Largest yields were observed for the Good Agricultural Practices [(GAP) + Offtake (OF) model] treatment where nutrients were supplied according to the CocoaSoils OF model. This treatment also seemed to result in higher estimated profits compared with national fertilizer recommendations [GAP + No Fertilizer (NF)], although the difference was only found to be significant in Cameroon (Fig. 8). Preliminary analysis of a selection of vegetative traits was performed on the 2021 data of the Ibadan core trial, to provide proof of the concept of data analytical methods. As expected, no treatment effects were evident.

Predicted means for 'trial_country' by 'Treatment' for each 'season'
with Aveg.LSD (5%) Bar

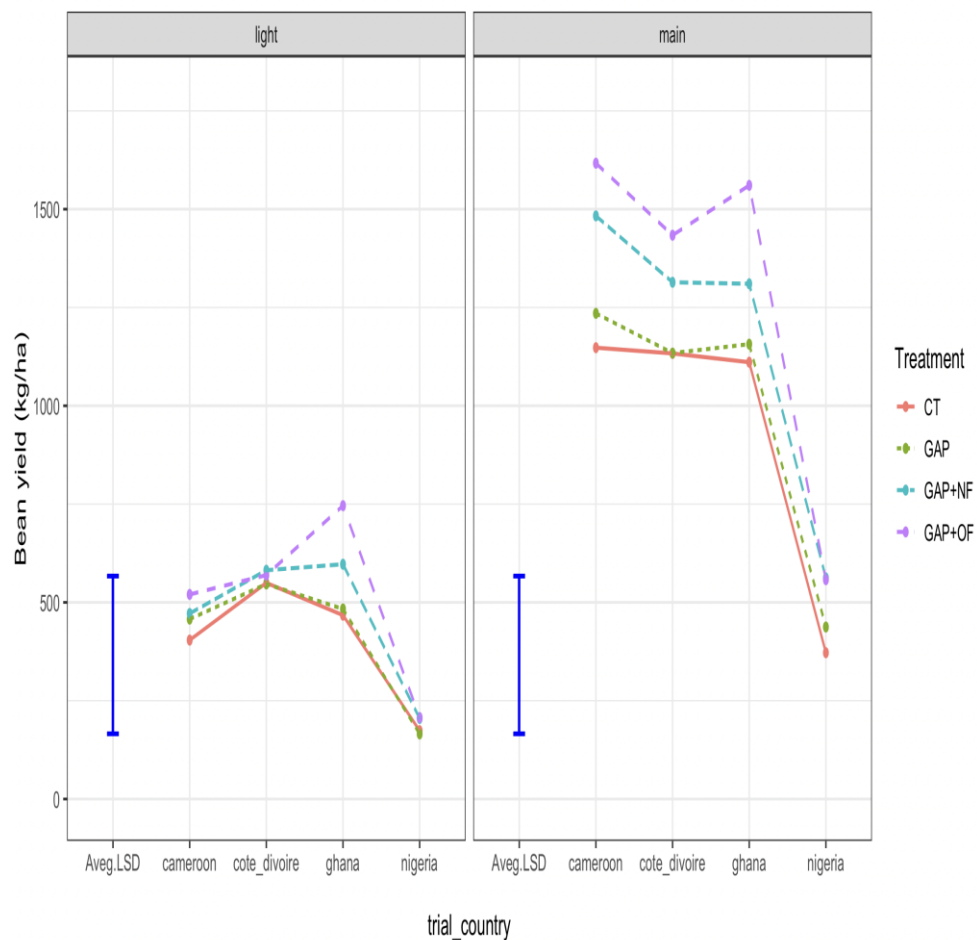


Figure 7. Mean treatment estimates for bean yield (kg/ha) per country, per season (CT-Current farmer practice; GAP-Good Agricultural Practice; NF-No fertilizer; OF-Offtake Model)

Predicted means for "trial_country" by "Treatment" with Aveg.LSD (5%) Bar

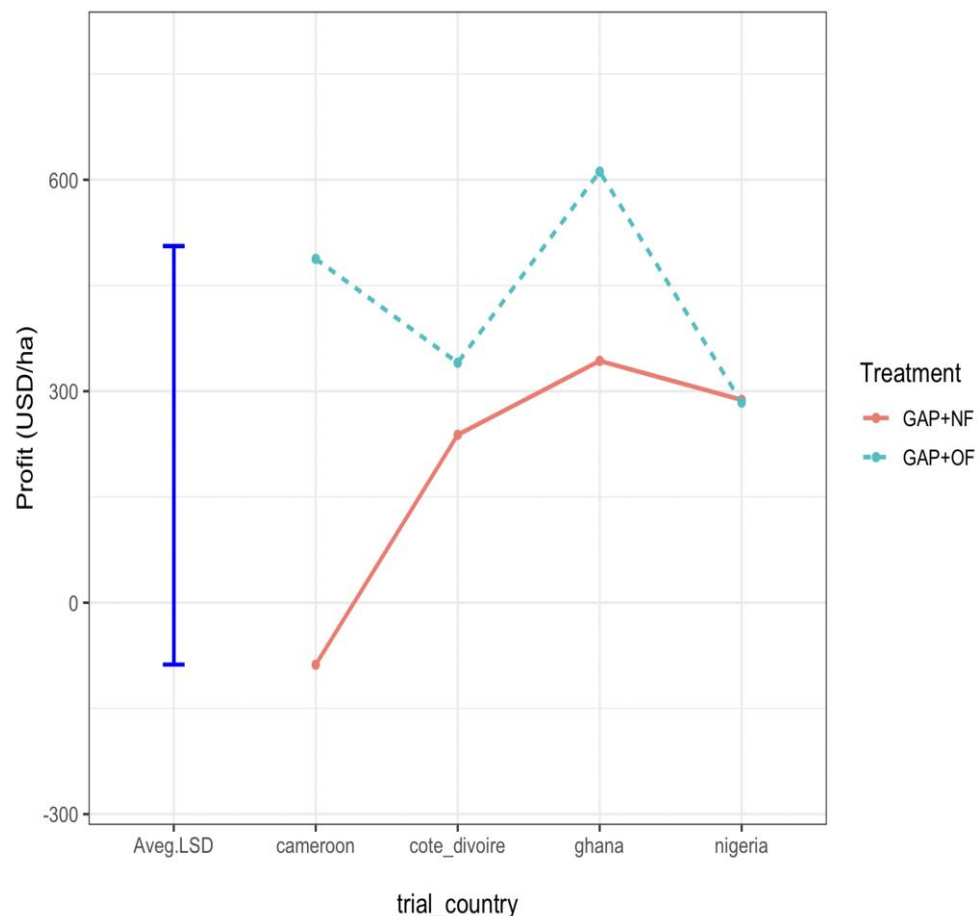


Figure 8. Modelled marginal treatment means for net profit (US\$/ha) over CT and GAP (2021 data for two seasons) (GAP-Good Agricultural Practice; NF-No fertilizer OF-Offtake Model)

Challenges and proposed changes in milestone timelines: High levels of mortality were present in some CTs (e.g., Owena in Nigeria, Divo in Côte d'Ivoire, and Nkoemvone in Cameroon), which delayed fertilizer application. To address this issue, dead plants were replaced in Q1 and Q2 of the reported year. In addition, fertilizer application was reformulated by adjusting the plantation year to the whole site and applied through Q3 and Q4. Regarding data collection, some trials faced issues with the ODK application which was resolved by training technicians to master the use of the application. Four ST sites in Ghana and one site Côte d'Ivoire had to be dropped due to non-conformity of farmers to required protocols.

Workplan for 2022

Activity 1.1.2. Implementation of the Core and STs

- Milestone 1.1.2.3. Manage Core and STs following the approved protocols by Q2, 2022.

Activity 1.1.3. Data collection and analysis of the trial data

- Milestone 1.1.3.2. Collect Core and ST data according to the data collection protocols by Q2, 2022.
- Milestone 1.1.3.3. Analyze Core and ST data by Q2, 2022.

Activity 1.1.4. Development of a set of site-specific ISFM recommendations

- Milestone 1.1.4.2. Develop version 1 of ISFM decision-support tool by Q2, 2022.
- Milestone 1.1.4.3. Version 2 of an ISFM decision-support tool developed Q4, 2022.

2.4.2 Output 1.2. Documented evidence for understanding the physiological basis of cocoa nutrient uptake and use

The target for this output in 2021 is to have at least four papers on cocoa ISFM/physiology accepted. Achievement of the following milestones is expected at the time of reporting. Table 7 and the subsequent information provide details on the progress to the milestones for 2021. Refer to **APPENDIX 1 – Status of Project Results with Mitigation Plans** for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 7. Status of milestones for Output 1.2

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
R4D (Research-for-Development)-related																				
Output 1.2. Understanding the physiological basis of cocoa nutrient uptake and use																				
Activity 1.2.1. Identification of factors determining high yield/quality in a range of genotypes/environments																				
Milestone 1.2.1.1. Protocols developed			X	X	X	X	X	X												
Milestone 1.2.1.2. Protocols implemented									X	X	X	X	X	X	X	X				
Milestone 1.2.1.3. Data analyzed and fed back into other activities													X	X	X	X	X			
Activity 1.2.2. Assessment of interactions between water, light, nutrient status, and growth efficiency																				
Milestone 1.2.2.1. Protocols developed			X	X	X	X	X	X	X											
Milestone 1.2.2.2. Protocols implemented											X	X	X	X	X	X	X			
Milestone 1.2.2.3. Data analyzed and fed back into other activities																	X			
Activity 1.2.3. Development of foliar norms for cocoa																				
Milestone 1.2.3.1. Protocols developed			X	X	X	X														
Milestone 1.2.3.2. Protocols implemented																				
Milestone 1.2.3.3. Data analyzed and fed back into other activities																				
Activity 1.2.4. Assessment of interactions between potassium nutrition and drought stress																				
Milestone 1.2.4.1. Protocols developed			X	X	X	X														
Milestone 1.2.4.2. Protocols implemented															X	X	X			
Milestone 1.2.4.3. Data analyzed and fed back into other activities																				

Progress on milestones: The PhD Student from Ghana, Paulina Asante, is still undertaking her study on the identification of factors determining high yield/quality in a range of genotypes/environments. Her manuscript entitled 'Unravelling drivers of high variability of on-farm cocoa yields across environmental

gradients in Ghana’ was completed in January 2021 and submitted to the Agricultural Systems Journal. The revised manuscript was submitted in May 2021 and accepted in June 2021. Open Access: <https://doi.org/10.1016/j.agsy.2021.103214>

Her second manuscript entitled “How to boost cocoa yield in Ghana—quantifying the cocoa yield gap and identifying its drivers” has been completed and submitted to Agricultural Systems Journal for publication. The paper is still under review. In this paper the cocoa yield gap was estimated by calculating water-limited potential yields for cocoa as the upper limit that can be achieved on existing land in a rainfed system using a physiological crop growth and production model for cocoa (CASE2) and comparing this with achieved yields by farmers across 93 cocoa farms in Ghana. The estimated absolute and relative cocoa yield gaps were related to environmental and management factors using mixed-effects models to identify potential causes of yield gaps and opportunities and entry points for sustainable intensification. Considerable yield gaps were found on all cocoa farms. Absolute yield gaps ranged from 2223 to 6071 kg/ha across sites (mean = 4577 kg/ha) and relative yield gaps from 49 to 98% (mean = 86%). Thus, current farmer yields are only 14% of the potential under rainfed conditions. Mixed-effects models showed that the absolute yield gaps were larger at sites with higher precipitation in the minor wet season and higher minimum temperature in the minor dry season. This model explained 22% of the variability in the yield gaps. In contrast, variation in the relative yield gaps was driven by management factors only, as normalizing water-limited yields results in a weak climate signal. The mixed-effect model showed that the relative yield gaps were reduced by increasing cocoa planting density and the application of fungicide against black pod, explaining 33% of the variability. In conclusion, the absolute cocoa yield gaps in Ghana are determined by climate with larger yield gaps in humid areas, whereas the relative yield gaps can be reduced by agronomic management practices. This suggests that improved practices offer opportunities to substantially increase cocoa production and close yield gaps without increasing planted area, regardless of current climate conditions.

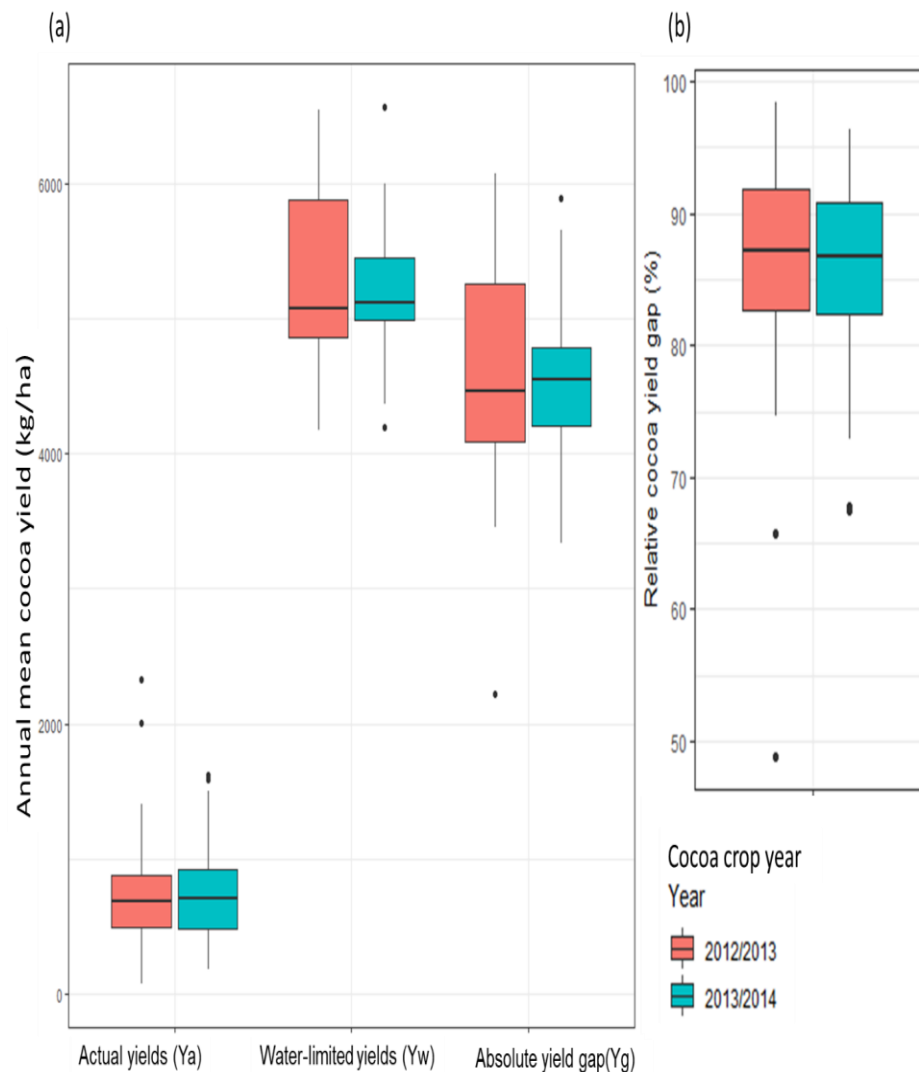


Figure 9. Annual mean cocoa yield (kg/ha)

Figure 9 shows variations in (a) actual yields from farmer fields, simulated water-limited potential yields, the absolute yield gap (difference between potential and actual) and (b) the relative yield gap, across 93 cocoa farms in Ghana for the 2012/2013 and 2013/2014 cocoa crop years. Yield refers to dry bean yield and cocoa crop year in March of a given year to February of the next year of 2012/2013 and 2013/2014, respectively.

For her third manuscript, Paulina Asante is looking into climate change effects on cocoa production and the potential cocoa-forest conflicts in West Africa. The objective of this study is to improve the understanding of impacts of climate change on cocoa yield by utilizing SUCROS-Cocoa (CASE2; Zuidema et al. 2005), a crop model that calculates the growth and production of cocoa with or without water (Zuidema et al. 2005). To enable CASE2 to predict the potential impact of elevated CO₂ on cocoa, a simplified version of the Farquhar model has been implemented in the model instead of the initial light response curve used in the calculation of photosynthesis in the original version of the model. This modification was done with the help of Dr Alejandro Morales, who has also translated the model from

Fortran to Julia language. Climate and soil data for simulations have been compiled and initial simulations tests are ongoing.

Luccette Adet's research to assess the interactions between potassium nutrition and drought stress is progressing. The statistical analyses related to the first manuscript have been carried out and discussed. Mixed-effects models were used to evaluate the effects of irrigation and potassium treatments on seasonal physiological traits. Initial results suggest leaf water potential, stomatal conductance, phenology, litter dynamic, and leaf traits are influenced by irrigation and season, and are genotype dependent. Surprisingly, including potassium in the mixed-effects model did not improve the best models for each parameter, suggesting that potassium did not affect the physiological traits. That could be explained by the previous application of fertilizer treatments before the experiment.

For her second manuscript, data has been organized and prepared for the next step of statistical analyses. This chapter addresses the effects of soil water deficit and potassium treatments on cocoa yield criteria. Therefore, the relationship between physiological traits, climate, tree morphology, yield, and bean properties were investigated using correlation analysis and mixed-effects models. Further steps need to be done to fully understand this relationship. Fertilizers trials (treatments with and without potassium) have been established and are ongoing. At the two chosen sites in Côte d'Ivoire, most of the planned experiments and protocols have been implemented. Data are being analyzed to underline stories contained in each dataset. To date, most of the monitored variables have been measured. Laboratory analysis was undertaken to determine physical and chemical properties on bean samples.

On the assessment of interactions between water, light, nutrient status, and growth efficiency, PhD student, Déo-Gratias Hougni monitored litterfall and cocoa leaf decomposition in low shade agroforestry systems. The objective was to understand the spatial variability of litterfall and to assess the importance of macrofauna in the nutrient release. It was found that with planting density set at 1000 trees/ha, there was no gradient in litterfall from the stem of cocoa trees to the area under the drip-line of the canopy, probably due to uncontrolled branch inter-locking. It was also observed that over one year, the presence of macrofauna (especially that of termites) was associated with faster cocoa leaf litter decomposition, increased N release, and reduced P immobilization.

Also, to test the relevance of N fertilizer application, a trial was established in 10 low shade plantations in Ondo state, Nigeria with two groups of farms (Fig. 10): (1) those that are responsive to N and not to PK and (2) those that are responsive to PK and not to N. Three rates of N (0, 50, and 100 kg N/ha) were compared, while P and K were supplied at recommended rates to reduce the probability of nutrient co-limitation. Pruning, weeding, and pest control were evaluated monthly. The dynamics of cocoa leaf biomass and early cocoa bean yield response were assessed in the first year. First-hand analysis suggests that:

1. Among evaluated management practices, only timely pruning was associated with cocoa yield increase.
2. Fertilizer application reduced leaf shedding consecutive to early drought but did not significantly increase cocoa leaf production.

Fertilizer application has been completed in the second year, and data have been collected to confirm observations made in the first year.

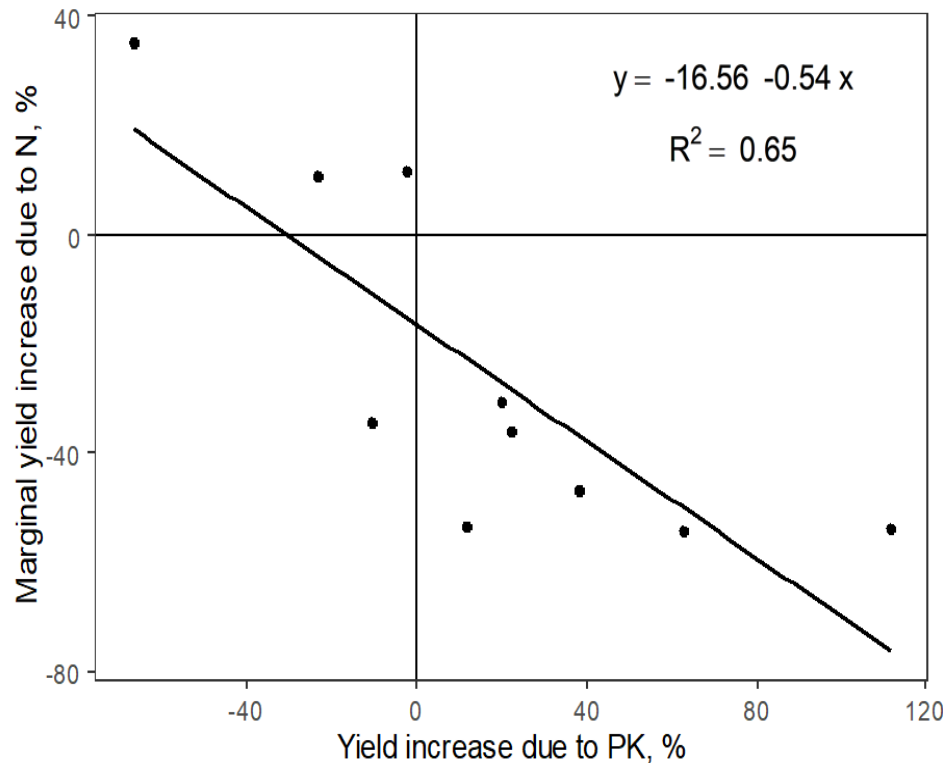


Figure 10. Yield increase of PK vs control and marginal yield increase of N vs PK application Only

Figure 10 shows the relationship between the yield increase of PK compared to control and marginal yield increase of N compared to PK application only. Yields were recorded in the main season of year 1 upon fertilizer application on 20-year-old cocoa trees.

Work on the recycling of nutrients in cocoa pods in Nigeria has been published in an article entitled ‘How nutrients rich are decaying cocoa pod husks? The kinetics of nutrient leaching’ in the Plant and Soil Journal. The manuscript was accepted in February 2021 and published in March 2021. Open Access: <https://doi.org/10.1007/s11104-021-04885-1>

Challenges and proposed changes in milestone timelines: To identify factors that determine high yield/quality in a range of genotypes/environments, there was a delay in the start of model development for running the Python version of CASE2 due to errors in the dry areas. Although these errors have been corrected, the delay affected the timeline for the completion of Chapter 3 which is likely to extend from the initially planned end date of March to May 2022.

The delay encountered during experiments set-up for the study by assessment of interactions between potassium nutrition and drought stress has been partially recovered. All the field experiments were successfully implemented in 2021 and have been terminated. The final round of data is currently being collected. This includes data for harvest, sap flow data, chemical content, and quality of beans. Data analysis for Chapter 1 (first article draft) took longer than expected due to the delay in data collection at the start of the experiments. The next step is to finalize the analysis and manuscript write-up of the first article.

Workplan for 2022

Activity 1.2.1. Identification of factors determining high yield/quality in a range of genotypes/environments

- Milestone 1.2.1.3. Analyze data collected on the yield and quality in a range of genotypes/environments by Q1, 2022.

Activity 1.2.2. Assessment of interactions between water, light, nutrient status, and growth efficiency

- Milestone 1.2.2.2. Finalize manuscript draft on the paradigm of ISFM in cocoa by Q1 2022.
- Milestone 1.2.2.3. Data analyzed and fed-back into other activities by Q2, 2022.

Activity 1.2.3. Development of foliar norms for cocoa

- Milestone 1.2.3.3 Analyze data collected on foliar norms. Integrate results (analyzed data) into other activities by Q2, 2022.

Activity 1.2.4. Assessment of interactions between potassium nutrition and drought stress

- Milestone 1.2.4.2. Implement protocols for assessment of interactions between potassium nutrition and drought stress by Q1 2022.
- Milestone 1.2.4.3 Analyze data collected on the assessment of interactions between potassium nutrition and drought stress by Q2, 2022.

2.4.3 Output 1.3. A decision-support system developed for intensifying cocoa production

As a target for this Output for 2021, the project will adapt tools for farmer segmentation and stepwise intensification for cocoa producing areas, with a “draft 2” of segmentation and stepwise investment tools made available. Achievement of the following milestones is expected at the time of reporting. Table 8 and the subsequent information provide details on the progress of the milestones for 2021. Refer to **APPENDIX 1 – Status of Project Results with Mitigation Plans** for status of the targets.

Columns with an ‘X’ indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 8. Status of milestones for Output 1.3

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
R4D (Research-for-Development)-related																				
Output 1.3. A decision-support system for intensifying cocoa production																				
Activity 1.3.1. Development of a decision-support framework for cocoa intensification																				
Milestone 1.3.1.1. Prototype decision-support framework developed							X	X	X											
Milestone 1.3.1.2. Decision-support tool populated									X	X	X	X	X	X	X	X			X	X
Milestone 1.3.1.3. Version 1 of a decision-support tool available											X	X	X	X	X	X			X	
Activity 1.3.2. Validation of the decision-support framework with target user groups																				
Milestone 1.3.2.1. Feedback on version 1 assembled																				
Milestone 1.3.2.2. Version 2 available and evaluated																				
Milestone 1.3.2.3. Final version delivered for scaling																				
Activity 1.3.3. Production and multiplication of a handbook on cocoa intensification																				
Milestone 1.3.3.1. Draft concept available																				
Milestone 1.3.3.2. First draft available and validated																				
Milestone 1.3.3.3. Handbook multiplied and available to the cocoa community																				

Progress on milestones: The CSC Implementer is a mobile application tool that combines the farmer segmentation tool (clustering) and stepwise investment pathways in Best Management Practices (BMP) for improved productivity. Based on emerging new insights, several changes and additions have been proposed and incorporated into the current version of the decision support application (CSC Implementer). The current version of the CSC app includes a segmentation module to understand farm diversity in the broader sense (e.g., farmers who use fertilizer and those who do not) and a BMP module.

Even though farmers belong to a broad segment, specific farm socio-ecological conditions differ. This situation makes advisory based on farm clusters challenging to implement. Figure 11 shows a simple comparison of cocoa productivity across the farm clusters using data from Ghana. Some of the variables used in constructing these clusters include proportion (%) of the farm under cocoa, plantation age, disease yield loss (%), amount of fertilizer used, number of cocoa trees replanted per hectare per year, cocoa tree population per hectare, the quantity of herbicides, and fungicides and pesticides applied per hectare. The wide standard deviation, especially for Cluster 3, highlights the challenges of assuming a farm cluster to be homogeneous. Additionally, farm clusters may be based on static data and may not capture the dynamic nature of farm decisions and activities from year to year.

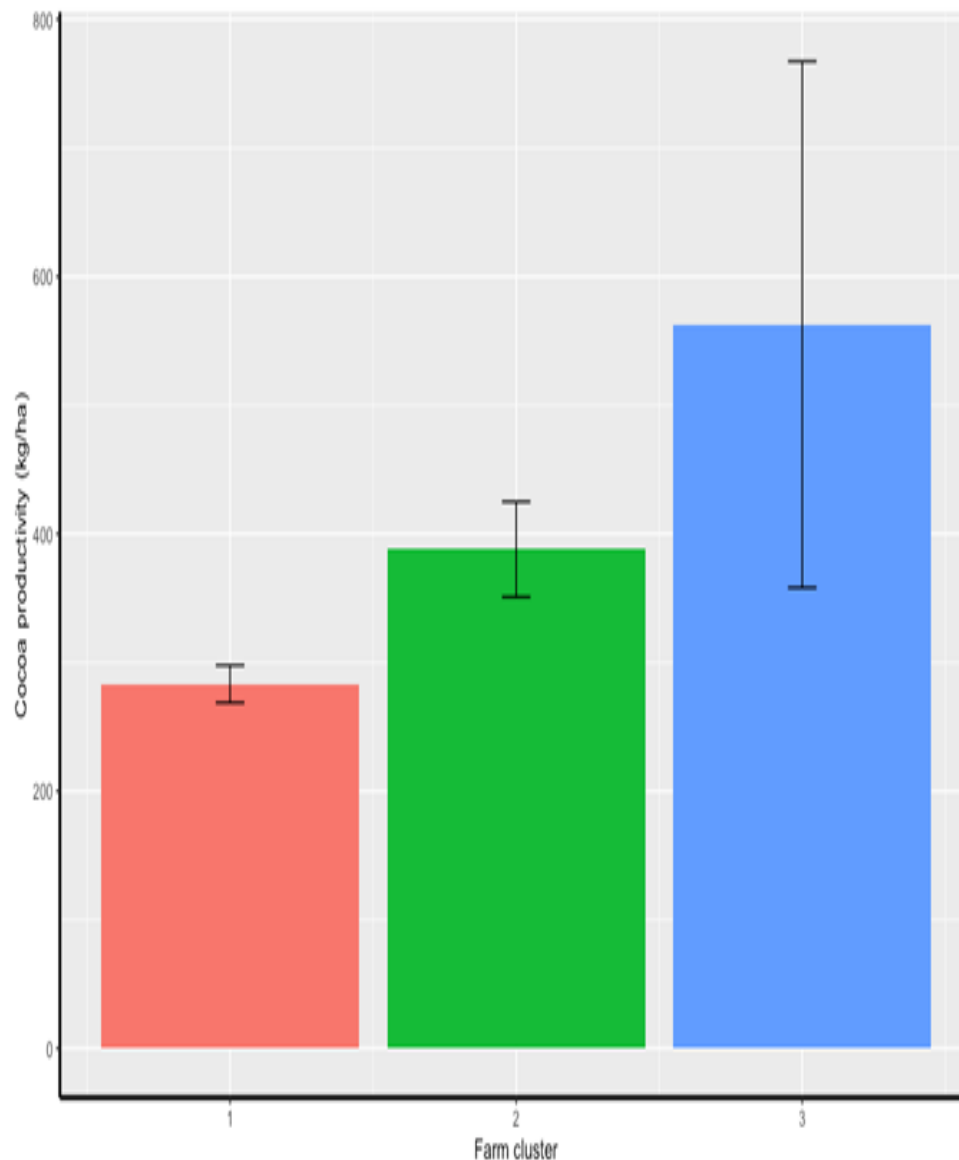


Figure 11. Clear significant differences in productivity among clusters of cocoa producers in Ghana

The BMP module is based on a Q&A to deduce the agronomic management intervention and the appropriate steps to take to achieve the desired outcome. An example of the BMP module Q&A related to fertilizer use is shown in Figure 12. Based on the responses given, an assessment is generated for a given plantation improving targeting in both space and time.



The screenshot displays the 'CSC Dashboard' with a status bar at the top showing 35% signal, 4G network, Wi-Fi, and a battery level of 71% at 9:08. The main heading is 'Best Management Practices Q/A'. Below this, there is a 'Do you apply fertiliser? ?' question with radio button options for 'Yes' and 'No'. The next section asks for the 'Amount of fertilizer(kg) applied per acre/hectare' with a text input field containing 'kg'. This is followed by 'Type of Fertilizer applied?' with a dropdown menu showing 'Granular'. The next two questions are 'Amount of Calcium(Ca) applied?' with a text input field containing 'Ca', and 'Amount of Magnesium (Mg) applied?' with a text input field containing 'number'. The final question is 'Amount of Sulphur (S) applied?' with a text input field containing 'Size (Ha)'. A large orange button labeled 'GENERATE ASSESSMENT' is positioned below the questions. At the bottom, there is a navigation bar with three icons: a house for 'CSC Dashboard', a calendar for 'Calender', and a bell for 'Forecast'.

Figure 12. BMP module of the current prototype of the application

Figure 12 shows the current prototype of the cocoa intensification decision application showing Q&A related to fertilizer use.

Other additions to the app include an activity calendar (Figure 13). In the activity calendar, an optimum date range when the activity should be carried out for a given location is provided. The given location is linked to a BMP manual that specifies how the activity is carried out. These significant changes and other capabilities listed in Figure 13 entail the development of a completely new version, which will be ready for testing by Q4 of 2023. The tool is scheduled to be populated for Ghana and the other three countries by Q4 of 2023. The tool also maps the farmers' clusters based on management intensity shown by their position on the stepwise pathway, and the CSA packages for easy use by the end-users (e.g., extension

workers from both private and public companies). This version will be available and is awaiting validation by the Research Committee in Q1 of 2022.

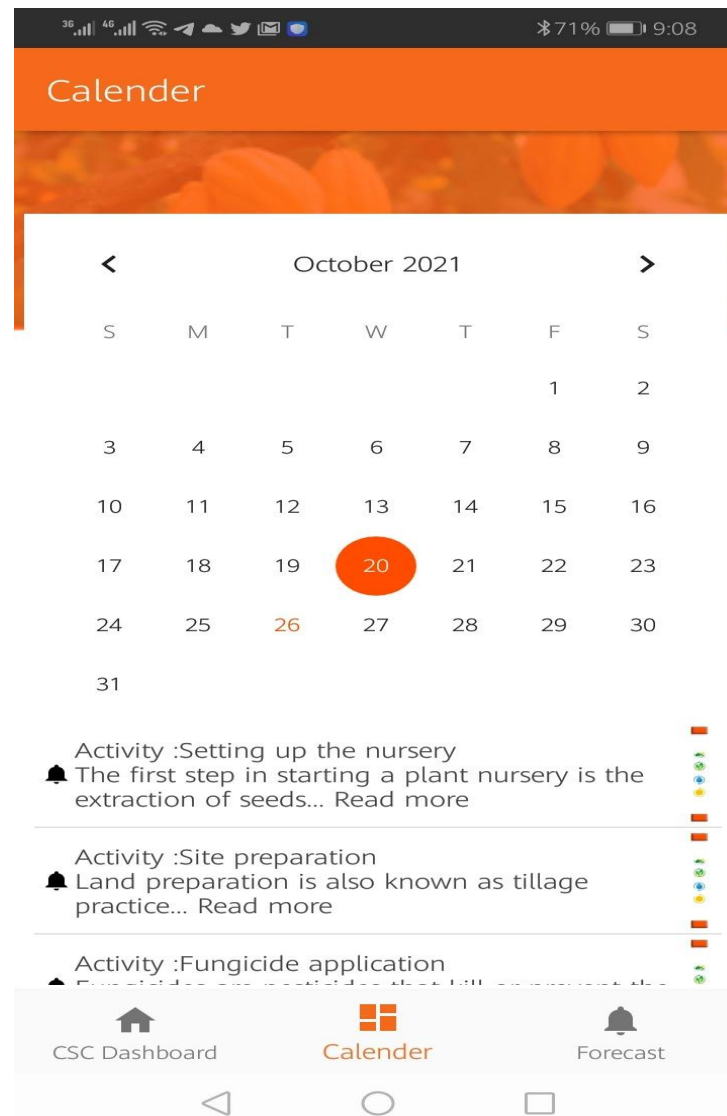


Figure 13. The activity calendar module of the current prototype of the application showing the date of activity and detailed guidelines

Challenges and proposed changes in milestone timelines: There were unforeseen delays in cleaning the CocoaSoils baseline data, which delayed some of the analytics. There were recorded cases of COVID-19 at the partner institution responsible for the engineering work resulting in significant delays in making the suggested changes to the tool. The analyses are pending for three other countries and will be undertaken in close cooperation with software engineers in Q4 of 2022.

There were unforeseen delays in cleaning the CocoaSoils baseline data, which delayed some of the needed analytics. There were recorded cases of COVID-19 at the partner institution responsible for the engineering work resulting in significant delays in making the suggested changes to the tool. The analyses

are still pending for three other countries and will be undertaken in close cooperation with software engineers in Q4 of 2022. The current version which houses mostly the GAPs and activity calendar was shared with selected partners who suggested some changes in terms of how the initial step of the farmer is determined. The sharing was difficult as this app is not in the play store and transmitting the apk file was considerably difficult.

The current version of the CSC app is inadequate and requires further development and alignment to the standard decision support tools in Excellence in Agronomy. The analytical framework for the yield and return on investments (ROI) has been set-up (Fig. 14) but requires experimental data from the STs and CTs to reliably calibrate CASE2 to simulate actual farm yields. It is important that each suggested Step for any farm (by geolocation) can be simulated in terms of productivity but also in terms of the costs and economic benefit. This process will take considerable time than anticipated due to these required capabilities. It is expected that for a fully functional application with spatial yield and profit prediction, the activity will go beyond 2022.

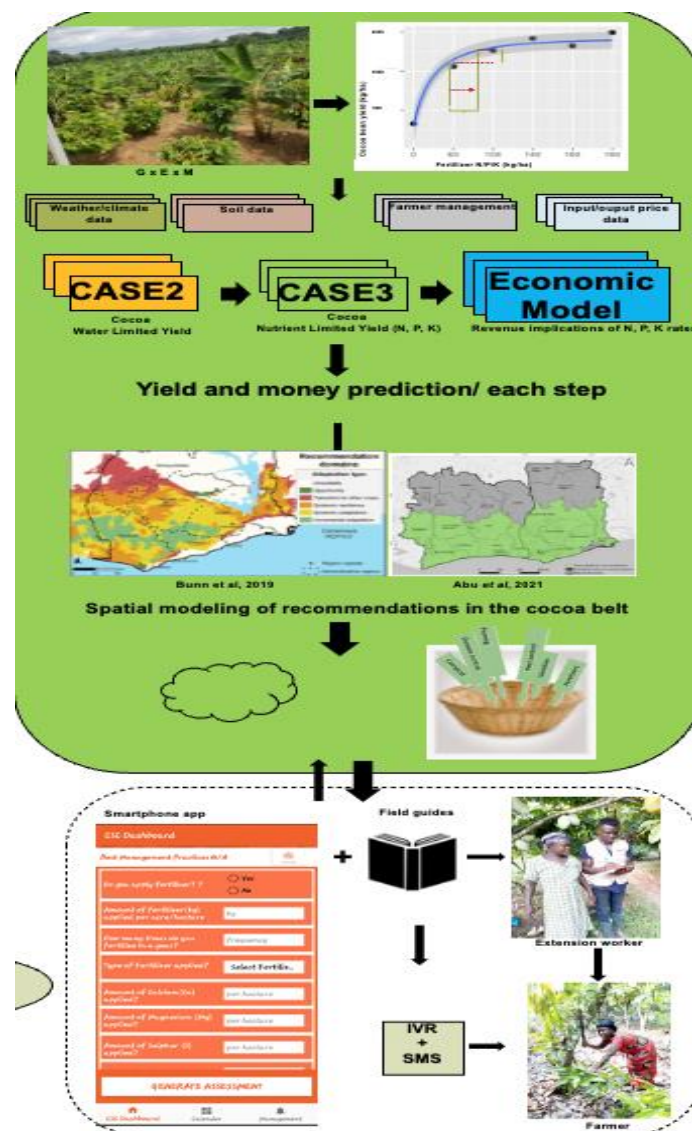


Figure 14. The analytical framework to support the stepwise investment pathways

The CASE2 model will be developed for spatial yield prediction loosely coupled to an economic model to generate a basket of production options at each farm and the economic implications. These options can be passed on to the farm in the form of an app, field guide, interactive voice messages (IVR), or short message services (SMS).

Workplan for 2022

Activity 1.3.1. Development of a decision support framework for cocoa intensification

- Milestone 1.3.1.2. Decision-support tool populated by Q4, 2022.
- Milestone 1.3.1.3. Make available to partners Version 1 of the decision support tool across the countries by Q4, 2022.

Activity 1.3.2. Validation of the decision support framework with target user groups

- Milestone 1.3.2.1. Assemble feedback on Version 1 by Q4, 2022.
- Milestone 1.3.2.3. Final version delivered for scaling Q4.

Activity 1.3.3. Production and multiplication of a handbook on cocoa intensification

- Milestone 1.3.3.3. Handbook multiplied and available to the cocoa community by Q2, 2022.

2.4.4 Output 1.4: Recommendation domains and impact of sustainable intensification on forest pressure identified

The target in 2021 for Output 1.4 was to quantify the impact of sustainable intensification deforestation and REDD+ schemes. Achievement of the following milestones is expected at the time of reporting. Table 9 and the subsequent information provide details on the progress of the milestones for 2021. Refer to **APPENDIX 1—Status of Project Results with Mitigation Plans** for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 9. Status of milestone for Output 1.4

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
R4D (Research-for-Development)-related																				
Output 1.4. Identification of recommendation domains and impact of sustainable intensification on forest pressure																				
Activity 1.4.1. Identification of representative trial sites under current and future climates																				
Milestone 1.4.1.1. Historical climate data compiled																				
Milestone 1.4.1.2. Future climates for the target regions down-scaled																				
Milestone 1.4.1.3. AEZ for site selection assessed					X	X	X	X												
Activity 1.4.2. Scale indicators and recommendations of trials to spatial domains																				
Milestone 1.4.2.1. Spatial proxies of key CSA																				

Furthermore, a workshop is planned in Accra in April 2022 to get feedback and relevant country specific information from policy stakeholders, academia, and implementing organizations. This engagement process will help ensure that the recommendation domains, in combination with the biodiversity and

ecosystem services toolbox from WCMC, respond to the policy needs of the different countries. The same framework is being adapted for the decision-making context of cocoa industry stakeholders. For this, we are collaborating with Mondelez and have initiated discussions with Barry Callebaut. After incorporating the feedback from public and private sector stakeholders, we will document the results in a peer-reviewed journal.

A collaboration was initiated with KNUST-Ghana to enable CocoaSoils use the land use maps developed by the Forest 2020 project, which includes cocoa monocropping and cocoa agroforestry as land use classes. Through this partnership, KNUST will bring their expertise in spatial modelling (incl. relevant data sets), knowledge on policy objectives and relevant initiatives to the landscapes of interest. A proposal has been submitted to the African Plant Nutrition Institute (APNI) to use drones and satellite imagery to map cocoa yield based on the information collected at the CocoaSoils ST. This proposal was successful, although the content was substantially modified. There is also collaboration ongoing with Johannes Reiche from WUR, who is testing new data and approaches for mapping cocoa plantations using satellite imagery.

To quantify the adaptation potential of CSA packages, an approach was developed to estimate cocoa yield gaps. This was done in collaboration with PhD student Paulina Asante and the supervisory team at Wageningen University and Research (WUR). The theoretical water limited yields were calculated using the cocoa physiological production (CASE2) developed by Zuidema et al. (2005) and compared to actual yield data for the case of Ghana. The yield data include detailed information on management and soil conditions. Daily climate data has been prepared from the ERA5 reanalysis data set (Boogaard et al. 2020). A mixed effects modelling approach is used to identify how environmental and management interactions affect the yield gap. These insights will provide more regionalized recommendations on closing the yield gap. The manuscript has been submitted to the journal *Agricultural Systems*. The approach will be useful to assess how the insights from the STs (i.e., cocoa yields from different treatments and related management practices) can contribute to sustainable intensification, climate change adaptation, and forest protection.

To assess climate change impacts on cocoa using CASE2, newly available CMIP6 GCM projections were processed. These data correspond to the newly released sixth assessment report of the IPCC (IPCC 2021). Because the data from the GCMs are at a coarse resolution (70–400 km), they are being downscaled and bias-corrected to be useful for agricultural applications (Navarro-Racines et al. 2020). The modelled climate change impact will then be combined with the previously generated spatial data on the remaining forests, deforestation trends, and conservation areas. This will feed back into the recommendation domains providing additional information on plausible future trajectories and related management options. Trade-offs and limits of different climate and management scenarios can be quantified and used for guiding investments in cocoa and for conservation.

Progress has also been made in defining and implementing different intensification scenarios on forest protection and deforestation for Ghana. Scenarios are defined based on policy objectives and climate-smart cocoa guidelines (Fig.15). Implications on cocoa yields are being modelled using CASE3 for various plausible future (2030–2060) climate projections.

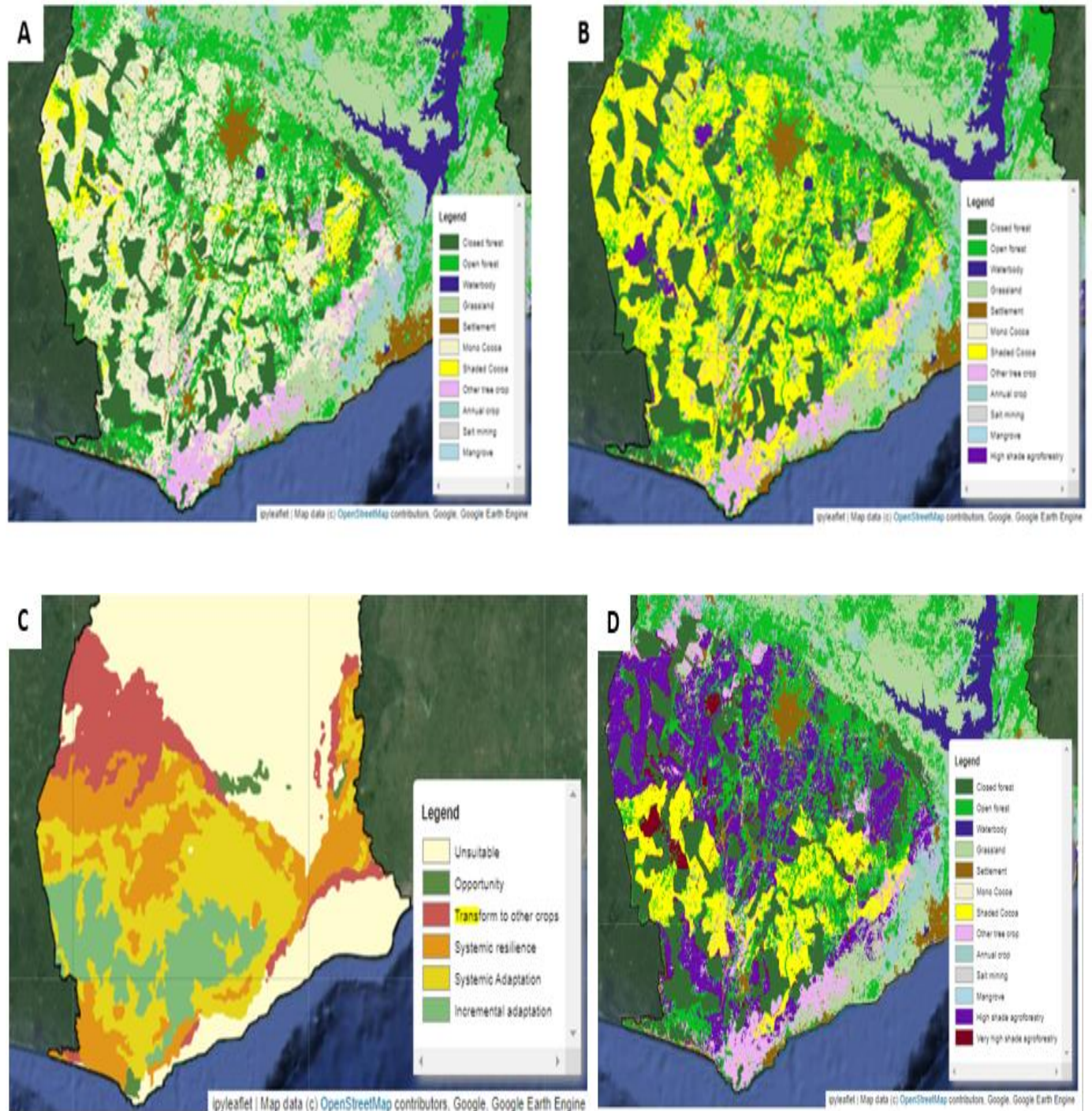


Figure 15. Progress on mapping impact of different intensification scenarios on forest protection/deforestation

On deforestation monitoring, previous assessments of deforestation had the disadvantage of detecting deforestation in forested areas that were already severely degraded. It is questionable whether further tree loss in already deforested areas should be classified as deforestation. To improve the assessment, newly available data sets were used to get a better picture of the degradation level (Hansen et al. 2022; Reiche et al. 2021). To do so, we classified areas with dense tree cover as forests, but differentiated

different height strata (i.e., 10–14 m, 15–19 m, 20–25 m, > 25 m) to include additional information on degradation level. Tree cover loss continues to be a concern (Fig. 16). However, most events are small and in Côte d'Ivoire and Ghana, approximately 1/3 of the areas are with trees of > 15 m height and 2/3 of the areas are with trees of < 20 m height. It is possible that these areas have already been converted to tree crops before CocoaSoils started. In Cameroon, on the other hand, most of the tree cover loss is related to large trees of > 25 m height (Fig. 17).

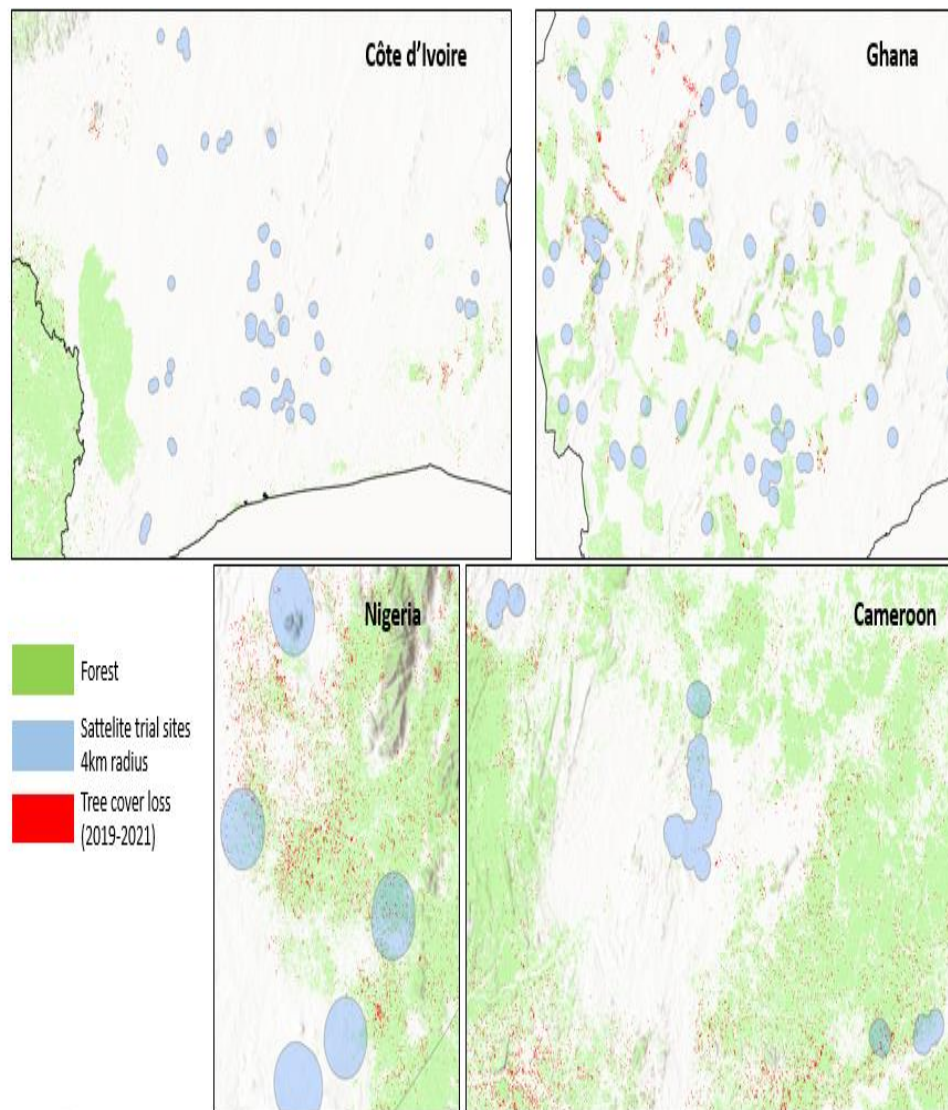


Figure 16. Tree cover loss in forests (i.e., land cover with dense tree covers)

RADD alerts in dense tree cover within 4 km of satellite trials

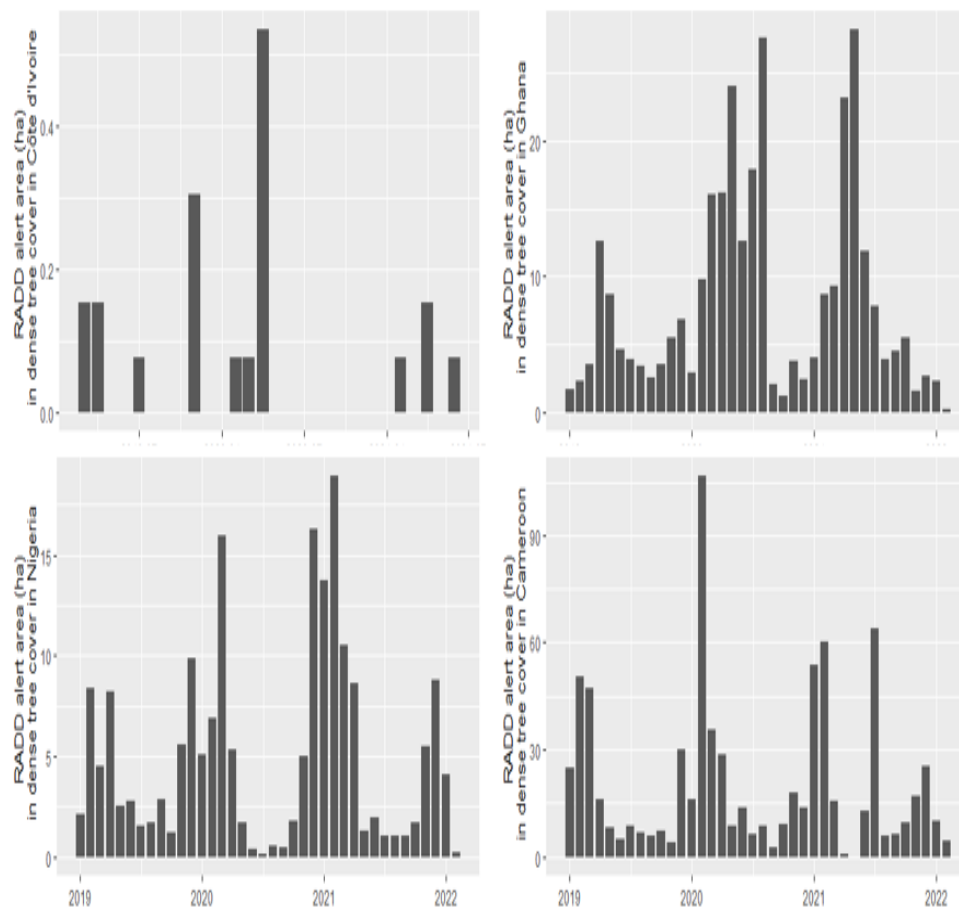


Figure 17. RADD alerts in dense tree cover areas within 4 km of the STs aggregated to monthly sums between 2019 and 2022

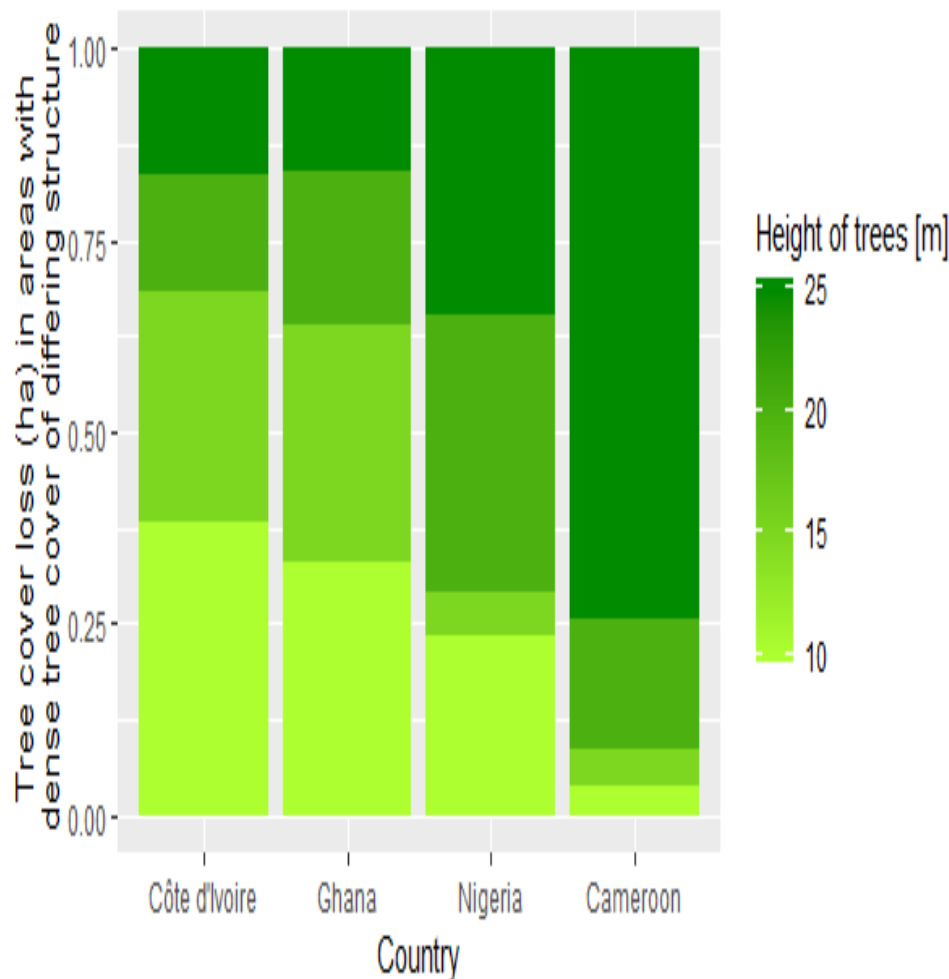


Figure 18. Vertical structure of tree cover loss within 4 km around the STs

Challenges and proposed changes in milestone timelines

The yield gap assessment is currently only done for Ghana where detailed cocoa yield data including information on agronomic management is available. This analysis is envisaged to be extended to the other countries using the yield data from the satellite trials. The project planned to organize webinars to discuss and validate the work with different stakeholders because physical workshops were not feasible due to the pandemic. However, due to the difficulties of making such an event productive, a physical event has been scheduled for April 2022 when travel restrictions are expected to be eased.

Workplan for 2022

Activity 1.4.3. *Ex-ante* assessment of cocoa intensification packages and interventions on cocoa suitability

- Milestone 1.4.3.1. Quantify the adaptation potential of CSA packages by Q2, 2022.
- Milestone 1.4.3.2. Re-run cocoa suitability models based on 3.1 by Q2, 2022.
- Milestone 1.4.3.3. Quantify intensification potential for each intervention spatially by Q2, 2022.

Activity 1.4.4. Quantification of the impact of intensification scenarios on forest protection/deforestation

- Milestone 1.4.4.2. Cocoa intensification with deforestation scenarios combined by Q2, 2022.
- Milestone 1.4.4.3. Impact of different intensification scenarios on forest protection/deforestation assessed by Q2, 2022.

2.4.5 Output 1.5: Sustainability assessment tools developed and validated to support the sustainable development of cocoa production in relation to biodiversity and the ecosystem services at the landscape level

Target for this Output for 2021 is to produce the second draft of sustainability assessment tools. Achievement of the following milestones is expected at the time of reporting. Table 10 and the subsequent information provide details on the progress for the milestones for 2021. Refer to [APPENDIX 1—Status of Project Results with Mitigation Plans](#) for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 10. Status of milestones for Output 1.5.

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
R4D (Research-for-Development)-related																				
Output 1.5. Sustainability assessment tools																				
Activity 1.5.1. Assessment of climate-smart cocoa scenarios and impacts on biodiversity and ecosystem services																				
Milestone 1.5.1.1. Baseline of natural capital and ecosystem functions produced.																				
Milestone 1.5.1.2. Implications for biodiversity and ecosystem services of potential shifts in cocoa suitability areas mapped							X	X	X	X					X					
Milestone 1.5.1.3. Potential impacts on biodiversity and ecosystem services of intensification scenarios assessed								X												
Activity 1.5.2. Assessment of landscape vulnerability and potential co-benefits of climate-smart cocoa																				
Milestone 1.5.2.1. Areas of vulnerability for natural capital and ecosystem services under shifting suitability ranges identified									X	X	X	X	X							
Milestone 1.5.2.2. Areas where climate-smart cocoa may help mitigate																				

Working with CIAT, a presentation was given on the potential for sustainable intensification of cocoa to contribute to forest protection and increasing ecosystem services in agricultural landscapes at the Annual CocoaSoils meeting in January 2021. This has led to the development of a draft spatially explicit decision-tree and guidance document to help target cocoa system design considering national to local level deforestation risks and opportunities to maintain or improve biodiversity and ecosystem services in cocoa growing areas.

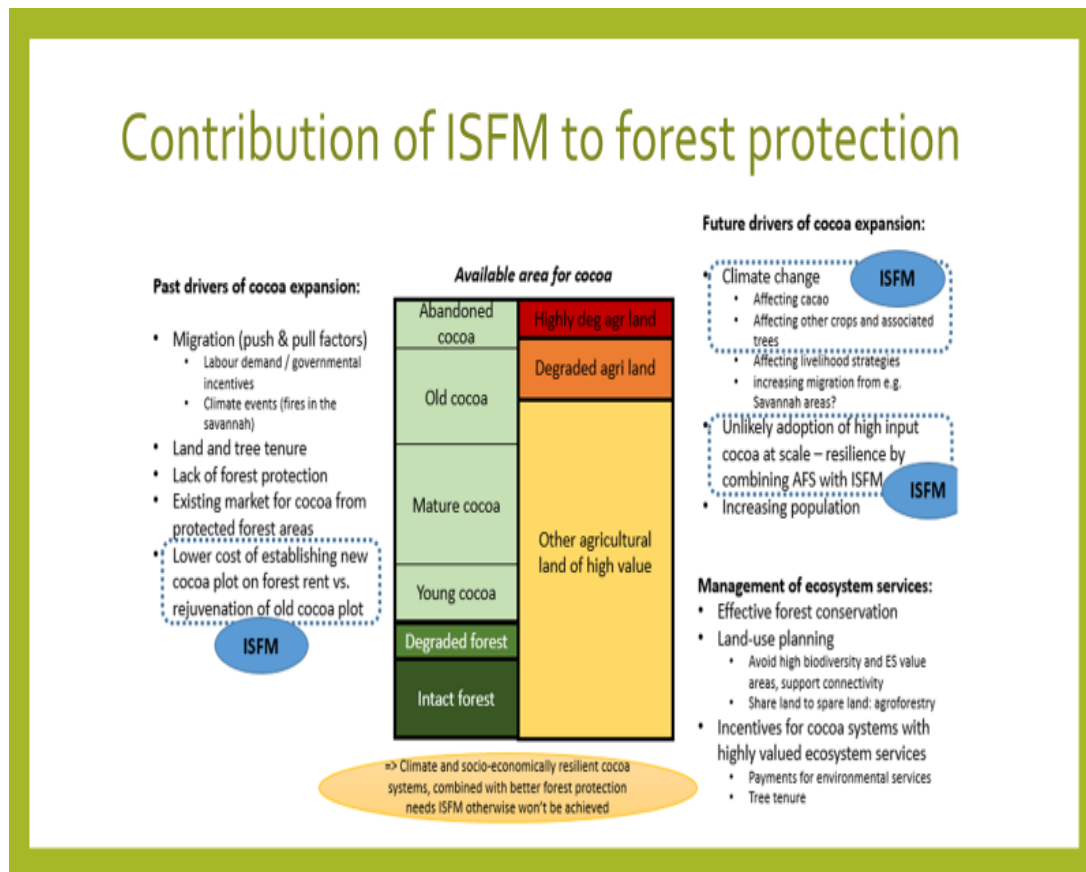


Figure 19. A slide from the presentation for the Annual CocoaSoils Forum in January 2021

The report on mapping potential areas to implement cocoa agroforestry in Côte d'Ivoire which was being finalized in August 2021, was finalized and published at the end of 2021 on the [CocoaSoils website](#) and the website of [UNEP-WCMC](#). The work sought to identify where different national forest-related policy objectives that look to cocoa agroforestry as a means to achieving their targets could be achieved and to identify opportunity areas for and co-benefits (e.g., carbon stocks below) from implementing agroforestry in full sun or low shade cocoa areas.

This work also contributed to UN-REDD program in support of the national forest restoration policy (REDD+) in Côte d'Ivoire. The report was finally launched in early 2022 and attracted good attention from companies and other stakeholders. The interest in prioritization of efforts and making the business case for implementing agroforestry, including carbon and biodiversity co-benefits is increasing among the cocoa private sector. A policy brief has been developed based on the results. A similar study is being undertaken for Ghana in 2022 in collaboration with KNUST, with further specificity on climate-smart scenarios.

Mapping Opportunities for Cocoa Agroforestry in Côte d'Ivoire

Assessing its potential to contribute to national
forest cover restoration targets, and ecosystem
services co-benefits



Figure 20. Cover page of the report on mapping opportunity for cocoa agroforestry in Côte d'Ivoire

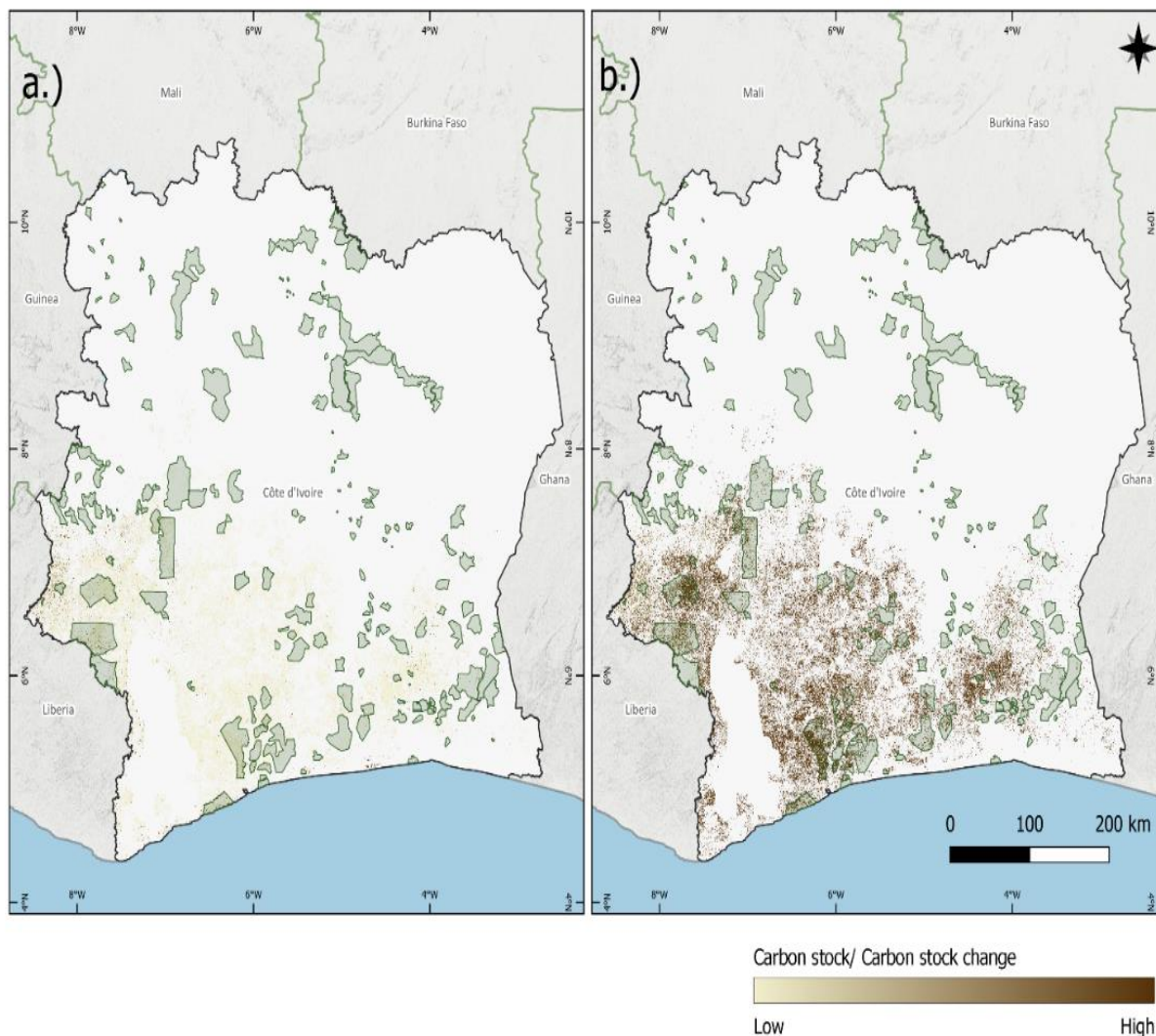


Figure 21 (a). Estimated carbon stocks in current cocoa growing areas in both classified forest and the rural domain. (b) Change in carbon stocks after transition to agroforestry. Current cocoa growing areas are restricted to areas climatically suitable for cocoa under a future climate projection

Guidance materials aim to support the consideration and balancing of trade-offs and synergies with forests, biodiversity, and ecosystem services when planning for sustainable cocoa production into the future. To this end, a draft guidance tree (Fig. 21) and document to support spatially explicit and integrated decision-making to increase productivity and farmer resilience, support biodiversity, and protect forests developed between Q1 and Q3 of 2021 is being finalized. This work will help national or supply chain stakeholders understand the risks and plan for opportunities arising from the interaction between increasing cocoa production through different strategies, climate change, deforestation, biodiversity, and ecosystem services (see details in 2020 report). A multi-stakeholder workshop has been scheduled for April 2022 to seek feedback on the tool and improve it. It integrates R4D components of the project, as well as part of the P4D, in support of Outcomes 1–3.

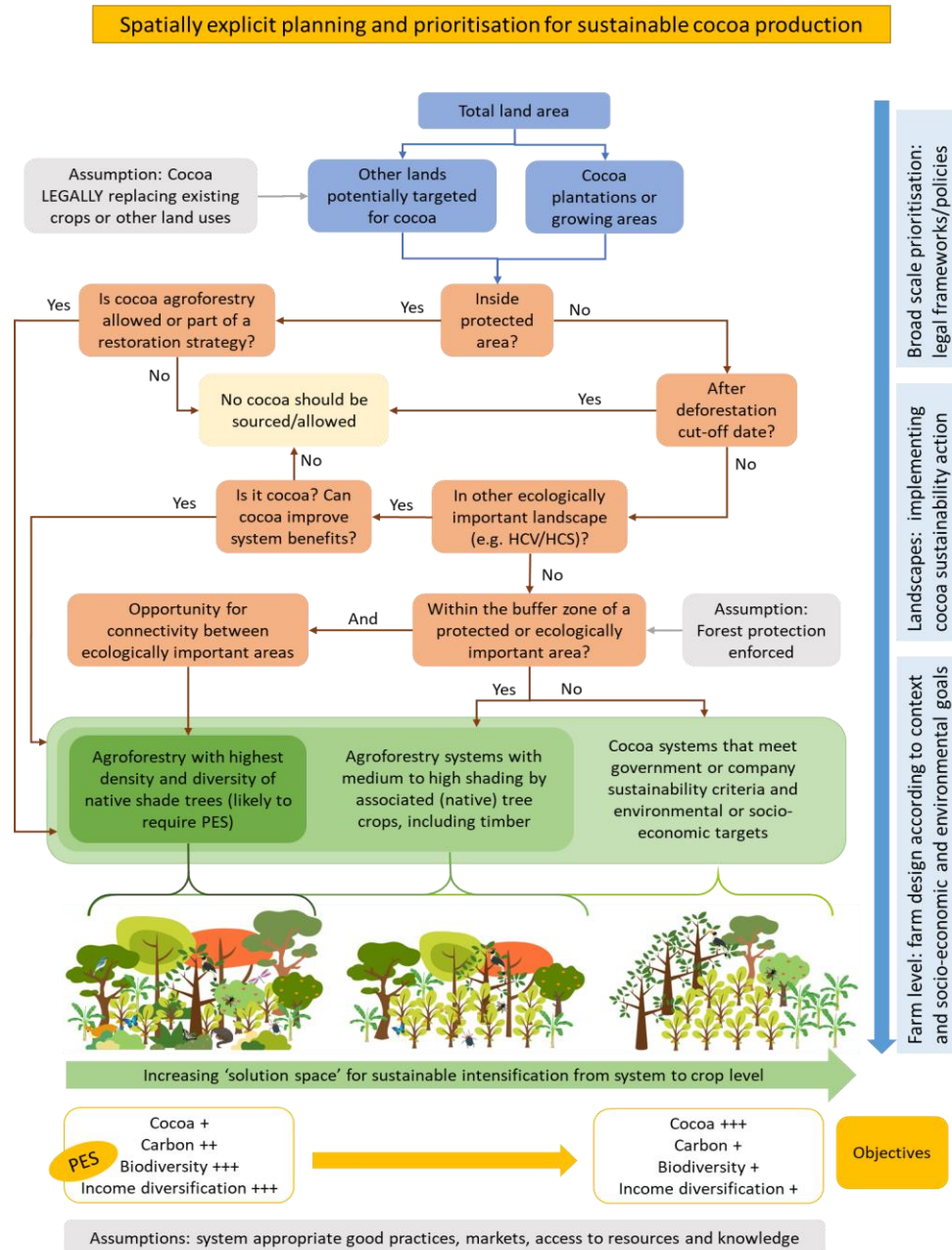


Figure 22. Draft guidance tree

For the landscape to site scale, the final draft of the toolkit to support planning for ecosystem services in cocoa landscapes, including user interface (Fig. 21) and the accompanying user guidance, are being finalized. The toolkit will be sent out for review by potential users and tool providers in 2022.

Toolkit: Planning for ecosystem services in cocoa landscapes

Aim & purpose

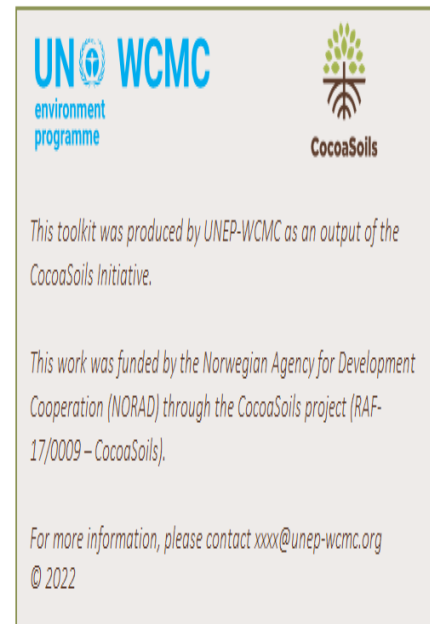
This toolkit aims to support the management of cocoa production to harness multiple benefits from nature and improve their availability. These benefits are described as **ecosystem services**, as they come from the trees, animals and soils in cocoa farms and their wider landscape.

The toolkit helps users to **select tools** that help consider how management of cocoa production can improve the availability of multiple ecosystem services across different scales, from local/site-based to regional.

The toolkit allows users to select tools and resources based on their specific objectives and priorities. Management objectives covered in this toolkit include implementing agroforestry and increasing climate resilience, to capacity building and economic evaluation of ecosystem services.

The toolkit provides detailed descriptions of the relevant tools, and how they can support users to achieve specific management objectives with regards to ecosystem services in cocoa landscapes.

Figure 23. Introduction page of toolkit in excel



Toolkit: Planning for ecosystem services in cocoa landscapes

How to use this toolkit

Select the objective(s) you want to achieve

1) Select your objective(s)

Objective that tool can help user to achieve

- Assessing risks & monitoring impacts on ecosystem services
- Capacity building & agricultural extension
- Identifying & mapping ecosystem services and stakeholders
- Planning & implementing interventions for ecosystem services
- Quantifying & valuing ecosystem services
- (blank)

2) Select your sub-objectives

Sub-objective that tool can help user achieve

- Assess and/or improve carbon sequestration potential in a specific area
- Develop action plans to address risks and opportunities for biodiversity in agricultural landscapes
- Identify & map ecosystem services and the people who depend on them
- Identify and assess impacts, risks and dependencies of agricultural activities on biodiversity and ecosystem services
- Identify and/or integrate climate risks into planning and management of cocoa landscapes
- Identify priority areas for ecosystem restoration in cocoa landscapes
- Identify/engage stakeholders for knowledge-gathering, planning or implementing decisions

Additional Instructions:

- Select multiple choices by clicking on this icon
- Clear your selection by clicking on this icon
- Scroll down using the arrows on the right of the search box
- Relevant selections are shown in darker colours
- Non-relevant selections are faded

Select tools from below

3) The table below will show you the relevant tools based on your selections above. Select one or more tools.

4) Filter by additional criteria (optional)

Find information about the tools

5) Go to the next tab [2. SELECTED TOOLS] for details on the relevant tool and how it can help you achieve your

Figure 24. Draft of the toolkit in excel

On exploring how to further support synergies among industry and national commitments through smart planning of sustainable intensification of cocoa, new initiatives and entry points for the work of CocoaSoils to support synergies on cocoa production, forests, biodiversity, and ecosystem services are being monitored. Individual companies are increasingly expressing interest in this topic. Products are being tailored to meet their needs and increase the impact of the project. These activities feed into Output 2.4 and Outcome 3.

The initial work on assessing the impacts of cocoa related land use on biodiversity (Milestone 1.5.1.3.) formed the basis for conversations with sustainability managers at Barry Callebaut, Nestle, and Cargill on biodiversity, metrics, scales, and ways of measuring the impacts of their (regenerative) programs. Existing corporate biodiversity footprinting approaches use generic land use categorizations and impact coefficients for biodiversity impact. Including commodity-specific land use intensity characteristics and biodiversity responses would increase the accuracy and relevance of impact assessments, for example, for cocoa sustainability programs that seek to promote context appropriate agroforestry models.

There is the need to ground truth and improve the published biodiversity impact model to include more cocoa (agroforestry) management types across agroclimatic zones (started in Ghana and Cameroon) and develop efficient and consistent biodiversity data collection and analysis methods for cocoa landscapes,

in a pre-competitive space. Overall, there is the need to better understand sector needs for measuring impacts on biodiversity and ecosystem services. These activities feed into Output 2.4 and Outcome 3.

Two multi-stakeholder workshops were originally planned for 2022. Due to the global health crisis, part of the resources were reallocated to smaller events in 2021/2022: one stakeholder consultation in Côte d'Ivoire (to support 1.5.2.2) and a multi-stakeholder workshop to be held in April 2022 in Accra to bring together people from research, civil society, and policy to discuss progress and challenges on reconciling economic, social, and environmental objectives in cocoa landscapes and research priorities to support better outcomes. On Milestone 15.4.2, One paper published, one paper accepted, and a third is in progress. The potential for policy briefs based on results is being considered.

Challenges and proposed changes in milestone timelines: COVID-19 thwarted plans for stakeholder consultation and engagement activities in 2021 and it is likely to cause further delays in 2022. A mitigation strategy being considered is holding online events and channeling additional time and resources into developing communication materials in support of project Output 2.4. and Outcome 3 (new stories, blogs, etc). Due to the lifting of travel restrictions, biodiversity, and ecosystem services data collection (including for biodiversity model validation and improvement) will take place in early 2022. Analysis will largely be carried out after 31 May, but results will be published as part of the project legacy.

Workplan for 2022

Activity 1.5.1. Assessment of climate-smart cocoa scenarios and impacts on biodiversity and ecosystem services

- Milestone 1.5.1.3. Assess potential impacts on biodiversity and ecosystem services of intensification scenarios by Q4, 2022.

Activity 1.5.2. Assessment of landscape vulnerability and potential co-benefits of climate-smart cocoa

- Milestone 1.5.2.2. Identify areas where climate-smart cocoa may help mitigate such impacts by Q4, 2021.
- Milestone 1.5.2.3. Work towards producing guidance materials has already started and will continue to Q4, 2021.

Activity 1.5.3. Review of potential synergies among industry and national commitments regarding forests supported by sustainable cocoa intensification

- Milestone 1.5.3.1. Review synergies and trade-offs among industry and national commitments supported by intensification scenarios by Q1, 2022.

Activity 1.5.4. Validation of results and stakeholder engagement

- Milestone 1.5.4.1. Organize multi-stakeholder workshops by Q2, 2022.
- Milestone 1.5.4.2. Finalize scientific papers submitted and policy briefs on workshop recommendations in Q1 and Q2, 2022.

2.4.6 Output 1.6. Operational open knowledge and data sharing portal for the storage, management, and dissemination of cocoa intensification research results

As a target for this Output in 2021, a final version of the data portal will be available and a minimum of 50 percent of all datasets submitted. Achievement of the following milestones is expected at the time of reporting. [Table 11](#) and the subsequent information provide details on the progress of the milestones for 2021. Refer to **APPENDIX 1—Status of Project Results with Mitigation Plans** for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 11. Status of milestone for Output 1.6

Activities and milestones	2018				2019				2020				2021				2022			
	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
R4D (Research-for-Development)-related																				
Output 1.6. Operational open knowledge and data sharing portal																				
Activity 1.6.1. Development of data capture, structure, and publication mechanisms, and user requirements analysis																				
Milestone 1.6.1.1. Data structure for all functions in AgroSTAC implemented			X	X	X	X	X	X	X	X	X	X	X	X						
Milestone 1.6.1.2. Overall architecture and publication mechanism designed			X	X	X	X	X	X	X	X	X	X	X	X						
Milestone 1.6.1.3. Data capture app developed				X	X	X	X	X	X	X										
Milestone 1.6.1.4. User requirements analysis completed				X	X	X	X	X	X	X	X	X								
Activity 1.6.2. Development of outward-facing parts of the knowledge and data-sharing portal																				
Milestone 1.6.2.1. Public-facing portal and data visualization platform, prototype 1 developed												X	X	X	X	X				
Milestone 1.6.2.2. Public-facing portal and data visualization platform, beta release available																X	X			
Milestone 1.6.2.3. Public-facing portal and data visualization platform, final release available																				
Activity 1.6.3. Development of consortium-dedicated parts of the knowledge and data-sharing portal																				
Milestone 1.6.3.1. Scientific analysis facility and data publication									X	X	X	X	X	X	X	X				

facility, prototype 1 developed																			
Milestone 1.6.3.2. Scientific analysis facility and data publication facility, beta release available											X	X	X						
Milestone 1.6.3.3. Scientific analysis facility and data publication facility, final release available																X	X		
Activity 1.6.4. Maintenance, user testing, and targeted improvements of knowledge and data-sharing portal																			
Milestone 1.6.4.1. Data and knowledge sharing portal maintained																			
Milestone 1.6.4.2. Testing and targeted improvements used																	X	X	

Progress on milestones: The ODK server has been developed and is used as the sole data capture application for the project. All data from the baseline survey were collected and submitted through the ODK platform. In Q1, Q2, and Q3 2021 substantial effort was dedicated to the development of a cocoa-specific ontology essential for the proper collection, management, and storage of data.

The data team from WENR developed the database structure and implemented a content management system coupled with an ODK server. The team has assisted in the development of data collection forms in ODK for all STs data and CTs data, which are being hosted over the ODK server.

The CocoaSoils ontology was presented at the CocoaSoils Annual Forum in January 2021 and the ontology documents were later shared with all attendees for second feedback. After the second round of feedback, the ontology was presented to the general stakeholders and it was suggested that for the CocoaSoils ontology to be widely accepted and utilized by all, a series of webinars should be organized where the ontology would be presented to a larger audience. The CocoaSoils ontology webinar was held in October 2021.

A new PostgreSQL database (curated data storage) with user management has been developed (Fig. 23). This database stores all quality checked databases and data associated with each partner. Within this database, the privacy-sensitive data and non-privacy sensitive data have been separated. Privacy sensitive data will be accessed by consortium partners only. The non-privacy sensitive data will be available for download.

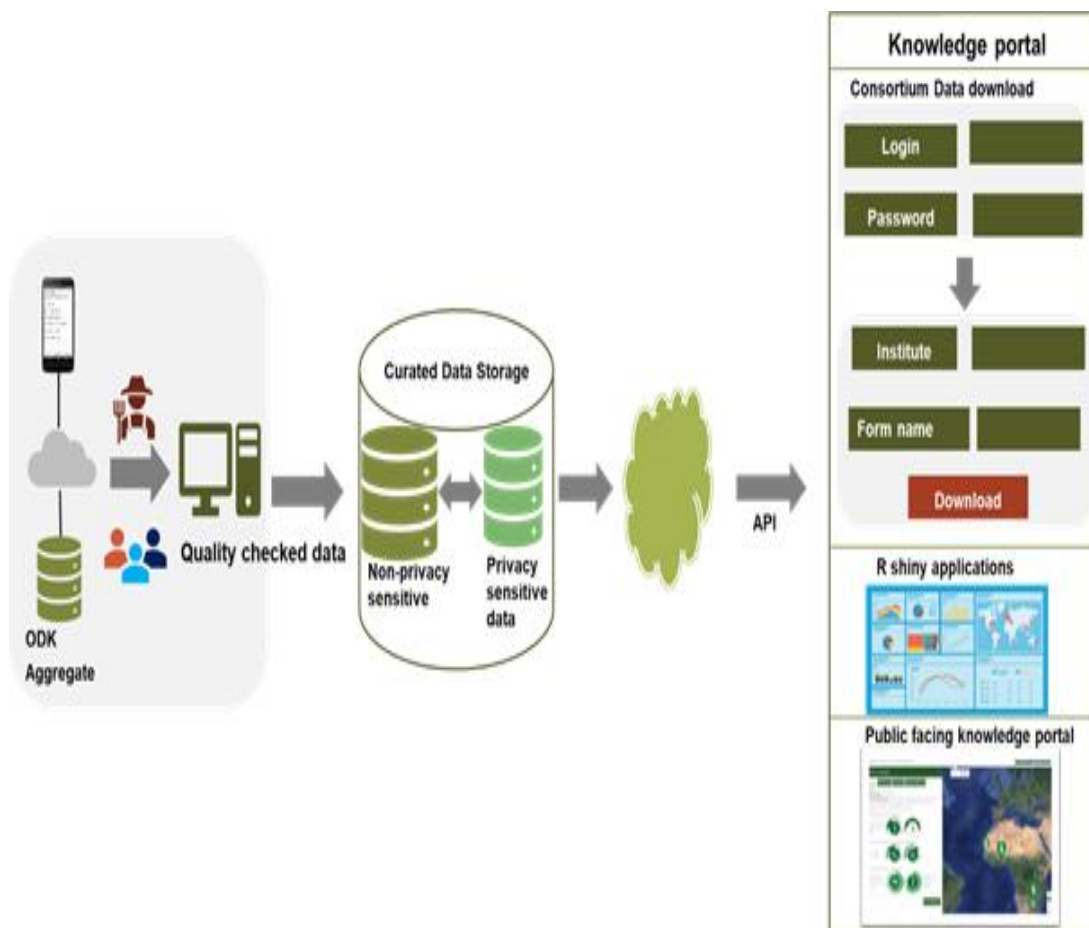


Figure 25. Plans for steps of data curation and sharing within the consortium

To summarize key achievements under this output: the program finalized the cocoa oncology for FAIRization of data and metadata interoperability and developed the data curation workflows that allows exchange of cocoa related datasets. A data analytics, interfaces, and visualizations of cocoa dataset for the public, policy making, and research domains has also been created.

- “Towards FAIR Data Stewardship: Managing & sharing data of cocoa field experiments as a public good” OFE conference 2021 <https://ofe2021.com/>
- The CocoaSoils ontology webinar was held on 26 October 2021. The aim is to further give the CocoaSoils ontology more publicity and credibility. https://us02web.zoom.us/webinar/register/WN_dZ3fnYZZRpSZ20d8APIPnw?mc_cid=4e29e5f8dd&mc_eid=9e83fb0c9f&mc_cid=ec0a76f0ed&mc_eid=9e83fb0c9f

Challenges and proposed changes in milestone timelines. A new PostgreSQL database (curated data storage) with user management was developed (Fig. 23). This will delay the development of the Knowledge Portal.

Workplan for 2022

Activity 1.6.2. Development of outward-facing parts of the knowledge and data-sharing portal

- Milestone 1.6.2.2. Make available public facing portal and data visualization platform by Q1 2022.
- Milestone 1.6.2.3. Make available the final release of the public facing portal and data visualization platform by Q3 2022.

Activity 1.6.3. Development of consortium-dedicated parts of the knowledge and data-sharing portal

- Milestone 1.6.3.3. Make available the final release of the scientific analysis facility and data publication facility by Q1, 2022

Activity 1.6.4. Maintenance, user testing, and targeted improvements of knowledge and data-sharing portal

- Milestone 1.6.4.1. Data and knowledge sharing portal maintained by Q2, 2022.
- Milestone 1.6.4.2. Use the testing and targeted improvements to develop the data portal further by Q2, 2022.

2.4.7 Output 1.7. A new cadre of PhD and MSc-holding cocoa scientists with knowledge in new cocoa intensification options (including Output 1.2 results)

As target for this Output in 2021, the project will approve at least four MSc theses. Achievement of the following milestones is expected at the time of reporting. [Table 12](#) and the subsequent information provide details on the progress of the milestones for 2021. Refer to [APPENDIX 1—Status of Project Results with Mitigation Plans](#) for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 12. Status of milestones for Output 1.7

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
R4D (Research-for-Development)-related																				
Output 1.7. A new cadre of PhD and MSc-holding cocoa scientists																				
Activity 1.7.1. Identification of PhD and MSc topics																				
Milestone 1.7.1.1. Agreements with universities hosting the students finalized																				
Milestone 1.7.1.2. Research proposals approved				X	X	X	X	X	X											
Activity 1.7.2. Implementation of the PhD and MSc projects																				
Milestone 1.7.2.1. Best candidates identified																				
Milestone 1.7.2.2. Regular discussions with																				

Progress on milestones: The following is a summary of the activities of the PhD students. Deo-Gratias Hougni, the PhD student working on ISFM in Nigeria has prepared a presentation of the partial results of the fertilizer trial for the 2021 OFE Conference. Chapter 1 of the thesis addresses the paradigm of ISFM in cocoa revolving around the role of nutrient cycling for crop nutrition. A conceptual diagram was used to highlight major nutrient stocks and fluxes within the agroecosystem. Chapter 2, which addresses cocoa farming characterization across West Africa, has been paused and may be replaced by an observational study dealing with the role of macrofauna in nutrient release under low-shade cocoa agroforests. Data analysis is almost finalized, and a paper draft is under development. Chapter 3, which focuses on dealing with nutrient release from cocoa pod husks under simulated watering regime, has been [published](#). Chapter 4 of the thesis focuses on the effects of fertilizer application on mature cocoa plantations, relying on experimental data. Data are being collected for the second consecutive year.

Urcil Kenfack, the PhD student based in Cameroon, presented two posters on sustainable cocoa intensification through ISFM adoption at the Annual CocoaSoils Forum. A manuscript entitled “Farmers’ perceptions as a driver of agricultural practices: Understanding soil fertility management practices in cocoa agroforestry systems in Cameroon” has been [published](#) in Human Ecology. Data collection for the next paper on services landscapes in the cocoa sector in Cameroon started in Q2 of 2021. Ten focus group discussions were held on the services farmers needed. Data on youth motivation and challenges when engaging in cocoa farming and as cocoa farmers was collected. Also, their level of GAP adoption was assessed. Urcil has contributed as a co-author of the paper by an MSc student entitled “*Effect of group dynamics on teamwork technical efficiency in agriculture: case of a cocoa farmers organization in Biwong-Bulu, South region of Cameroon*”. He has also contributed a chapter to a book entitled “Tree commodities and resilient green economies in Africa: case study of cocoa and coffee”. The chapter is entitled ‘*Institutional Innovations in Tree Crop Producer Organisations in Africa*’. The article has been [published](#) and the book chapter has been accepted.

Thirteen MSc students have been recruited in Nigeria, Cameroon, Ghana, and Côte d'Ivoire. See Annual Report 2020 for details.

Lucette Adet, a PhD student stationed in Côte d'Ivoire is working on cocoa physiology. The writing of the first draft of an article entitled 'Experimental imposed water stress effects on cocoa development' is progressing. Results from the study are being discussed. The writing of the draft for the article: "Cocoa leaves stomatal conductance and leaf water potential responses to water deficit variation and potassium supply" is also ongoing. It focuses on understanding the influence of water deficit and potassium treatments, and their interaction during seasons on the physiological responses of different cocoa genotypes. The initial result suggested an effect of irrigation and seasons on the physiological traits of cocoa trees.

Workplan for 2022

Activity 1.7.2. Implementation of the PhD and MSc projects

- Milestone 1.7.2.1. Identify best MSc candidates in Cameroon, Côte d'Ivoire, and Nigeria by Q2, 2022
- Milestone 1.7.2.2. Hold regular discussions with the Supervisory Committees of all students across the countries by Q2, 2022

Activity 1.7.3. Submission and approval of the PhD and MSc theses

- Milestone 1.7.3.1. Write and submit the manuscripts of PhD theses' chapters by Q2, 2022
- Milestone 1.7.3.2. Submit theses by Q2, 2022

2.5 P4D-related outputs

The P4D component ensures the transfer of the research products to end-users through existing initiatives for dissemination to partners. The main outcomes of the P4D component are to ensure that the research products and tools are used by target households and policymakers.

2.5.1 Output 2.1: Agreements with private (including digital partners) and/or governmental scaling partners developed and signed to disseminate new recommendations/knowledge through their existing structures/ frameworks (H.E protocol or ILO protocol)

The target for Output 2.1 for 2021 is to develop and sign at least 10 agreements (at least eight with scaling partners, and at least two with digital partners). The following milestones were expected to be achieved at the time of reporting. [Table 13](#) and the subsequent information provide details on the progress of the milestones for 2020. Refer to [APPENDIX 1—Status of Project Results with Mitigation Plans](#) for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 13. Status of milestones for Output 2.1

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
P4D (Partnerships-for-Delivery)-related																				
Output 2.1. Agreements with private and/or governmental scaling partners																				
Activity 2.1.1. Identification of relevant dissemination networks																				
Milestone 2.1.1.1. Potential scaling partners/initiatives mapped			X	X	X	X	X	X												
Milestone 2.1.1.2. Preliminary agreements with scaling partners established			X	X	X	X	X	X	X	X										
Activity 2.1.2. Facilitation of agreements with partners having dissemination networks																				
Milestone 2.1.2.1. Agreements with scaling partners formalized					X	X	X	X	X	X	X	X	X	X	X	X				
Milestone 2.1.2.2. Agreements updated (as relevant/needed)									X	X										

Progress on milestones: A total of 11 partners (Barry Callebaut, Kuapa Kokoo, Cargill, Mars, Mondelez, Nestlé, Olam, Olatunde International, Rockwinds, Sucden, and Tulip Cocoa) have signed agreements either through the Cooperation Agreement or later through the Participation Statement. In addition, Mondelez Ghana has signed the dissemination agreement thereby increasing the number of dissemination agreements signed by the seven scaling partners (Olam, Cargill, Mondelez, Kuapa Kooko, Rockwinds/Transroyal, Sucden, and Olatunde International) from nine as of August 2021 to ten as of December 2021. Table 14 shows the details of scaling partners and the status of agreements.

The project also explored the use of digital dissemination platforms and radio to help in scaling activities. In Q4, 2020, the two service providers which were contracted (Viamo and ANADER) to undertake digital dissemination in Ghana, Nigeria, Cameroon, and Côte d'Ivoire, completed their pilot work in July 2021. In addition to the two digital dissemination partners, Radio Gognoa in Côte d'Ivoire also completed its broadcasting using the content from the CocoaSoils manual. In all, the 13 signed agreements represent over 100 percent achievement of the 2021 targets of eight scaling partners, two digital dissemination partners, and a radio station. See [status on agreements with partners](#).

Table 14. Scaling partners and status of agreements

Partner	Country	Participation Agreement	Workplan (Dissemination/scaling Agreements)
Olam	Cameron	Signed	Signed
	Côte d'Ivoire	Signed	Signed
	Ghana	Signed	Signed
	Nigeria	Signed	In progress
Cargill	Côte d'Ivoire	Signed	Signed
	Ghana	Signed	In progress
Mondelez	Côte d'Ivoire	Signed	Signed
	Ghana	Signed	Signed
Kuapa Kooko	Ghana	Signed	Signed
Rockwinds/Transroyal	Ghana	Signed	Signed
Sucden	Nigeria	Signed	Signed
Olatunde International	Nigeria	Signed	Signed
Tulip Cocoa	Nigeria	Signed	In progress

Challenges and proposed changes in milestone timelines: Discussions with AMS and ETG to increase dissemination in Cameroon have not progressed as anticipated. The delay is due to unresolved issues on data confidentiality. Discussions with Barry Callebaut in Cameroon and ECOM for increased dissemination in Cameroon and Nigeria have stalled. Discussions with Bayer to supply pesticides for STs in Cameroon, Ghana, and Nigeria have stalled because the company's operations were negatively impacted by COVID-19.

Workplan for 2022

Activity 2.1.2. Facilitation of agreements with partners having dissemination networks

- The program is ending in May 2022. No new activities have been planned.

2.5.2 Output 2.2: Appropriate extension tools assembled and revised for integration in partner-led scaling including integration into digital platforms of new recommendations/tools

As target for this Output in 2021, the project will develop and make available Version 2 of adapted extension tools based on information and feedback from ME&L, and Version 1 of adapted digital platform based on secondary ISFM-related information. [Table 15](#) and the subsequent information provide details on the progress of the milestones for 2021. Refer to [APPENDIX 1—Status of Project Results with Mitigation Plans](#) for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 15. Status of milestones for Output 2.2

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
P4D (Partnerships-for-Delivery)-related																				
Output 2.2. Appropriate extension tools for integration in partner-led scaling																				
Activity 2.2.1. Assessment of cocoa producers' capacity needs																				
Milestone 2.2.1.1. Producer associations identified					X	X	X													
Milestone 2.2.1.2. Training needs assessed					X	X	X													
Activity 2.2.2. Production of extension tools																				
Milestone 2.2.2.1. Draft version of the extension tools produced					X	X	X	X	X	X										
Milestone 2.2.2.2. Extension tools validated with cocoa producers' associations					X	X	X	X	X	X										
Milestone 2.2.2.3. Extension tools multiplied										X	X	X								
Activity 2.2.3. Facilitation of feedback sessions with dissemination partners on the extension tools																				
Milestone 2.2.3.1. Feedback session schedule organized									X	X	X	X	X	X	X	X	x	X		
Milestone 2.2.3.2. Feedback received and analyzed																				

Progress on milestones: The [training manual](#) and the [farmers' handbook](#) were developed, finalized, and printed in 2021. The manual was presented to the government of Cameroon at a handover ceremony held at the Ministry of Agriculture and Rural Development in Yaoundé on 11 October 2021. The training manual was received on behalf of the government by the Minister of Agriculture and Rural Development, Gabriel Mbairrobe. Read about the handover ceremony [here](#). Preparations are underway to handover the manual to the governments and relevant agencies in Côte d'Ivoire, Ghana, and Nigeria.

Copies of the training manual have been submitted to private partners and are being used for ToT sessions for EAs, farmer training, and digital dissemination. In Ghana, the manual was unveiled to both private and public sector partners at a P4D Committee Meeting held in October 2021. Read about the unveiling ceremony [here](#). The content of the manual has been integrated into the digital platform of the two partners (Viamo/ANADER) to serve as Version 1 of the adapted digital platform based on existing information. The content was also used for radio dissemination. The P4D committees in the four countries have been tasked to draw plans of action to collect feedback from dissemination partners and EAs on the use of the manual.

As part of EA training sessions, evaluation of the manual content and other aspects (i.e., lessons learned, methodology, and logistics) is conducted. Analysis of this data from initial training in Ghana shows a high acceptance rate of the content. Out of 22 EAs trained, 82 percent of participants strongly agreed that the content met their expectations, while 14 percent agreed. See [here](#) for a report. Detailed analysis of this data will be done across all countries to address any gaps in the content. MEL is also designing a feedback session structure for partner EAs and selected farmer group leaders to provide feedback on the manual content and the farmer handbook.

Challenges and proposed changes in milestone timelines: Some partners were reluctant to release their EAs for training due to the yearly compulsory audit of their field. Partners are being engaged with to organize more training for farmers in 2022. Feedback sessions with dissemination partners on the extension tools have not been organized. However, initial feedback on content has been received through the training of EAs. The Version 2 of the training manual will be developed when new recommendations from research activities are available.

Workplan for 2022

Activity 2.2.2. Production of extension tools

- Milestone 2.2.2.3. Multiply the extension tools produced by Q1, 2022.
- Activity 2.2.3. Facilitation of feedback sessions with dissemination partners on the extension tools
- Milestone 2.2.3.1. Feedback session schedule organized by Q2, 2022.
- Milestone 2.2.3.2. Feedback received and analyzed by Q2, 2022.

2.5.3 Output 2.3: Appropriate ToT manuals developed for use in the training sessions for EAs

The target for Output 2.3 for 2021 is to develop Version 2 of adapted extension tools, at least two digital platforms integrate ISFM knowledge, at least 20 ToT sessions organized (including digital platforms), at least 500 EAs trained including training on digital platform for dissemination, and at least 90 000 cocoa farmers trained on new recommendations and child labor concept.

The following milestones are expected to be achieved at the time of reporting. [Table 16](#) and the subsequent information provide details on the progress of the milestones for 2021. Refer to [APPENDIX 1—Status of Project Results with Mitigation plans](#) for current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 16. Status of milestones for Output 2.3

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
P4D (Partnerships-for-Delivery)-related																				
Output 2.3. Appropriate training-of-trainers manuals for use in the training sessions for extension																				
Activity 2.3.1. Identification of EA for engaging in training-of-trainers' activities																				
Milestone 2.3.1.1. Functioning of participating dissemination networks mapped					X	X	X													
Milestone 2.3.1.2. EA identified					X	X	X	X	X	X										
Milestone 2.3.1.3. Training needs assessed					X	X	X	X	X											
Activity 2.3.2. Implementation of training-of-trainers' sessions																				
Milestone 2.3.2.1. Training schedule organized					X	X	X	X	X	X										
Milestone 2.3.2.2. Training sessions held																				
Activity 2.3.3. Collection of feedback on the effectiveness of the training-of-trainers sessions and eventual modification of the approach																				
Milestone 2.3.3.1. Collection of feedback on the effectiveness of the training																				
Milestone 2.3.3.2. Continuous improvement of the training modules and processes																				

Progress on milestones: A total of 466 EAs were trained through 15 training sessions from January to August 2021. An additional 69 EAs were trained between October and December 2021, taking the number of EAs trained by the program in 2021 to 535 and the number of training sessions to 20. The total number of EAs trained represents 107 percent of the 2021 target of EAs to be trained (500 EAs). The total number training sessions conducted represents 100 percent of the target for 2021 (20 training sessions). EAs were also trained on MEL to enhance their knowledge on the use of ODK; tools required to document types of training; location, numbers, and sex of farmers trained; and to capture and upload these farmers' information.

Table 17. List of EAs submitted and trained

Country	Partners	Number of EAs submitted for training	Number of EAs trained in 2021
Cameroon	Olam	62	57
Côte d'Ivoire	Olam	202	188
	Cargill/Mondelez	120	24
Ghana	Cargill	27	5
	Kuapa Kooko	62	32
	Mondelez	34	35
	Olam	5	26
	Rockwinds	20	16
	CHED	5	5
Nigeria	Olam	77	77
	Olatunde International	18	15
	Sucden	20	17
	Tulip Cocoa	20	20
TOTAL		667	535

The feedback system developed under the MEL component is being implemented during P4D training sessions. This includes participant evaluation on content, methodology, master trainers' skills, logistics, and knowledge gained. See report on participants' feedback [here](#). More training sessions for EAs and farmers have been scheduled for the period January to May 2022.

The total number of farmers trained using the training manual between January and August 2021 was 13800. Between October and December 2021, the program engaged with partners' EAs to train more farmers in the four countries. The constant engagement with EAs increased the number of farmers to 32472 (29% female). In addition, 30782 farmers (19% female) have been trained through Viamo and ANADER digital dissemination platforms. This gives a total of 63254 (25% female) farmers trained with the existing ISFM content. This represents 70 percent of the 2021 target of 90 000 farmers. View reports from Viamo and ANADER [here](#). Details of partners' EA training activities can be seen [here](#). A [report](#) on the broadcast by Radio Gognoa on the content of the manual indicates a listenership reach of about 2,309,136 hits from October 2020 to March 2021.



Figure 26. Training of EAs in Ghana



Figure 27. Training of EAs in Côte d'Ivoire



Figure 28. Training of farmers in Cameroon



Figure 29. Training of farmers in Nigeria

Challenges and proposed changes in milestone timelines: COVID-19 restrictions on travel, movement, and gatherings delayed the training of EAs and farmers in 2021. To address these delays, training sessions

were done in small numbers to comply with the COVID-19 protocols and a cash reward was introduced to motivate the EAs to conduct face-to-face training sessions for farmers. The low pick-up rates of the digital dissemination programs in the beginning were a challenge and were attributed to low sensitization. To increase awareness, extension officers were deployed to sensitize farmers about the dissemination programs.

Workplan for 2022

Activity 2.3.2. Implementation of ToT sessions

Activity 2.3.3. Collection of feedback on the effectiveness of the ToT sessions and eventual modification of the approach

- Milestone 2.3.3.1. Collection of feedback on the effectiveness of the training held by Q2, 2022.
- Milestone 2.3.3.2. Continuous improvement of the training modules and processes by Q2, 2022.

2.5.4 [Output 2.4: Engagement in policy action in support of sustainable cocoa intensification ensuring avoidance of deforestation and child labor in applying new recommendations](#)

The targets for Output 2.4 for 2021 are at least two policy briefs, at least four extra interactions with policymakers in at least three countries, and at least 15 public and private sector partners trained in using the developed tools and knowledge. Achievement of the following milestones is expected at the time of reporting. [Table 18](#) and the subsequent information provide details on the progress of the milestones for 2021. Refer to [APPENDIX 1—Status of Project Results with Mitigation Plans](#) for the current status of the targets.

Columns with an 'X' indicate new timelines for the milestone. Columns in grey indicate the original timeline for the milestone according to the implementation plan in the proposal.

Table 18. Status of milestones for Output 2.4

Activities and milestones	2018				2019				2020				2021				2022			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
P4D (Partnerships-for-Delivery)-related																				
Output 2.4. Engagement in policy action in support of the sustainable intensification of cocoa																				
Activity 2.4.1. Identification of relevant and specific policy briefs																				
Milestone 2.4.1.1. Cocoa-related policy environment documented for target countries						X	X	X	X	X	X	X	X	X						
Milestone 2.4.1.2. Policy briefs formulated									X	X	X	X	X	X	X	X	X	X		
Activity 2.4.2. Engagement with relevant policymakers																				
Milestone 2.4.2.1. Relevant policy-related processes identified and activated					X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Milestone 2.4.2.2. Interactions with policymakers held in relation to products developed under Outputs 1.3, 1.4, and 1.5																				

Progress on milestones: In the first half year of 2021, IDH successfully coordinated the documentation of cocoa-related policies collected from government agencies and other relevant stakeholders. The documentation has been completed and was officially validated within the partnership committees in Q4 of 2021 with the aim of developing a set of recommendations that will feed into policy brief formulation. These policy briefs will provide sufficient basis for engaging and interacting with policymakers for adaptations in the current policy frameworks.

In addition, the CocoaSoils training manuals were handed over to relevant public authorities, with the participation of private sector representatives in October 2021 in Cameroon. Similar activities will be held in Côte d'Ivoire, Ghana, and Nigeria in 2022.

Since the start of the project, there have been 16 interactions with policymakers. This has been done through the organization of the partnership committees in Cameroon (5), Côte d'Ivoire (2), Ghana (3), and Nigeria (6). In Cameroon, Côte d'Ivoire, Nigeria, and Ghana, 12, 10, 6, and 2 public officials, respectively, from relevant sectors and private sector companies were engaged.

Challenges and proposed changes in milestone timelines: The collection and documentation of cocoa-related policies in the four countries were not finalized until Q4 of 2021 due to the establishment of the

partnership committees, the occurrence of the COVID-19 pandemic, and the validation of training manuals. This has now paved the way for the commencement of the formulation of policy briefs which depended on the completion of the documentation of cocoa-related policies.

Workplan for 2022

Activity 2.4.1. Identification of relevant and specific policy briefs

- Milestone 2.4.1.2. Policy briefs formulated by Q2, 2022.

Activity 2.4.2. Engagement with relevant policymakers

- Milestone 2.4.2.1. Relevant policy-related processes identified and activated by Q2, 2021.
- Milestone 2.4.2.2. Interactions with policymakers held in relation to products developed under Outputs 1.3, 1.4, and 1.5 (sustainability and impact domains) by Q2, 2022.

APPENDIX 1—Status of Project Results with Mitigation Plans

Project results	2021 Targets	Status as of December 2021	Delays experienced and reasons why	Mitigation plans to recover delays
Project impact				
<u>Impact 1.</u> Smallholder cocoa farmers benefit from sustainably increased cocoa productivity and income generated through cocoa production	→Yields 20% increased against baseline →Income 15% increased against baseline →Income 15% increased against baseline →No visible increases in deforestation compared to control sites →No evidence for child labor obtained →No change in carbon stock, water, and biodiversity indexes in cocoa zones of Côte d'Ivoire and Ghana	There is no data yet on the impact indicators.	This is because training sessions for farmers across the countries took place mainly in 2021.	Effects of the knowledge gained, i.e., yield, incomes, will be assessed in the coming years through farmer surveys. This will give some time for application or otherwise of the knowledge by farmers.
Project outcomes				
<u>Outcome 1</u> New cocoa ISFM-related research products are used by private and public stakeholder partners	→At least four research products validated and used by private and/or public stakeholders. →At least 350 extension agents are using the new research products.	Training manuals and handbook for farmers have been finalized and printed. 535 (7% female) EAs have been trained with the content of the manual. EAs are training farmers with the content of the manual.	The COVID-19 restrictions caused delays in EA training in all countries. Some partners were also reluctant to release their EAs for training due to the yearly compulsory audit of their field work. Digital dissemination	Multiple EA trainings were organized in the different countries to ensure that COVID-19 protocols were observed.
<u>Outcome 2.</u> Recommendations generated through research products are used by target households	→At least 10 000 cocoa farmers using the new recommendations/new knowledge. →At least 30 000 cocoa farmers using the existing recommendations/new knowledge	63 254 (25% female) farmers have been trained physically by partner EAs and through digital platforms (Viamo and ANADER). An endline survey (to assess knowledge gained and practices) after farmer training through the digital platforms shows that farmers		

Project results	2021 Targets	Status as of December 2021	Delays experienced and reasons why	Mitigation plans to recover delays
	→At least two new recommendations are being used →At least five existing (old) recommendations are being used	have gained knowledge and most have started using new knowledge. For example, in Nigeria, out of a sample of 250 farmers, between 52% and 64% of farmers had already weeded and pruned their farms per the recommendations. There is appreciation of good farm maintenance such as timely and yearly pruning of cocoa trees and weeding of farms. No new recommendations are being used	projects were challenged by low pick-up rates.	
<u>Outcome 3.</u> Decision-makers (public and private) are using tools and knowledge to avoid increased deforestation and child labor while promoting cocoa intensification.	→Draft maps of land use patterns and ecosystem services in target countries. →At least one policy document of the target countries has integrated into new tools. →At least four public and private sector organizations are using new tools and knowledge to promote deforestation free supply chains. →All public and private sector organizations engaged in CocoaSoils initiative are enforcing the H.E. and ILO protocols on child labor-free production to promote new recommendations/	Draft maps of land use patterns and ecosystem services in target countries have been developed and are being validated with different stakeholders. The documentation of cocoa related policies has been completed and will be officially validated within the partnership committees has been completed and validated. This paves way for the formulation of policy briefs.	The collection and documentation of cocoa-related policies in the four countries were delayed due to the establishment of the partnership committees - which was agreed to be the driving force of the policy component, the occurrence of the COVID-19 pandemic, and the validation of training manuals.	The documentation has been completed. This paves the way for the formulation of policy briefs.

Project results	2021 Targets	Status as of December 2021	Delays experienced and reasons why	Mitigation plans to recover delays
	Knowledge.			
Project results				
Project Outputs				
<u>Output 1.1.</u> A set of integrated soil fertility management options.	→A first set of ISFM recommendations generated, ready for integration in scaling.	All the eight CTs with additional two in Indonesia and Ecuador are being managed, based on agreed protocols. A new CT established by Mondelez has planting materials ready for transplanting. Fertilizer treatments were developed and executed in six core trials: Nigeria (IITA), Ghana (GRIG), Côte d'Ivoire (CNRA, Nestle, Barry Callebaut) and Indonesia (Mondelez) based on maize data and soil analyses information Early evaluation has been conducted in Côte d'Ivoire (CNRA, Nestle and Barry Callebaut), Nigeria (IITA), Cameroon (IITA) and Indonesia (Mondelez). Advanced evaluation has been conducted in Nigeria (IITA and CRIN) and Cameroon (IITA). A total of 389 STs sites have been installed in accordance with the approved protocols: 64 in Cameroon, 132 in Côte d'Ivoire, 127 in Ghana, and 66 in Nigeria.	High levels of mortality were present in some CTs (e.g., Owena in Nigeria; Divo in Côte d'Ivoire; Nkoemvone in Cameroon), delaying fertilizer application. Fertilizer application was delayed in some trials due to a high replacement rate.	To counter this issue, dead plants were replaced in the affected plots. A new ODK form to register planting dates was designed to record the actual situation of the trial. Fertilizer application was reformulated to adjust the plantation year to the whole site and applied through Q3 and Q4.

Project results	2021 Targets	Status as of December 2021	Delays experienced and reasons why	Mitigation plans to recover delays
<u>Output 1.2.</u> Understanding the physiological basis of cocoa nutrient uptake and use.	→ At least four papers on cocoa ISFM/physiology accepted.	Three papers were accepted and published. A peer-reviewed article by Paulina Asante titled 'Unravelling drivers of high variability of on-farm cocoa yields across environmental gradients in Ghana' was published in Agricultural Systems Journal. https://doi.org/10.1016/j.agsy.2021.103214. A peer-reviewed article from Déo-Gratias Hougni's thesis 'How nutrients rich are decaying cocoa pod husks? The kinetics of nutrient leaching' was published in Plant and Soil Journal. Open Access: https://doi.org/10.1007/s11104-021-04885-1	To identify factors that determine high yield/quality in a range of genotypes/environments, there was a delay in the start of model development for running the Python version of CASE2 due to errors in the dry areas. Although these errors have been corrected, the delay affected the timeline for the completion of chapter 3 which is likely to extend from the initially planned end of March to May 2022.	RCASE2 (R wrapper for CASE2 model) is being used to simulate water-limited yields for selected (92) farms across a climate gradient in Ghana. This issue was solved with the help of experts at WUR. The simulations of water-limited yields were completed for all farms in August 2021.
<u>Output 1.3.</u> A decision-support system for intensifying cocoa production	→Draft 2 of segmentation and stepwise investment tools validated in Côte d'Ivoire and Ghana	The Draft 2 of the CSC implementer app has been developed to include a segmentation module to understand farm diversity and a best management practices (BMP) module.	The current version of the CSC app is inadequate and requires further development and alignment to the standard decision support tools in Excellence in Agronomy. The analytical framework for the yield and return on investments (ROI) has been set-up but requires experimental data from the STs and CTs to reliably	It is important that each suggested Step for any farm (by geolocation) can be simulated in terms of productivity but also in terms of the costs and economic benefit. This process will take considerable time than anticipated due to these required capabilities. It is expected that for a fully functional application with spatial yield and profit

Project results	2021 Targets	Status as of December 2021	Delays experienced and reasons why	Mitigation plans to recover delays
			calibrate the CASE2 to simulate actual farm yields.	prediction, the activity will go beyond 2022.
<u>Output 1.4.</u> Recommendation domains and impact of sustainable intensification on forest pressure identified.	→Impact of sustainable intensification deforestation and REDD+ schemes quantified	The project through its partners has developed guiding principles that can be adapted to the context of the different countries. To quantify the adaptation potential of CSA packages, an approach has been developed to estimate cocoa yield gaps through one of the PhD students' works. To assess climate change impacts on cocoa using CASE2, newly available CMIP6 global climate model (GCM) projections are currently being processed.	The yield gap assessment has only been completed for Ghana where detailed cocoa yield data including information on agronomic management is available.	Yield assessment will be conducted for the remaining countries when the yield data from the STs sites are available
<u>Output 1.5.</u> Sustainability assessment tools developed and validated to support the sustainable development of cocoa production in relation to biodiversity and ecosystem services at the landscape level	→Draft 2 of sustainability assessment tools available.	Final maps on biodiversity and ecosystem services risks available - Biodiversity in cocoa modelling available - Toolkit final draft available - Decision tree draft 2 available	COVID-19 is thwarting plans for stakeholder consultation and engagement activities, likely into 2022 as well.	Dedicate additional time on communication materials in support of project Output 2.4. and Outcome 3. Fieldwork to take place in 2022, though not in all countries (Ghana and Côte d'Ivoire only). Results will be published after the end of this phase of CocoaSoils.

Project results	2021 Targets	Status as of December 2021	Delays experienced and reasons why	Mitigation plans to recover delays
<u>Output 1.6.</u> Operational open knowledge and data sharing portal for the storage, management, and dissemination of cocoa intensification research results	→ Final version of a portal available → At least 50% of all datasets submitted	The development of the data portal started in Q4. Data is being collected based on the calendar of activities per country. Data collection forms for CT and ST are in current use.	There is a need for a new PostgreSQL database (curated data storage) with user management. The non-privacy sensitive data will be available for download and this may delay the developments on the Knowledge Portal for the publication process of data till 2022.	While the data portal is under construction, data as csv files is sent to the partner companies when requested.
<u>Output 1.7.</u> A new cadre of PhD and MSc-holding cocoa scientists with knowledge on new cocoa intensification options	→ At least four MSc theses approved	All PhD students are currently working on their thesis chapters, fieldwork, and manuscripts.	Some delays in fieldwork and data collection have been observed since some travel restrictions were enforced in some countries due to COVID-19.	Some alternatives to methods were applied. Additionally, several discussions and meetings with supervisors are constantly held.
<u>Output 2.1.</u> Agreements with private and/or governmental scaling partners developed and signed to disseminate new recommendations/knowledge through their existing structures/frameworks (HE Protocol or ILO Protocol)	→ At least eight agreements with scaling partners developed and signed. → At least two agreements with digital partners developed and signed.	A total of 11 partners (Barry Callebaut, Kuapa Kokoo, Cargill, Mars, Mondelez, Nestlé, Olam, Olatunde International, Rockwinds, Sucden, Tulip Cocoa) have signed agreements either through the cooperation agreement or later through the Participation Statement. In addition, 10 dissemination agreements have been signed by seven scaling partners (Olam, Cargill, Mondelez, Kuapa Koko, Rockwinds/Transroyal, Sucden, and Olatunde International).	Discussions held with new partners to increase reach of dissemination in Cameroon has not progressed as anticipated. This is due to unresolved issues on data confidentiality.	Partners are being assured of the confidentiality of their data.

Project results	2021 Targets	Status as of December 2021	Delays experienced and reasons why	Mitigation plans to recover delays
		Viamo and ANADER completed their pilot work in July. In addition to the two digital dissemination partners, Radio Gognoa in Côte d'Ivoire also completed its broadcasting using the content from the CocoaSoils manual.		
<u>Output 2.2.</u> Appropriate extension tools assembled and revised for integration in partner-led scaling of new recommendations/tools	→Version 2 of adapted extension tools available, with inclusion of new information and feedback from ME&L. →Version 1 of adapted digital platforms available, based on secondary ISFM-related information.	The Training Manual and the farmers' handbook were finalized and printed in 2021. Copies have been submitted to private partners and are being used for training-of-trainers' sessions, farmers training, and digital dissemination. Copies of training manual were handover to the government of Cameroon. The content of the manual has been integrated into the digital platform of the two partners to serve as version 1 of the adapted digital platform based on existing information	Training of EAs and farmers was delayed because of COVID-19 restrictions.	Partners are being engaged to organize more training sessions in smaller groups before May 2022.
<u>Output 2.3.</u> Appropriate ToT manuals developed for use in the training sessions for EAs	→Version 2 of adapted extension tools available →At least two digital platforms integrate ISFM knowledge →At least 20 ToT sessions organized →At least 500 EAs trained (gender disaggregated)	535 (7% female) EAs have been trained through 20 training sessions. A total of 32472 farmers have been trained by partners' EAs. 30782 farmers have been trained through Viamo and ANADER digital dissemination programs.	COVID restrictions on travel, movement, and gatherings delayed the training of EAs and farmers. The low pick-up rates of the digital dissemination programs in the beginning were challenge	To address these delays, training sessions were done in small numbers to respond to the COVID-19 Protocols. To increase awareness, extension officers were deployed to sensitize farmers about the

Project results	2021 Targets	Status as of December 2021	Delays experienced and reasons why	Mitigation plans to recover delays
	→At least 90 000 cocoa farmers trained on new recommendations and child labor concept	This gives a total of 63254 (25% female) farmers trained with the existing ISFM content.	and these were attributed to low sensitization.	dissemination programs while observing COVID-19 protocols.
<u>Output 2.4.</u> Engagement in policy action in support of sustainable cocoa intensification ensuring avoidance of deforestation and child labor in applying new recommendations.	→At least two policy briefs →At least four extra interactions with policymakers in at least three countries →At least 15 public and private sector partners involved in testing/validating the draft tools and knowledge	The documentation of cocoa-related policies has been completed and validated to pave the way for the formulation of policy briefs 16 interactions with policy makers. This has been done through the organization of the partnership committees for which five were held in Cameroon, two each in Côte d'Ivoire and Ghana, and six in Nigeria. In Cameroon, there are 12 public officials from relevant sectors and private sector companies engaged, in Côte d'Ivoire there are 10, in Nigeria there are six and in Ghana there are three.	The formulation of policy briefs has been delayed because of the late start of the documentation of cocoa-related policies	As the documentation of cocoa-related policies has been validated plans are underway to begin the formulation of policy briefs.

APPENDIX 2—Financial Report