



**Verified Carbon
Standard**

COMACO LANDSCAPE MANAGEMENT PROJECT



Document Prepared by Community Markets for Conservation
(COMACO)

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Prepared By	COMACO
Contact	Dale Lewis Director, COMACO Head Office, Light Industrial Area, Plot No: 7223, Kachidza Road, Lusaka, Zambia Tel +260-977-373747, E-mail: dlewis@itswild.org Website: http://www.itswild.org/

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The COMACO Landscape Management Project promotes sustainable agriculture and forest conservation at a landscape level. The project comprises two components:

1. Sustainable Agricultural Land Management (SALM) – which promotes widespread adoption of agricultural practices aimed at achieving sustainable agricultural production, and increasing farmers' income, and sequestering carbon. This involves the adoption by farmers of legume-based alley cropping, residues management, and reduced tillage among other SALM practices. The eligible land for adoption is agricultural land.

2. REDD+ (Avoided Unplanned Deforestation) – which aims to reduce forest loss, and protect and expand areas under natural forest, and conserve biodiversity. This is achieved primarily through creation of Community Conservation Areas (CCA), while promoting sustainable forest management including sustainable utilization of Non-Timber Forest Products (NTFPs), e.g., honey.

This monitoring report covers the third monitoring period for both components with implementation dates of the project activities from 1 November 2017 to 31 October 2020.

Community Markets for Conservation (COMACO) is the project proponent. The project is a grouped project, and stretches across the Eastern Province of The Republic of Zambia as outlined in the PD. The project area which is subject to verification in this monitoring period is 44,944 ha of agricultural land and 102,380ha of forest as REDD+ areas.

The project has promoted adoption of SALM practices such as residue management (e.g. mulching; cessation of residue burning), alley-cropping, and reduced tillage among other SALM practices. To do this, the project is using participatory group approach to provide extension services to farmers: The farmers have been organized into farmer groups/cooperatives, each having an Executive Committee, which is responsible for day-to-day coordination and mobilization of its members. The group members receive training and capacity building to implement SALM practices. This is done by COMACO extension staff, as well as through lead/model farmers from within the group. The adoption of practices among farmers is monitored through annual monitoring surveys. The adoption of SALM practices increases crop yields and sequesters carbon. For the REDD+ component, the main activities implemented are: 1) demarcation of Community Conservation Areas, 2) creation of Community Conservation Plans (CCPs) with attendant rules governing permitted activities and sanctions, 3) protection of the forest through monitoring of the activities known to drive deforestation/forest degradation, 4) promotion of non-extractive use of the forest, particularly bee -keeping, and 5) protecting the forest from fires. The resultant emission reductions generated from the project is a key co-benefit, and an important source of revenue – meant to be used for furthering extension and support for adoption and implementation of the project activities.

In this third monitoring period, the net GHG emission reductions are 987,300C02-e. Over its twenty-year crediting period, the net GHG emission reductions of the project have been estimated at 4,523,090 tC02-e.

1.2 Sectoral Scope and Project Type

The SALM component of the project activities fall under the category “Agricultural Land Management (ALM) according to the VCS AFOLU Requirements v4.2. Eligible ALM activities are those that reduce net GHG emissions on cropland and grassland by increasing carbon stocks in soils and woody biomass and/or decreasing CO₂, N₂O and/or CH₄ emissions from soils.

Under the ALM, this project falls under the following activity category:

Improved Cropland Management (ICM): This category includes practices that demonstrably reduce net GHG emissions of cropland systems by increasing soil carbon stocks, reducing soil N₂O emissions, and/or reducing CH₄ emissions. Among these practices, the project focuses on:

a) Practices that increase soil carbon stocks by increasing field residue inputs to soils and/or reducing soil carbon mineralization rates, and introduction of agroforestry practices.

For the REDD+ component, the AFOLU category is Reducing Emissions from Deforestation and Forest Degradation (REDD). The REDD Project activity type is Avoided Unplanned Deforestation (AUD), since the land in the project is not legally authorized or documented to be converted to non-forest in the baseline.

The project is a grouped project as defined by the VCS Standard version 4.2: “grouped projects are projects structured to allow the expansion of a project activity subsequent to project validation. Validation is based upon the initial project activity instances identified in the project description. The project description sets out the geographic areas within which new project activity instances may be developed and the eligibility criteria for their inclusion. New instances meeting these pre-established criteria may then be added to the project subsequent to project validation”.

The new project activity instances of this grouped project which are subject to validation in this third monitoring period are 27,814 ha of agricultural land under SALM and 2,8430ha under REDD+ from Luembe. The project activity instances, which are subject to verification in this third monitoring period are 44,944 ha of agricultural land and 102,380ha of forest.

1.3 Project Proponent

The project is implemented by Community Markets for Conservation (COMACO), which is registered in Zambia as a non-profit limited-by-guarantee company. COMACO has more than 15 years of working experiences in sustainable agriculture and forest conservation using a market incentive approach, where it incentivizes adoption of sustainable agriculture and forest conservation by providing premium prices for crops marketed through it, and technical support for farmers adopting sustainable land management and conservation practices.

Organization name	Community Markets for Conservation (COMACO)
Contact person	Dale Lewis
Title	CEO
Address	COMACO Head Office Light Industrial Area Plot No: 7223, Kachidza Road Lusaka, Zambia
Telephone	+260-977-373747
Email	dlewis@itswild.org, http://www.itswild.org

1.4 Other Entities Involved in the Project

The initial Project development support was provided by UNIQUE forestry and land use, and the carbon projects related development activities have been financed by the World Bank.

Organization name	World Bank
Role in the Project	Investor
Contact person	Neeta Hooda
Title	Senior Carbon Finance Specialist
Address	1818 H Street, NW Washington, D.C. 20433, USA
Telephone	+1-202-4585182
Email	nhooda@worldbank.org

Organization name	UNIQUE forestry and land use GmbH
Role in the Project	Project development support
Contact person	Matthias Seebauer

Title	Carbon Project Development Expert
Address	Schnewlinstrasse 10 D-79098 Freiburg Germany
Telephone	+49 (761) 208534-0
Email	matthias.seebauer@unique-landuse.de

1.5 Project Start Date

Project start date: 1 July 2012.

1.6 Project Crediting Period

Periods

Project crediting start date 1 July 2012

Project crediting end date 30 June 2032

Project crediting period 1 July 2012 to 30 June 2032

Total number of crediting years 20 years

1st Monitoring period 1 July 2012 to 31 October 2015

2nd Monitoring period 1 November 2015 to 31 October 2017

3rd Monitoring period 1 November 2017 to 31 October 2020

1.7 Project Location

The project is located in the Eastern Province of Zambia and stretches across twenty-eight chiefdoms in nine districts as shown in Table 1 and Figure 1 below. These Chiefdoms and the five districts constitute the geographic boundary for the first, second and third project activity instances, where both the project proponent and the Chiefdom communities have agreed to implement the project. The project area for the SALM component consists of agricultural lands only in the twenty-eight chiefdoms while for the REDD+ component, it consists of numerous parcels of forested lands found within the initial nine chiefdoms. Therefore, while the outer boundary of the project is defined by the 28 chiefdoms for the SALM component, in the future no REDD+ activity instances will be developed outside of the Reference Region, i.e., outside of the nine chiefdoms henceforth.

Hence, the project outer boundary comprising the 9 chiefdoms (see details in Appendix 1 of the PD) is used throughout this monitoring report as the analytical domain for the REDD+ and 28 Chiefdoms for the SALM since this is where the project has developed all the project instances.

Table 1: Project Chiefdoms and Districts

Chiefdom	District	Community Conservation Area for REDD+ component	SALM farm plots
1. Chikomeni	Lundazi	Chamukoma and Kabinga CCAs	Yes
2. Chikuwe	Chipata	Mbenjele and Mphomwa CCAs	Yes
3. Jumbe	Mambwe	Jumbe CCA	Yes
4. Luembe	Nyimba	Luembe Revised CCA	Yes
5. Magodi	Lundazi	Magodi CCA	Yes
6. Mwasemphangwe	Lundazi	Kalindi and Mwase Central CCA	Yes
7. Mwape	Petauke	Mwape CCA	Yes
8. Nyamphande	Petauke	Nyamphande CCA	Yes
9. Zumwanda	Lundazi	Zumwanda, Lwasila, and Kalungambaba CCAs	Yes
10. Nyalugwe	Nyimba	No	Yes
11. Chinunda	Chipata	No	Yes
12. Ndake	Nyimba	No	Yes
13. Mumbi	Petauke	No	Yes
14. Mwanjawuntu	Petauke	No	Yes
15. Kalindawalo	Petauke	No	Yes
16. Nyanje	Sinda	No	Yes
17. Kathumba	Sinda	No	Yes
18. Sandwe	Mambwe	No	Yes
19. Msoro	Mambwe	No	Yes
20. Mbangombe	Katete	No	Yes
21. Kawaza	Sinda	No	Yes
22. Nzamane	Chipata	No	Yes
23. Mpezeni	Chipata	No	Yes
24. Mnukwa	Chipata	No	Yes

25. Kazembe	Lundazi	No	Yes
26. Madzimawe	Chipata	No	Yes

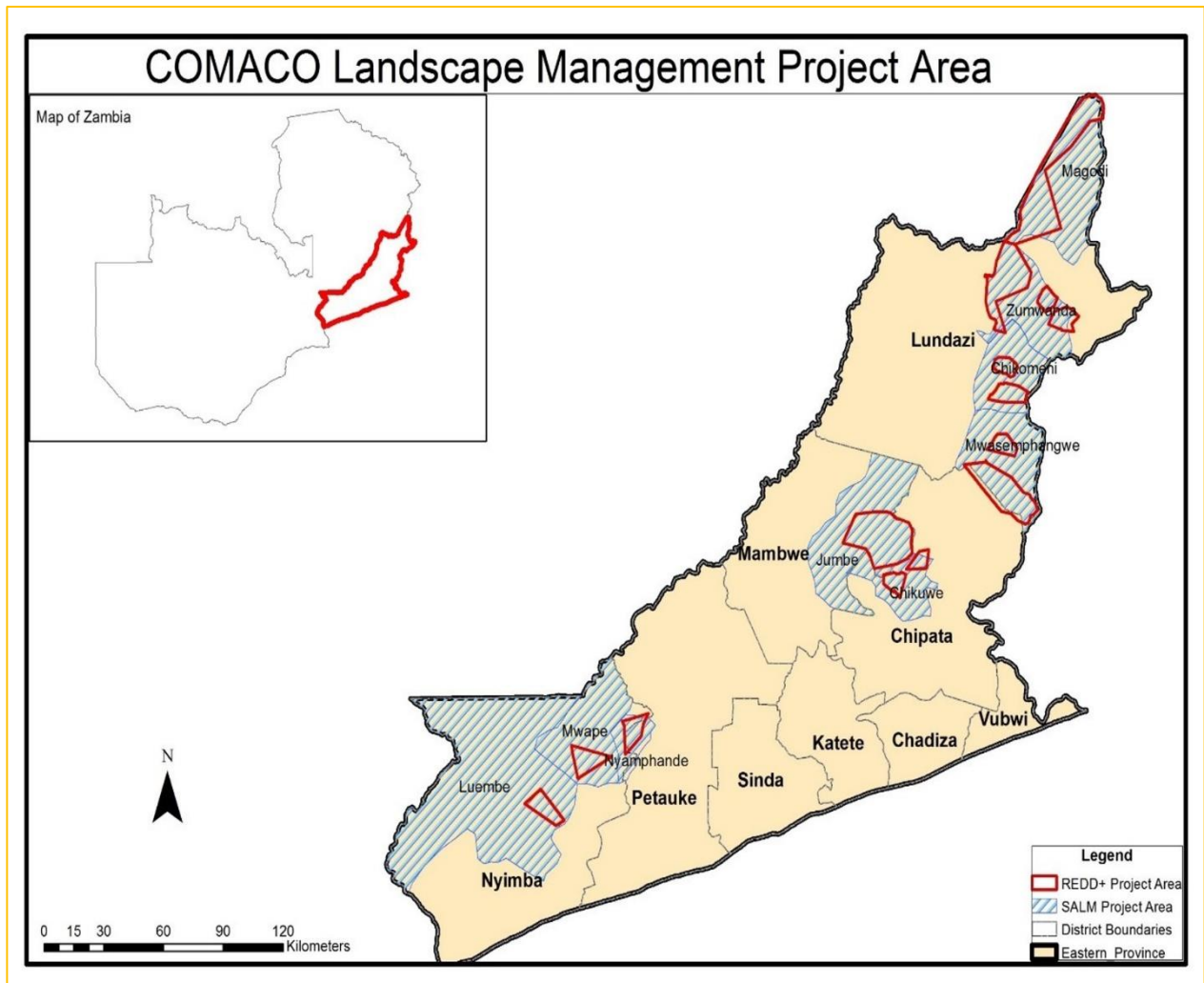


Figure 1: Project location – REDD+

The project location GIS files are available to the Verifier.

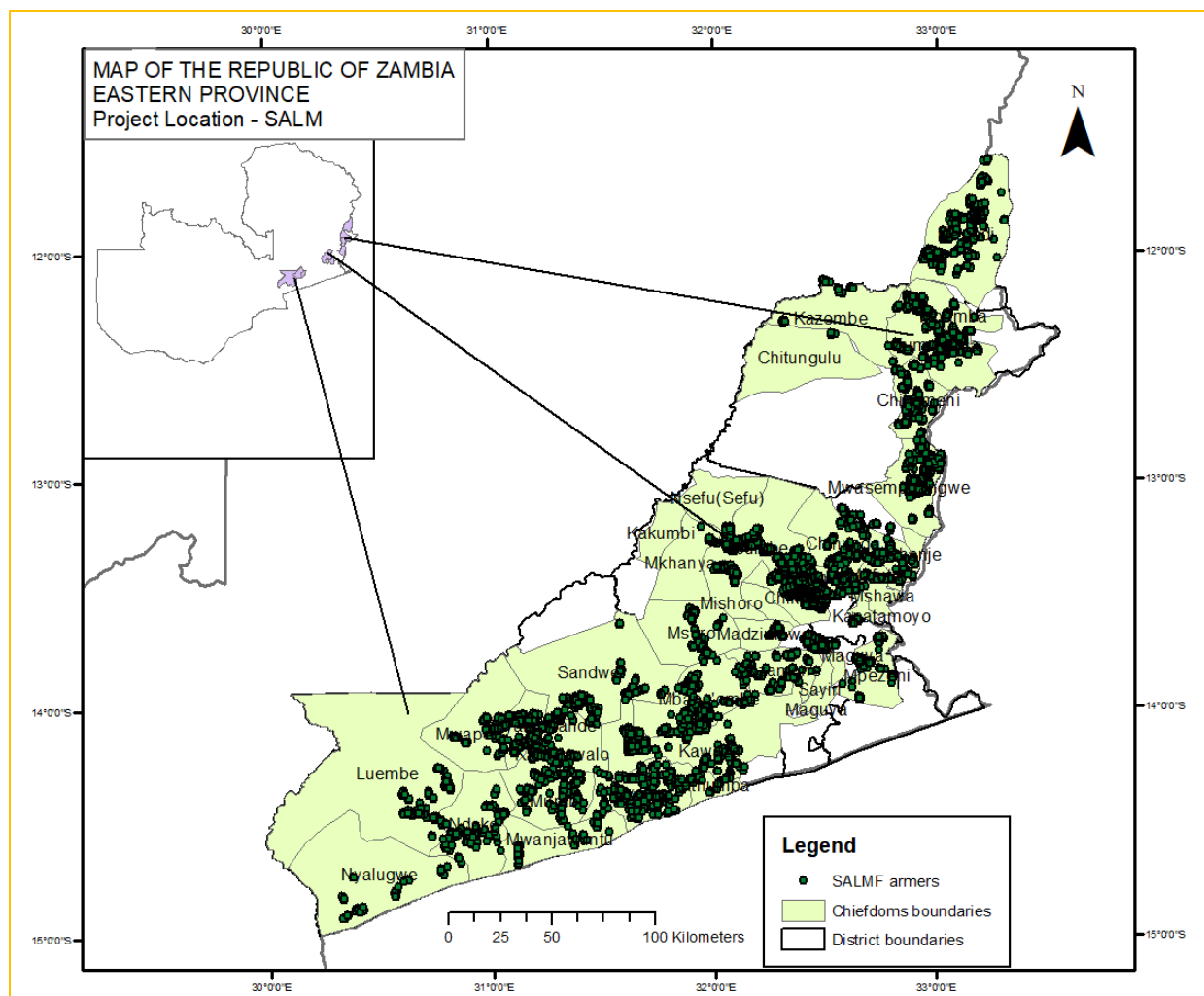


Figure 2: Project location – SALM

1.8 Title and Reference of Methodology

- 1) SALM component: Approved VCS Methodology VM0017: Adoption of Sustainable Agricultural Land Management, version 1.0. Under this methodology, the following tools have been used;
 - i) CDM A/R Tool version 1 “Estimation of direct nitrous oxide emission from nitrogen fertilization”
 - ii) Non-Permanence Risk Tool version 4; for conducting the non-permanence risk analysis; CDM A/R Tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities” version 04.1
- 2) REDD+ component: Approved VCS Methodology VM0015 for Avoided Unplanned Deforestation, version 1.1.

- i) AFOLU Non-Permanence Risk Tool version 4; for conducting the non-permanence risk analysis; CDM A/R Tool “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*” version 04.1

1.9 Participation under other GHG Programs

This grouped project is not participating under other GHG programs.

1.10 Other Forms of Credit

There are no other forms of credit which the project is eligible to create another form of GHG-related environment credit.

1.11 Sustainable Development Contribution

COMACO is working with 75,048 farmers on this project in the Eastern province of Zambia. 52% of these farmers are women. The majority of these farmers entered the program with high risks of hunger and malnutrition and poverty-level incomes without the skills and markets to reverse their socioeconomic situation. Farmers gain access to valuable technical services, higher farm-gate prices, and a COMACO dividend payment if they comply with a relatively small set of conservation farming and natural resource conservation practice standards. Compliance is founded on the principal of collective culpability. This means that if a few farmers in a community, as defined by their local chief, fail to comply with these rules all farmers in the community risk losing the privileges provided by COMACO membership. Compliance with COMACO standards is high because of a cooperative organization at the chiefdom level that self-monitors and trains farmers to maintain compliance to qualify for benefits of being a compliant member of COMACO.

In return, for complying with farming best-practices, and regulations designed to conserve wildlife and forests, cooperative members received four primary benefits: 1) higher farm-gate prices at harvest time, 2) training on how to maintain soil fertility and increase agricultural production sustainably, 3) lower seed costs and loans to support COMACO farmers with quality seeds produced by cooperative members who are certified seed growers, and 4) a dividend paid to the cooperative based on an annual conservation compliance audit to help finance and expand farmer support service.

Over time, these rules become improved and more community - specific as cooperatives work with their traditional rulers to help formulate their own Community Conservation Plan and seek greater commercial benefits derived from its adherence. At this stage, community enforcement of this plan is a key component of conservation compliance.

To date, 86% of the farmers are food secure, income levels have more than tripled, farmer cooperatives exist to support farmer needs and help enforce community conservation plans, and rates of tree loss and wildlife poaching in most areas are declining.

The project is not required yet to demonstrate specific contributions to SDG, as stated in Appendix 2 of the VCS Standard v4.2. The project will monitor and report specific contributions to SDGs by January 2025.

2 SAFEGUARDS

2.1 No Net Harm

Each activity, as the project planning and implementation phase gets underway, could contribute to a scenario where adverse environmental, habitat or social impacts might arise and where such impacts could be avoided through a functioning Environmental and Social Management Framework (ESMF). The table below provides a summary of the activities the project might support, and the potential negative environmental and socio-economic impacts and the steps taken to mitigate them.

Table 3. Project Activities with Potential Adverse Environmental or Social Impacts and Proposed Mitigation Measures

Project Target Areas, Potential Activities	Adverse Environmental Impacts	Adverse Social Impacts	Mitigation measures
Farm performance through conservation farming and CSA results in increased yields to achieve food security and increases farmer income and welfare by linking market incentives to the adoption of these practices that reduce forest loss, habitat loss and poaching.	Increased human immigration into area leads to increase in human disturbances, loss of trees and habitat in project area.	Increased human immigration into area leads to non-compliant farming practices and other harmful practices, such as poaching and charcoal-making. Households with surplus income may choose to invest in harmful practices-e.g. charcoal making, bush meat	Through a participatory process, COMACO works with traditional authorities and communities (including COMACO farmers) to develop a Community Conservation Plan (CCP) for each chiefdom participating in the Project. The CCP is a vision for land use and becomes the basis for the Chief and his/her Headmen/Headwomen to communicate to all subjects the importance of conservation to sustain a better future from their natural resources. The CCP also provides a basis for reducing risks of unplanned settlements and destructive uses of the land and resources that could deplete this chiefdom of its natural resources. Chiefs and village headmen consults any settlement policies to provide guidelines/criteria that conform with CCP when granting consent to issue land parcels to families. The CCP is endorsed by the chief, his subjects through a participatory process, as well as district-level officials in the Forestry Department. The CCP forms the basis of payment-for-performance for REDD+ generated emission reductions on a community-wide basis-therefore communities are incentivized to work with each other to achieve compliance with the CCP. Each CCP consists of three key sections: 1. Community Conservation Areas (Zoning); 2. General land and natural resource management needs and responsibilities; 3. Conservation plan governance. COMACO works with traditional authorities to designate Community Conservation Areas (CCAs) in their respective chiefdoms. These Community Conservation Areas are subject to rules for land and natural resource

Project Target Areas, Potential Activities	Adverse Environmental Impacts	Adverse Social Impacts	Mitigation measures
			management laid out in the Community Conservation Plan to be established for each chiefdom. The boundaries of each CCA are mapped by longitudinal and latitudinal coordinates, and these maps are included in the CCP that is approved and signed by the chief with the designated authority over the chiefdom. As part of its overall programmatic approach, COMACO is committed to providing support to communities and chiefs in order to improve farmer welfare, increase incomes and achieve food security, and increase food diversification and yields. Together these positive trends combat the spread of harmful practices such as charcoal-making and lead to habitat loss and deforestation, and include: • Introduce new high-yielding, vitamin A-enriched sweet potato varieties. • Support farmer members with cassava cuttings to mitigate drought-related food crop losses. • Introduce cowpeas (<i>Vigna unguiculata</i>), pigeon peas (<i>Cajanus cajan</i>) or velvet beans (<i>Mucunus pruriens</i>) as cover crops to enhance soils and reduce weeds • Introduce skills (and inputs) for dry season gardening with possible development of dry processing technologies to increase market value of vegetables • Increase food crop varieties, particularly maize, to vary crop maturing times. • Introduce permaculture skills (and inputs) to maintain diverse fruit trees (and other selected plants, e.g. chili, moringa, lufa, pigeon peas, spices) around homes. • Continue promoting rice intensification system and water management for higher yielding rice production. • Promote livelihood skills traditionally used by women and for which markets exist that can reduce dependency on charcoal-making as a source of

Project Target Areas, Potential Activities	Adverse Environmental Impacts	Adverse Social Impacts	Mitigation measures
			income, such as poultry raising and vegetable growing, and training in collecting and semi-processing wild mushrooms and caterpillars. • Train and transform charcoal makers with alternative livelihood skills and market support. • Train and certify transformed poachers in chili-blasting for elephant crop damage control and formalize as community-paid seasonal workforce. • Assess alternative technologies to reduce elephant conflicts in settled areas with high risk of conflict (e.g. trip line with strobe lights and alarm) and adopt if practical and feasible. • Assist communities with maps and relevant GIS information to explain land management threats and appropriate solutions • Distribution of 60,000 mud brick energy-efficient 'rocket stoves' provided to COMACO and distributed to its farmers as a conservation dividend • Assist local chiefs with pilot initiative to help register farmer land holdings for monitoring land settlements in a given Chief's area
Farmer compliance in exchange for premiums price on surplus commodities: COMACO's farmer support services rely on farmer loyalty to sell crop surpluses to COMACO so the sales revenues can maintain incentive prices to drive compliance to	Increase in human disturbances, loss of trees and habitat in project area	Increased exposure to illegal markets and people who may exploit local residents. Side-selling of surplus to buyers other than COMACO and competing with other companies that might influence farmer members to grow other crops by	Mitigating this risk involves a combination of strategies: • Participation and engagement of all sectors in developing CCPs and monitoring compliance through COMACs. COMACs performs increased monitoring role by all stakeholders to ensure farmers are complying to conservation practices, thereby meriting premium prices. • Farmers are offered premium prices based on community compliance with conservation farming practices that are also defined in each CCP. Furthermore, Potential for carbon revenues to help pay for farmer-support services and increase incentive payments. • COMACO's core approach is to intensify farmer adoption of practices that COMACO promotes through training and extension support: ○ minimum tillage, composting, alley-cropping, cover crops, crop rotation, fire breaks, tree rows (e.g. G. sepium fence rows to reduce insect pests);

Project Target Areas, Potential Activities	Adverse Environmental Impacts	Adverse Social Impacts	Mitigation measures
improved farming practices.		matching COMACO prices.	○ Promote and expand improved apiary management; Increase training on beehive maintenance, honey harvesting, and hive replication ○ Improve food storage (granary) technology to reduce post-harvest food crop losses (e.g. use of Gliricidia sepium leaves). • Other support services provided by COMACO to encourage community compliance with improved farming practices and minimize negative impacts include: ○ Convene periodic meetings of NGO and private sector partners to enhance collaboration for diversifying farmer skills ○ Promote selected chiefs as role models and conservation champions to inspire other chiefs through exchange visits or by interview on COMACO Farm Talk. ○ Improve and support systems for monitoring conservation compliances ○ Problems of side-selling and competition with other crops and buyers has become progressively reduced as COMACO continues to build price incentives for producers and is able to guarantee reliable logistics for on-site payment, bulking and collection. ○ Produce community scorecards communicated to chiefs and PGCs for CCP compliance and eligibility for premium prices and conservation dividends ○ Enhance information sharing by government stakeholders to promote monitoring efforts • Promoting the establishment of an institutional framework for low-carbon development: ○ The Project engages other stakeholders for whom farmer support services are a form of ecosystem services that key stakeholders like Department of National Parks and Wildlife (DNPW) and the tourism industry may want to support through the COMACO system

Project Target Areas, Potential Activities	Adverse Environmental Impacts	Adverse Social Impacts	Mitigation measures
			of household-level payments. Once example is the establishment of formal partnership with tourism lodges or safari operators to promote wildlife conservation through joint incentive-based approaches for conservation as a basis for complementing and adding to COMACO's own farm-based incentives. ○ Effective oversight of coordinated landscape-wide land use management through the Luangwa Valley Ecosystem Partnership Management Initiative. Launched in 2007, the Luangwa Valley Ecosystem Partnership Management Initiative was conceived to promote a Luangwa Valley ecosystem that is able to sustain diverse, healthy wildlife populations, year-round water flow of the Luangwa River, and improved rural livelihoods. The Initiative has two main goals: 1) Unify rural communities living across the valley and plateau landscapes of the Luangwa Valley ecosystem with livelihood skills and improved leadership that promote better land management and natural resource conservation, and 2) Develop effective oversight structures by government and partners to maintain community commitment to conservation in ways that reward the right livelihood choices and leadership decisions. COMACO is an active member in this Initiative, which includes the Forestry Department, Ministry of Agriculture and Lands, Fisheries, Planning, Land alliance, DNPW, and a growing number of private sector partners. The framework of the Initiative enhances coordination through governance and developmental support structures, especially at the provincial level of government, to promote conservation and good land stewardship at the farmer and community level. Accountability of results and activities will be reinforced through Community Conservation Plans at the chiefdom level, which will be incorporated as benchmarks into annual district conservation plans and monitored at biannual roundtable

Project Target Areas, Potential Activities	Adverse Environmental Impacts	Adverse Social Impacts	Mitigation measures
			meetings, involving district senior government officers and key provincial officers together with non-government and private sector partners. This could also be a forum for working with private sector to ensure legitimate investments are compliant with CCPs.
Development of participatory land use plans for chiefdoms in project area, including community conservation zones	Improved chiefdom-wide management of natural resources leads to leakage as harmful practices (such as charcoal making) and poaching shift to non-project areas. Some levels of ecosystem disturbance is possible if new settlements are developed as a result of relocation of some households from potential forest reserve areas to new farming areas.	Shifts in land use in demarcated conservation zones could limit access to wild resources and harmful income-generation activities (charcoal-making). May also require resettlement of villagers living in conservation zones to new farming areas.	- Any required resettlement will conform with the Resettlement Process Framework and Resettlement Action Plan - COMACO operates not only in project areas, but across these chiefdoms implementing the same market incentive structure based on compliance with conservation agriculture practices. Compliance is evaluated across communities. - The boundaries of each CCA are mapped by longitudinal and latitudinal coordinates, and these maps are included in the CCP that is approved and signed by the chief with the designated authority over the chiefdom. - The Luangwa Valley Ecosystem Partnership Management Initiative is a cross-sectoral partnership that encourages community commitment to conservation across the entire Luangwa Valley and establishes the effective oversight structures by government and partners to maintain this commitment.

2.2 Local Stakeholder Consultation

The COMACO Landscape Management Project has been implemented within the framework of existing laws and World Bank Safeguards as well as within a formal process of collaboration among all relevant stakeholders, particularly the local community.

This concern relates to the larger purpose of the Project, which is to maintain a clear and committed focus on building district, community, and stakeholder commitment to the needs of improved environmental management and social welfare within the COMACO Landscape Management Project areas. The project adopts appropriate steps that enhance environmental and social planning and impacts in the COMACO Landscape Management project area. The project incorporates underlying principles of land and natural resource management, as well as lessons and experiences from work currently in practice in the Project area that enhance the level of cooperation among community stakeholders to support improved protected area management. This has been achieved through conducting regular meetings with the community members and local traditional leaders to get their input on various ways that helped further improve sustainable environmental and resource management.

Project oversight and governance

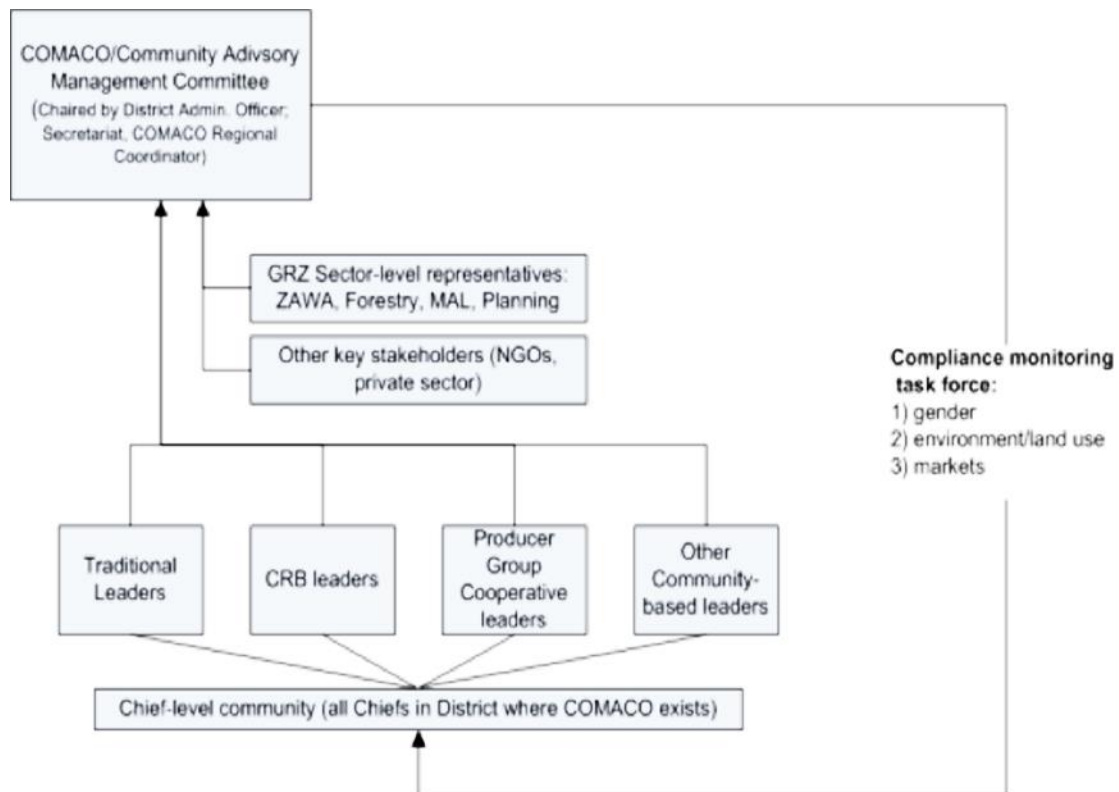


Figure 2: Community Advisory Management Committee (COMAC) members and their functional relationships

The Project is implementing the guidelines contained in the Environmental and Social Management Framework to promote a participatory process of community involvement, as well as other relevant stakeholders, to support an accurate assessment of such impact before the project activities commence.

This oversight was organized primarily through district-level COMACO/Community Advisory Management Committees (COMACs).

These committees provide transparent oversight to levels of compliance by both participating communities and COMACO to their respective pledges of market support and conservation compliances. Over time, the process as supported under this project has led to improved capacity to monitor and report on compliance and will increase the level of dialogue and collaboration for more long-term conservation results.

Chaired by District Commissioners in districts within the Project area, COMACs convenes twice annually to increase transparency by both the community and COMACO in meeting their respective commitments as overseen by third-party District Government Officers, including DNPW, Ministry of Agriculture and Livestock, and the Forestry Department. These government officials play an active role in COMACs together with chiefs' representatives, Community Resource Board (CRB) representatives, and other participating non-government partners who provides guidance, particularly on local land, traditional and political issues. Figure 2. Shows COMAC members and their functional relationships and the organizational structure of these committees. The oversight role of government officers provides a means to validate eligibility for conservation dividend payments and to recognize the achievements by local leadership.

The review process at these meetings qualifies communities for potential conservation dividend payments. Alternatively, if these committees find communities have violated their compliance agreements, disincentives in the form of reduced commodity prices is considered. In support of this process, COMACO supports improved technologies and partnership roles for monitoring and objective scoring of community compliance to required conservation guidelines.

These COMAC's hold a range of functions including the following:

- Strategies on how to ensure natural resources are well managed such as gun and snare surrendering, controlled selling of charcoal.
- Enhance food security at household level by encouraging more crop diversification and conservation farming; and
- Increased monitoring by all stakeholders to ensure farmers are complying to conservation practices, thereby meriting premium prices.

All the stakeholders have a role to play to ensure that these efforts to overcome the challenges being faced in natural resource management are successful. COMACO relies heavily on the role of the Advisory committees to ensure that the environment is well managed and the communities living within the COMCO Landscape project areas are all satisfied with the outcome of the programme.

COMACO ensures that communities, through their respective representatives, can voice their concerns through an appropriate grievance redress mechanism if they feel that agreed upon guidelines and policies are not being adhered to by either party, in this case, COMACO (being the company) and the Community (being the beneficiaries). An important safeguard is to ensure that the communities, through COMACs, are assisted in developing and executing their own Community Conservation Plans, as outlined in the steps listed below.

Community Conservation Plan process:

STAGE ONE: Household level

Producer group cooperatives and all its members commit to household-level conservation practices in a formal document signed by every producer group chairperson and a copy of the document is given to the local chief and district government authorities. Essential requirements include:

- Good soil management practices (low tillage, rotation with legume, legume cover crop, non-burning of crop residue, use of mulch, etc.
- Adoption of agroforestry and local woodlots.
- Compost-making as fertilizer substitute.
- Diverse food crops.
- No ownership of illegal firearms.
- No poaching or snaring with wires; and
- No charcoal-making for commercial sale

STAGE TWO: Chief/Headmen level

Local chiefs with his/her headmen/women agree on a land use governance code to be appended to the STAGE ONE document that helps prevent depletion of natural resources with clearly stated intentions to enforce the code with penalties for people who violate them. Examples of the code include:

- Restrictions of fishing net mesh size, where to fish.
- No making of charcoal for commercial sale;
- No bush burning after a given date; and
- No illegal Firearms

STAGE THREE: Community level

The CCP is further amended through consultation among community leaders and residents, with the help and support of the local chief and district government authorities, to establish a long-term land zoning of agreed settlements, land use practices and conservation targets, including:

- Settlement policy to provide guidelines/criteria that conform with CCP for use by chiefs/village headmen when granting consent to issue land parcels to families.

- Goals and targets for wildlife protection (collection of snares and illegal firearms) as well as wildlife monitoring plans to be developed at the chiefdom level in cooperation with Department of National Parks and Wildlife (DNPW); and
- Resettlement plans to be carried out through the Resettlement Policy frameworks.

Meetings are conducted at District and Provincial level to discuss issues and conservation challenges in the province and how these affect the carbon project. Outcomes are documented through minutes of meetings and reports which are circulated to all stakeholders in the province.

During these meetings, suggestions from participating stakeholders are captured in the minutes of meetings and reports and are included for adoption as part of the general action plans. No suggestions or inputs from these meetings justified the need to update the project design in this third monitoring period. It is also at these meetings that COMACO communicated results of project implementation such as how many CCAs were formed, number of farmers enrolled, monitoring results of compliance to practices promoted by the project and the expected reduced emissions and the benefits to the project. In this monitoring period, there has not been any changes to the relevant laws and regulations covering workers' rights in Zambia.

2.3 AFOLU-Specific Safeguards

The table 4 below shows activities implemented to mitigate risks to stakeholders due to project implementation.

Table 4: Activities implemented for risk mitigation

Identify Risk	Potential impact on stakeholders	Actions needed and designed to mitigate the risk
Project Management	Failure to achieve goals and meet success criteria at a specified time	1. A team with various expertise and wide experience in place 2. Clearly defined goals and objectives 3. Clearly defined roles and responsibility for all staff and stakeholders. 4. Clear monitoring plan involving all stakeholders
Project Financial Benefits	Failure to actualize full financial benefit – stakeholder not getting the fair share of the revenues from the project.	Benefit sharing plan in place
Opportunity Cost	Potential farmland – stakeholders not able to use the land that has been protected for agriculture	Implementation of other income generating activities such as bee keeping, mushrooms and caterpillars.
Project Longevity	Urbanization – a project with a very long time period is at risk of population influx and urbanization in the project area. Vision carriers might not be present anymore	1. Stakeholder sensitization and total buy-in. 2. Project sub agreements
Political risk	Policy change	Sensitization for all stakeholders.
Land and resource tenure	Change in Land tenure systems Encroachments into project zones Loss of biodiversity and livelihoods	Country implementing REDD+ Readiness or other activities such as: a) The country is receiving REDD+ Readiness funding from the FCPF, UN-REDD or other bilateral or multilateral donors b) The country is participating in the CCBA/CARE REDD+ Social and Environmental Standards Initiative c) The jurisdiction in which the project is located is participating in the Governors' Climate and Forest Taskforce d) The country has an established national FSC or PEFC standards body e) The country has an established NDA under the CDM and has at least one registered CDM A/R project
Natural risks	Fire – GHG emissions, loss of alternative livelihoods from forests, biodiversity loss Pest and Disease Outbreaks – loss of livestock/wildlife and crops, reduced potential yield Extreme Weather – loss of livestock/wildlife and crops, reduced potential yield and infrastructure Geological Risk – change of tenure, biodiversity loss,	Risk management plan in place

Farmers Pledge

Farmers under the project sign a pledge to follow agreed upon conservation guidelines that protect the environment and the biodiversity. In this monitoring period, there has been no updates to the property and land use rights of the local stakeholders.

The table 5 below highlights the mechanisms set for engaging and communicating with various stakeholders during project implementation and monitoring.

Table 5: Mechanisms for engaging and communicating with various stakeholders

Stakeholder	Procedures or methods used for engaging	Procedures or methods used for documenting the outcomes	Mechanism for on-going communication
Traditional leaders	The engagement is started with a phone call and followed up with a face-to-face meeting.	During the face to face meeting the project team documents all outcomes and prepares a report and minutes of the meeting	For on-going communication, phone calls, letters, reports are used with traditional leaders
Community Forest Management Groups (CFMGs), Community Resource Boards (CRBs) and Farmer Cooperatives	A combination from questionnaires, public meetings, Forum or other group meetings, round table discussion, facilitated workshops, seminars, conferences and discussion group	The task of documenting outcomes is Undertaken by the project implementation team, for writing up the report on stakeholder engagement and for maintaining Catalogue of responses.	Communication is done through calls to the group chairpersons, round table meetings, radio announcements
Government agencies at district, provincial and National level.	The engagement with government agencies is through official letters, meetings, round table discussion, facilitated workshops, seminars, conferences	Meeting minutes, Memorandums of understanding, Reports	Company newsletters, web site, media appearances, letters to stakeholders, partners meetings

Grievance redress Mechanism:

No grievances arose during the monitoring period and the grievance redress mechanism was not affected.

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

For the SALM component, COMACO has deployed agricultural extension staff as the primary means to provide advisory and monitoring services to farmers for implementing the project activities. In addition, the farmer group approach has been used: in this approach, all members of the farmer groups learn collectively, led by the group leaders, who are usually model farmers within their groups.

The extension staff identify or facilitate formation of registered farmers' groups, who they recruit, sensitize, train, and contract to adopt SALM practices on their farms. The process used to recruit and provide extension is as follows:

1. Stakeholders' awareness meeting as an entry point to raise awareness and contact potential project-participating farmers and collaborators/partners e.g., government agencies and NGOs. The project's goals/objectives, expected benefits, obligations for participating farmers, etc. were thoroughly described and discussed.
2. Sensitization and trust-building of farmers/farmer groups via follow-up meetings.
3. Recruitment and registration of farmer groups (cooperatives);
4. Strategic planning with cooperative members, and regular training and advisory services on specific SALM practices.
5. Guidance and technical support for bulk crop processing, marketing, and input purchase to strengthen the membership and add value to the produce.
6. Annual compliance monitoring and post-harvest surveys to determine adoption rates and address adoption barriers.
7. Further registration of farmers in future project activity instances.

The agricultural extension/advisory services provided aimed primarily at promoting appropriate SALM practices that increase yield in a sustainable manner and sequester carbon/reduced GHG emissions. In addition, it aimed at capacity building on farm-planning, and farm enterprise and home economics.

To-date the project has sensitized, trained, and registered into the project a total of 75,048 farmers and a total of 44,944 ha of agricultural land. These constitute the total project activity instance, which are subject to verification in this monitoring period. In the first monitoring period, the project activity instance comprised of 18,310 farmers and a total of 7,372 ha of agricultural land. In the second monitoring period, the project registered an additional 1, 089 farmers and 442 ha of agricultural land while 18, 304 farmers from the first project activity instance have added 9,316 ha of agricultural land to the project activity instance for the second verification. In this third monitoring period, the project has added 13,636 farmers and 6,815ha of agricultural land from the first 9 Chiefdoms and 42,155 new farmers and a total of 18, 548ha agricultural land from 19 new Chiefdoms from within Eastern province. This brings the total number of farmers for this monitoring period to 75,048 and a total of 44,944ha of agricultural land. These figures are conservative as these are only the farmers and fields that COMACO was able to register from among a large number of farmers/fields that the project has been supporting to adopt SALM practices in the project area.

Table 6: Farmer instances in the third monitoring period

Monitoring Period	Category	Number of Plots	Number of farmers	Hectares (ha)
2013 - 2015	1st Instance	18,310	18,310	7,372
	2nd Instance:			
2015 - 2017	New recruited farmers	1089	1,089	442
2015 - 2017	Additional farm fields from farmers in the 1st instance	18304	18,304	9,316
2018 - 2020	3rd Instance:			
2018 - 2020	Farmers from new 19 Carbon Chiefdoms	41,605	41,605	20,591
2018 - 2020	Farmers from new 19 Carbon Chiefdoms with two fields each	816	408	408
2018 - 2020	New recruited farmers from the first 9 Chiefdoms	13,636	13,636	6,815
Total		93,760	75,048	44,944

These farmers are members of farmer groups (cooperatives), who have formally signed an agreement known as SALM pledges with COMACO to undertake the project to generate carbon credits by adopting SALM practices such as: legume-based alley cropping, residues management (e.g., mulching; cessation of residue burning), and reduced tillage. The agricultural lands where these farmers are implementing the SALM practices constitute the third project activity instances, and only these areas are the subject of this third monitoring.

The main activities implemented for the REDD+ component are as follows:

1. Participatory demarcation of Community Conservation Areas as a form of land use zoning to protect the forest from deforestation/degradation. Thirteen CCAs were demarcated and included in the first and second monitoring period. In this third monitoring period, only Luembe_revised CCA has been added during this monitoring period. The other CCAs include Jumbe CCA, Nyamphande CCA, Mwape CCA, Mphomwa CCA, Mbenjele CCA, Mwase Central CCA, Kalindi CCA, Kalungambeba CCA, Chamukoma CCA, Kawinga CCA, Luasila CCA, Zumwanda CCA, Magodi CCA, , , The CCA boundaries are available as GIS files in supporting documentation.

2. Fourteen Community Conservation Plans (CCPs) in total and attendant rules governing permitted activities and sanctions have been created and are being implemented. The CCPs are provided as supporting documentation, and encompass the CCAs as summarized in Table 7 below:

Table 7: Community Conservation Plans and Areas

Chiefdoms/Community Conservation Plans	Community Conservation Areas	Forest Area (ha)
Chikomeni CCP	Chamukoma CCA	3,248
	Kawinga CCA	3,762
Chikuwe CCP	Mbenjele CCA	1,307
	Mphomwa CCA	1,067
Jumbe CCP	Jumbe CCA	19,908
Luembe CCP	Luembe Revised CCA	2,843
Magodi CCP	Magodi CCA	32,204
Mwape CCP	Mwape CCA	1,298
Mwasemphangwe CCP	Kalindi CCA	14,933
	Mwase Central CCA	5,214
Nyamphande CCP	Nyamphande CCA	2,590
Zumwanda CCP	Kalungambeba CCA	744
	Lwasila CCA	905
	Zumwanda CCA	12,357
Total		102,380

3. Protection of the forest through monitoring of the activities known to drive deforestation/forest degradation to check if set rules are being followed/broken and imposing agreed sanctions in case of unpermitted activities (see, e.g., CCP monitoring forms/books in supporting documentation).

4. Promotion of non-extractive use of the forest, particularly bee - keeping (see e.g., bee-keeping report in supporting documentation).

5. Protecting the forest from fires (see e.g., CCP monitoring forms/books in supporting documentation).

6. Training of farmers in improved agricultural land management practices to improve crop yields on existing farmlands in order to reduce the need for agricultural expansion in forest areas, hence, reducing deforestation (see e.g., Extension summary report in supporting documentation).

These activities involved extensive consultation and participatory planning, implementation and monitoring involving local communities, chiefdoms, government agencies (e.g., Forest Department), and COMACO extension staff.

The project area comprise 102,380 ha of forests for the REDD+ component, which are subject to verification in this monitoring period (see section 3.3, Table 7 for details).

The continuous monitoring and engagement between COMACO and the participating communities regarding the project ensures constant feedbacks, thus, minimizing risks of project performance failures. The non-permanence risk assessment resulted into 11% risk. The risk assessment report is available as supporting document.

The potential for leakage in the SALM component is negligible. As per the project methodology, the only potential source of leakage is an increase in the use of fuelwood and/or fossil fuels from non-renewable sources for cooking and heating purposes due to the decrease in the use of manure and/or crop residuals as an energy source. In the project area, the predominant traditional cooking method makes use of the three-stone open fires. None of the farmers used manure or crop residues for heating/cooking; firewood and to a very small extent charcoal are the only sources of wood fuel used. Nonetheless, through the whole farm approach, the project is enhancing the supply of firewood as the stems of *Gliricidia sepium* planted in alley-cropping provide additional firewood. Therefore, the leakage risk due to this switch to non-renewable biomass or fossil fuels use is accounted for as zero.

For the REDD+ component, leakage is assessed at each verification event as the deforestation that is over and above the extent projected to occur in the baseline scenario (see section 4.3).

Risk factors on leakage and non-permanence risk are monitored through the existing COMACO monitoring systems. These include the annual Compliance survey, Financial Systems and Post-harvest surveys conducted by COMACO.

3.2 Deviations

3.2.1 Methodology Deviations

According to the VCS Standard v4.2, “deviations from the applied methodology are permitted where they represent a deviation from the criteria and procedures relating to monitoring or

measurement set out in the methodology (i.e. deviations are permitted where they relate to data and parameters available at validation, data and parameters monitored, or the monitoring plan). In addition, the VCS Standard v4.2 states that: methodology deviations shall not negatively impact the conservativeness of the quantification of GHG emission reductions or removals, except where they result in increased accuracy of such quantification". The methodology deviations made in this monitoring period are as follows:

1. Timescale of emission reduction calculations

Description of the deviation:

The SALM methodology specifies that most of the activity data to be monitored (listed in section 4.1 and 4.2) should be collected on an annual basis, and that calculation of emission reductions and removals, in particular the modelling of soil organic carbon should refer to one year. The specific nature of the cropping season in the project area spanning over two consecutive calendar years means that calculating and modelling emission reductions on an annual basis would not reflect the real physical conditions of generating emission reductions. Therefore, the soil carbon modelling is always done for a particular cropping season in that year: one cropping season in a year starts from July of a calendar year to May of the subsequent calendar year; for example, for 2017, the cropping season is from July 2016 to May 2017.

Timeline of the deviation and justification:

This deviation is applied since the start of the project in order to follow the real physical conditions in the project within the cropping season spanning over two consecutive calendar years. This is consistent because all the data collected from the farmers implementing SALM practices refer to the cropping season, and farmers always plan, implement and monitor their farm activities according to the full season.

This methodology deviation does not affect the conservativeness of the quantification of GHG emission reductions or removals – rather it results in increased accuracy of GHG emission reductions quantification by taking into account the actual time period over which activities that generate GHG emissions reductions are implemented.

2. Organic input from soil fertility trees to the soil

Description of the deviation:

The methodology includes agroforestry activities to be modelled with RothC to account for soil carbon benefits and stipulates that for use with the RothC model, the monitoring system should record area of agroforestry, number and species of trees used, DBH of trees and future number of trees to be planted. However, the methodology does not give any guidance on how to estimate the organic inputs from the trees (e.g. from litter fall, pruning and roots) which are needed for the RothC model (in comparison, the methodology specifies how to convert crop yields and livestock information into residue inputs and manure inputs respectively using IPCC

conversion factors). Since planting of fast-growing soil fertility trees, i.e., *Gliricidia sepium* to increase organic inputs to the soil is an important agroforestry practice promoted in this project, a default approach was selected to determine this organic input for the modelling: The estimate of the annual amount of carbon inputs from *Gliricidia sepium* into the soil has been taken from a local published study.

Timeline of the deviation and justification:

This approach is applied in this monitoring period in line with the CDM SOC default approach. In the baseline, GHG removals due to changes in SOC are not estimated as per the methodology. To be conservative, the default and the modelled average SOC value from soil fertility trees in this project is defined to be always below the CDM default value of 0.8 – with the assumption that the CDM value was derived for A/R projects and this project can only be implemented on agricultural land and grassland following the applicability of the SALM methodology. See section 4.2 for more information on how the specific model input values were derived for this verification period based on a peer-reviewed study and adapted to the specific tree densities per ha. Hence, the modelled SOC change input values are used only if they are below 0.8 to be conservative.

This methodology deviation does not affect the conservativeness of the quantification of GHG emission reductions or removals, since the modeled average SOC change used is conservative.

3. Calculation of evapotranspiration

Description of the deviation:

The RothC model requires monthly data of evapotranspiration (PET) to parameterize the models. The methodology requires using 5-year averaged values. In this project, a calculation method (modified Hargreaves method) was chosen to estimate PET from average radiation and the 5-year averaged temperature and precipitation data. The modified Hargreaves method uses monthly temperature and precipitation data applying the formula:

$$ET_0 = 0.0013 \cdot 0.408RA \cdot (T_{avg} + 17.0) \cdot (TD - 0.0123P) \cdot 0.76$$

Where,

RA extraterrestrial radiation in (MJ m⁻²d⁻¹)

T_{avg} average monthly temperature (°C)

TD temperature range (°C), computed as the difference between monthly maximum and mean monthly minimum

P monthly precipitation (mm)

In the excel sheet 'Meteo' of the RothC models, PET is automatically calculated from climate data and radiation averages.

Timeline of the deviation and justification:

This deviation is applied since the start of the project because the meteorological station used do not record or calculate PET. Therefore, an indirect calculation method had to be used. The FAO developed a widely used method for calculating reference evapotranspiration on a daily time step (Farmer et al. 2011). Unfortunately, the data demands (air temperature, wind speed, relative humidity, and solar radiation data) make this Modified Penman-Monteith method (PM) problematic, especially for applications in data-poor, developing regions – as is the case in this project. Furthermore, the choice for a simple method than the Penman-Monteith was driven the substantial likelihood for inaccuracy in weather data measurement and collection, especially for developing countries and meteorological stations potentially not always managed with highly qualified experts, and quality equipment. In these situations, accuracy of data and especially of more advanced parameters such as radiation and humidity can be very low. Consequently, to minimize inaccuracies for the calculation of PET for the RothC model application, the modified Hargreaves method has been used, based on the assumption that the observations of precipitation and temperature are collected at a reasonably reliable level for a majority of meteorological stations around the world. Droogers & Allen, (2002) have shown in their study that this equation was less sensitive to inaccuracies in measurements, and that for situations where accuracy in weather stations is expected to be low, the consideration of this equation is encouraged to simulate evapotranspiration as predicted by the Penman-Monteith method.

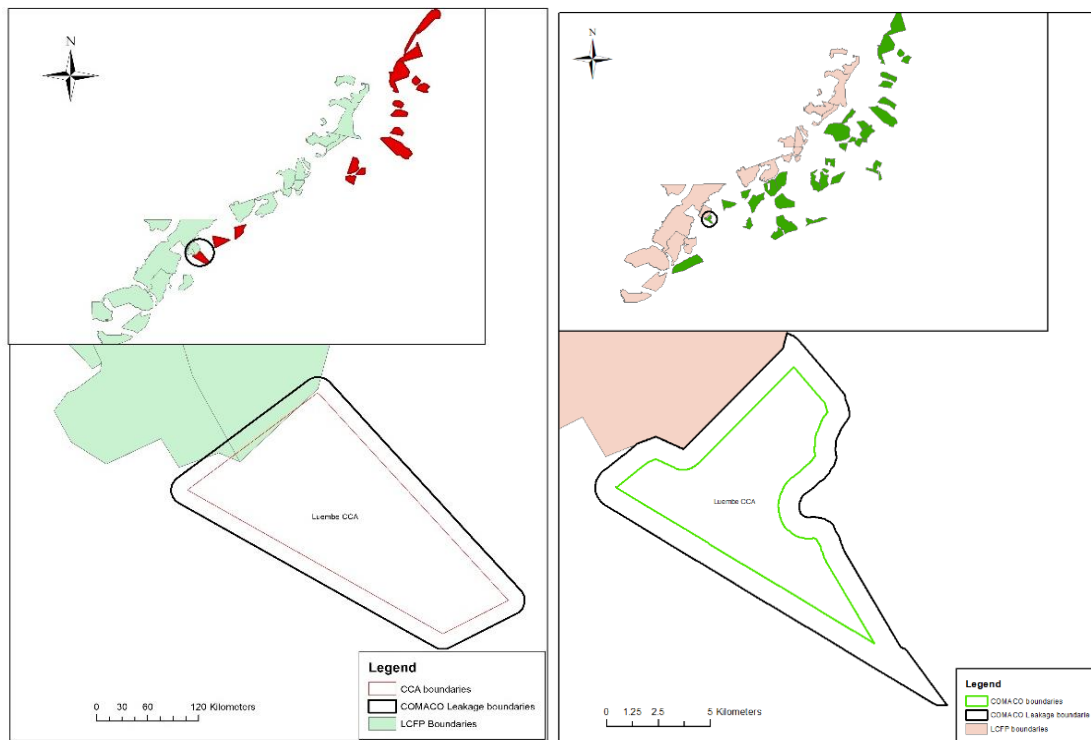
This methodology deviation results in increased accuracy of GHG emission reductions quantification; hence, it does not affect the conservativeness of the quantification of GHG emission reductions or removals.

3.2.2 Project Description Deviations

In the last monitoring report, the project boundary had deviated from the initial boundary after realising that the 1km leakage belt of the community Conservation Area (CCA) in Luembe chiefdom was falling in the new project boundary for Bio-Carbon Partners BCP which was up for verification by VCS. It was taken into consideration that no GHG emission reductions have been claimed from this CCA. The initial meetings that were held by both parties resolved that this CCA boundary be moved 2km inwards. For this reason, COMACO decided to remove the entire CCA from the project area in the last monitoring. After continued engagement with the community in Luembe Chiefdom, COMACO continued to engage with BCP, and the Communities and finally came up with a new Community Conservation Area as Luembe_Revised CCA which has been included in this monitoring period.

Luembe Revised CCA boundary

The monitoring report that covers the 2nd monitoring period (implementation dates 1 November 2015 to 31 October 2017) describes a deviation of the project boundary: It became known that the 1km leakage belt of the Community Conservation Area (CCA) in Luembe Chiefdom overlaps with a new project boundary for Bio-Carbon Partner (BCP) which was up for verification by VCS. Taking into consideration that no GHG emission reduction was claimed from this CCA, it was decided to remove the entire CCA from the project area for the 2nd monitoring period. However, after continued engagement with both the community in Luembe Chiefdom and BCP, a new Community Conservation Area was delineated within Luembe Chiefdom. This CCA has been named “Luembe-revised”. The old and new boundaries of Luembe CCA are shown in the maps below. This CCA has been included in this 3rd monitoring period.



Luembe CCA during the overlap with BCP project area Luembe Revised CCA after community engagements

These changes in the project area in the Luembe chiefdom do not impact on the applicability of the methodology and/or the appropriateness of the baseline scenario. This CCA has been included in this 3rd monitoring period.

The outer boundary is a list of 9 Chiefdoms that can be added to the project. Also, refer to section 1.7 – project location As a grouped project, 27 chiefdoms are planned to be included into the project in future and additional project areas from within the boundaries of these chiefdoms would be included as further project activity instances – as long as these areas meet the eligibility criteria for inclusion outlined in section 1.13. Hence, the project outer boundary includes the first 9 chiefdoms plus the additional 27 chiefdoms (see details in Appendix 1 of the PDD). Through an error, three chiefdoms were left of the appendix list in the PDD. These Chiefdoms include Kazembe, Madzimawe and Kawaza. See Map below,

Map highlighting 3 Chiefdoms that were left of the PDD appendix list but have been included in the Project

These changes in the decisions to include these Chiefdoms as part of the project area do not impact on the applicability of the methodology and/or the appropriateness of the baseline scenario. Furthermore, there are no GHG emission reductions reported in the first or second monitoring period.

3.3 Grouped Projects

This is a grouped project as defined in section 1.2. For the SALM component, the first project activity instance comprises 18,310 farmers and 7,372 ha of agricultural land. The second project activity instances comprise 19,393 farmers, of which 1,089 are newly recruited farmers to the project while 18,304 farmers are old farmers in the first instance who have added new farm fields to the project. This translates into additional 442 ha and 9,316 ha of agricultural land respectively. The third project activity instance comprises 55,649 farmers and 27,814 ha of agricultural land. These constitute the total project activity instance of 44,944 ha, which are subject to verification in this monitoring period (Table 8). For the REDD+ component, for this third monitoring period, the project activity instances comprise 102,380 ha of forest of which 102,380 ha of forest are subject to verification.

Table 8: Project instances in this monitoring period – SALM component

Monitoring Period	Category	Number of Plots	Number of farmers	Hectares (ha)
2013 - 2015	1st Instance	18,310	18,310	7,372
	2nd Instance:			
2015 - 2017	New recruited farmers	1089	1,089	442
2015 - 2017	Additional farm fields from farmers in the 1st instance	18304	18,304	9,316
2018 - 2020	3rd Instance:			
2018 - 2020	Farmers from new 19 Carbon Chiefdoms	41,605	41,605	20,591
2018 - 2020	Farmers from new 19 Carbon Chiefdoms with two fields each	816	408	408
2018 - 2020	New recruited farmers from the first 9 Chiefdoms	13,636	13,636	6,815
Total		93,760	75,048	44,944

Table 9: Project instances in this monitoring period – REDD+ component

Chiefdom	CCA name	Total Area Under CCAs	<u>Included for verification in the 2nd monitoring period</u>	Not included for verification in the 2nd monitoring period	Included for verification in this 3rd monitoring period	Not Included for verification in this 3rd monitoring period
Chikomeni	Chamukoma	3,248	☒		☒	
	Kawinga CCA	3,762	☒		☒	
Jumbe	Jumbe CCA	19,908	☒		☒	
Magodi	Magodi CCA	32,204	☒		☒	
Mwasemphangwe	Kalindi CCA	14,933	☒		☒	
	Mwase Central CCA	5,214	☒		☒	
Zumwanda	Kalungambeba CCA	744	☒		☒	
	Lwasila CCA	905	☒		☒	
	Zumwanda CCA	12,357	☒		☒	
Chikuwe	Mbenjele CCA	1,307	☒		☒	
	Mphomwa CCA	1,067	☒		☒	
Mwape	Mwape CCA	1,298	☒		☒	
Nyamphande	Nyamphande CCA	2,590	☒		☒	
Luembe	Luembe_Revised CCA	2,843		☒	☒	
Total		102,380	99,537	2,843	102,380	0

In this monitoring period, the total REDD+ area which is subject to verification is 102,380ha. This comprise 99,535ha of forest as of 2017 from the second monitoring period and a third instance of 2,843ha of forest in Luembe CCA which have been added as new instances as shown in the table above. Luembe CCA has been included in this monitoring period as Luembe_Revised CCA after resolving the extent of the Community Conservation Area boundary among the traditional leadership of this Chiefdom. See section 3.2.2 Project Description Deviation for more details.

In addition to the first project instances, from 2015/2016 onwards, additional project activity instances have been and will be included by recruiting more areas into the project. Following the guidance on grouped projects under the VCS, all the new project activity instances shall meet the eligibility criteria for inclusion as explained in the PD, section 1.13 and copied here in Table 10 below:

Table 10: Eligibility criteria for inclusion of new project activity instances

Criteria	Component applicable to		Justification	Relevant Documents
	SALM	REDD+		
The new instances are located within the boundaries of the chiefdoms listed in Appendix 1.	☒	☒	All project instances are within the project boundaries	Map showing project boundaries and farmplot instances within project boundaries on Dropbox
Participating farmer groups have willingly agreed to adopt and apply SALM practices being promoted, evidenced by pledge/agreement.	☒		All farmers have signed Conservation Agriculture pledge forms	Conservation Pledge forms on Filed in the office (Not scanned and uploaded due to volume of documents)
The farming system is typically low-input agriculture.	☒		The farming system is typically low-input small-holder subsistence, with a low-level crop diversification. Measured using the Simpson Diversity Index, crop diversification averages 0.45 in the project region	Tembo and Sitko 2013. Technical Compendium: Descriptive Agricultural Statistics and Analysis for Zambia
In the baseline, there is generally low level of application of SALM practices on the agricultural lands, hence, the lands can be assumed to be degrading.	☒		SALM related Farming practices as a percentage of agricultural land in the baseline are all less than 20%	Information from project baseline surveys, and agricultural statistics by Tembo and Sitko 2013 (on Dropbox) Summarised in Table 1: <i>Baseline conditions, page 53 of the PDD</i>
	☒		Land classification of the project area based on the GlobCover 2009	

The land is either cropland or grassland at the start of the project, and is not a wetland.			land cover map (Wetland defined according to the 2003 IPCC GPG LULUCF guidance)	Figure 3, page 29 of the PDD on Dropbox
The lands have not been cleared of native forests 10 years prior to inclusion into the project.	☑		Land classification of the project area based on the GlobCover 2009 land cover map	Figure 3, page 29 of the PDD on Dropbox
There is evidence that the land is degraded/degrading e.g. through any local, regional, national or international land classification system or peer-review study, participatory rural appraisal, satellite imagery and/or photographic evidence.	☑		Landuse maps for the project showing degrading landscape. Also, Drivers of Deforestation Study reports degrading landscape	2015-03-20 Drivers and Effectiveness Factor Analysis CLMP on Dropbox
The area of land under cultivation in the region is constant or increasing.	☑		Agricultural land increased from 398,000 ha to 505,000 ha between 2000 and 2009 in the Eastern Province according to surveys from the Central Statistical Office of Zambia.	CSO/MACO/FSRP Crop Forecast Surveys. Various years. Lusaka: GRZ in Sitko et al. 2011. Technical Compendium: Descriptive Agricultural Statistics and Analysis for Zambia in Support of the USAID Mission's Feed the Future Strategic Review on Dropbox
Forest land, according to the national forest definition, in the region is constant or decreasing over time.	☑		Forest cover change over 11 years (2002 to 2013) has been analysed for the REDD+ component showing an average annual deforestation rate of 2.3%	Page 31 of the PDD. Other sources corroborate this trend of forest loss: the UN-REDD report on the drivers of deforestation in Eastern province (1965 -2005) of 0.85%. Source: Vinya et al., 2011. Preliminary study on the drivers of deforestation & potential for REDD+ in Zambia
	☑			

There is evidence through research that the RothC carbon model or an appropriate and similar model is appropriate for use in the climatic regions or AEZs in which the new project instances are situated			The study by Kaonga and Coleman (2008) tested the performance of the RothC model using empirical data in the project area.	Kaonga M. L., Coleman K. (2008). Modelling soil organic carbon turnover in improved fallows in eastern Zambia using the RothC-26.3 model. Forest Ecology and Management 256. pp 1160-1166
The new project instances have the same regional baseline scenario as the first project activity instances i.e. the land will continue to be used for low-input farming, and is degraded or continue to degrade in the absence of the project intervention.	☒		Recent studies indicate that the drivers of land degradation, which are essentially poor land management practices are still prevalent across the project areas and the entire province	Reversing Agro-Based Land Degradation through Conservation Agriculture: Emerging Experiences from Zambia's Smallholder Farming Sector. Accessed: here
The adoption and application of SALM practices/project intervention activities are not already occurring at a large-scale in the area prior to the project intervention.	☒		SALM related Farming practices as a percentage of agricultural land in the baseline are all less than 20%	Information from project baseline surveys, and agricultural statistics by Tembo and Sitko 2013 (on Dropbox) Summarised in Table 13: Baseline conditions, page 53 of the PDD
The approach to forest conservation, e.g., Community Conservation Area (CCA) and Community Conservation Plan (CCP) established to manage the forest area has been willingly agreed upon by the communities		☒	Community Drafted and Signed Conservation guidelines	Copies of Community Conservation Plan Documents on Dropbox
The area included as project area meets the definition of a forest at the date of inclusion and should have been forest at least 10 years before.		☒	Project baseline involving landuse/cover maps for 2002 and 2013	Project Design Document

The area is subject to unplanned deforestation as defined in the VCS AFOLU Requirements/ VCS Standard.		☒	The land in the project is not legally authorized or documented to be converted to non-forest in the baseline	The Forest Act No. 4 of 2015
The area is similar to the reference region as described in section 2.3 in terms of enforced policies and regulations, socio-economic and cultural conditions, landscape configuration and ecological conditions, and agents and drivers of deforestation.		☒	A shapefile (and KML file) of the new project activity instances (CCAs included in this monitoring period) shows areas falling within reference region	KML file and shapefiles of the CCAs uploaded to Dropbox "Project GIS data" folder
The project activity is avoided deforestation of secondary forest		☒	The project aims to reduce forest loss, and protect and expand areas under natural forest, and conserve biodiversity.	Community Conservation Plan documents in "Community Conservation Plans" folder on Dropbox
The area does not have peat.		☒	Land classification of the project area based on the GlobCover 2009 land cover map	Figure 3, page 29 of the PDD
The area is not already subject to activities that protect forest loss or enhance carbon storage, or where these activities exist, they are not adequately implemented.		☒	Production per hectare for smallholders is less than 15 percent that of commercial farmers because of inadequate access to inputs (e.g., fertilizer and seeds), improved technologies, extension services, and output markets.	See USAID Report (2013) here for further details on the socio-economic baseline conditions in the Eastern Province
	☒	☒	The baseline scenario and the demonstration of additionality	The project monitoring system ensures that the baseline scenario and the additionality are

The area has the same baseline scenario as the first project activity instances identified in section 2.4			are determined for the entirety of the geographic project area within which project activity instances are developed.	representative for all potential farms in the project as well as the initial project activity instances (farms currently adopting SALM). This also applies to REDD
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4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

4.1.1 SALM Component

Data / Parameter	$BSN_{t=0}$
Data unit	kg/ha
Description	Synthetic fertilizer use
Source of data	Published study. See section 5.1.1
Value applied	120
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$Crop_{i,t=0}$
Data unit	kg d.m./ha
Description	Harvested seasonal dry matter yield for crop i
Source of data	COMACO baseline survey 2012 and Post-Harvest Survey 2017
Value applied	See the web-based Project Management Information System (MIS) : Project Summary >> Crop Residue (Group) Project (All)
Justification of choice of data or description of measurement methods and procedures applied	n/a

Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$Area_{i,t=0}$
Data unit	ha
Description	Total annual area harvested of crop i or N-fixing trees i
Source of data	COMACO baseline survey 2012
Value applied	See the web-based Project Management Information System (MIS) : Project Summary >> Crop Residue (Group) Project (All)
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$Areaburnt_{i,t=0}$
Data unit	ha
Description	Annual area of crop i or N-fixing trees i burnt
Source of data	COMACO baseline survey 2012
Value applied	See Project MIS: Project Summary >> Emissions
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$MB_{C,t=0}$
Data unit	t d.m.
Description	Mass of crop residues burnt
Source of data	COMACO baseline survey 2012
Value applied	See Project MIS: Project Summary >> Emissions
Justification of choice of data or description of	n/a

measurement methods and procedures applied	
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$MB_{G,t=0}$
Data unit	t d.m.
Description	Mass of grasslands residues burnt
Source of data	n/a only activities on agricultural land included in this project
Value applied	n/a only activities on agricultural land included in this project
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	C_F
Data unit	Unitless
Description	Combustion factors that depend on vegetation type
Source of data	IPCC 2006, Table 2.6
Value applied	0.8
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$BA_{C,m_C,t=0}$
Data unit	% of total agricultural land
Description	Baseline areas in cropland with management practice, m_c
Source of data	COMACO baseline survey 2012
Value applied	See Project MIS: Project Summary >> SALM Practices Project(All)

Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-
Data / Parameter	$SOC_{C,m_c,t=0}$
Data unit	tC/ha
Description	Soil organic carbon density, to a depth of 30 cm, at equilibrium for cropland with management practice, m_c
Source of data	Model
Value applied	See Roth C models in worksheet 'Results'.
Justification of choice of data or description of measurement methods and procedures applied	Modeled using Roth C carbon model
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$BP_{C,m_c,t=0}$
Data unit	t/ha/season
Description	Baseline production in cropland per season with management practice from within the project, m_c
Source of data	COMACO baseline survey 2012
Value applied	See the Project MIS: Project Summary >> Crop Residue (Group) Project (All)
Justification of choice of data or description of measurement methods and procedures applied	The calculation of production is based on the crop yields, which converted using default equations from the Volume 4 of the 2006 IPCC Guidelines (See table 11.2 Volume 4 of the 2006 IPCC Guidelines). Hence, $BR_{C,m_c,t=0}$ is calculated automatically from the crop yield data.
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$BR_{C,m_c,t=0}$
Data unit	tC/ha /season

Description	Baseline fraction of production returned as residues per month (calculated from $BP_{C,m_C,t=0}$) in cropland with management practice, mc
Source of data	COMACO baseline survey 2012. COMACO baseline survey 2012. Calculation of $BR_{C,m_C,t=0}$ using default equations from Volume 4 of the 2006 IPCC Guidelines to convert crop yields into $BP_{C,m_C,t=0}$ and then into $BR_{C,m_C,t=0}$ using % of area of cropland with management practice, mc
Value applied	See Project MIS: Project Summary >> Crop Residue (Group) Project (All)
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	Since GHG emissions and removals are estimated at the scale of a season, a season's value is used.

Data / Parameter	$BM_{C,m_C,t=0}$
Data unit	tC/ha/season
Description	Baseline composted manure input in cropland per season with management practice, mc
Source of data	ILUA I survey & IPCC default factors See section 4.1.6
Value applied	See Excel: COMACO_compost_input
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Determination of Baseline GHG emissions and removals
Comments	-

Data / Parameter	$BCC_{C,m_C,t=0}$
Data unit	
Description	Baseline cover crop flag per season in cropland per season with management practice, mC

Source of data	COMACO baseline survey 2012
Value applied:	See Project MIS: Project Summary >> SALM Practices Project (All)
Justification of choice of data or description of measurement methods and procedures applied	Residue management and cover crops are not easily separable in this project, so are combined. Beans are the main crop used as the over crop. Residue management is represented by SlashCropResidues in the project MIS portal.
Purpose of Data	Baseline GHG emissions and removals
Comments	-

Data / Parameter	$BA_{G,m_G,t=0}$
Data unit	ha
Description	Baseline areas in grassland with management practice, m_G ,
Source of data	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Justification of choice of data or description of measurement methods and procedures applied	n/a only activities on agricultural land included in this project
Purpose of Data	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$SOC_{G,m_G,t=0}$
Data unit	tC/ha
Description	Soil organic carbon density, to a depth of 30 cm, at equilibrium for grassland with management practice, m_G
Source of data	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Justification of choice of data or description of measurement methods and procedures applied	n/a only activities on agricultural land included in this project
Purpose of Data	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$BP_{G,m_G,t=0}$
Data unit	t/ha/month

Description	Baseline production in grassland per month with management practice from within the project, m_G
Source of data	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Justification of choice of data or description of measurement methods and procedures applied	n/a only activities on agricultural land included in this project
Purpose of Data	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$BR_{G,m_G,t=0}$
Data unit	t/t prod/month
Description	Baseline fraction of production returned as residuals per month (calculated from $BP_{G,m_G,t=0}$) in grassland with management practice, m_G
Source of data	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Justification of choice of data or description of measurement methods and procedures applied	n/a only activities on agricultural land included in this project
Purpose of Data	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$BM_{G,m_G,t=0}$
Data unit	t/ha/month
Description	Baseline manure input in grassland per month with management practice, m_G
Source of data	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Justification of choice of data or description of measurement methods and procedures applied	n/a only activities on agricultural land included in this project
Purpose of Data	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$BCC_{G,m_G,t=0}$
Data unit	
Description	Baseline cover crop flag per month in grassland per month with management practice, mG
Source of data	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Justification of choice of data or description of measurement methods and procedures applied	n/a only activities on agricultural land included in this project
Purpose of Data	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$\overline{Temp}_m$
Data unit	°C
Description	Average temperature per month
Source of data	Local weather records: Local weather records: Chipata, Lundazi, Mfuwe, and Petauke meteorological stations
Value applied:	Monthly data are compiled in the Excel file 'Monthly Max-Min Temp_1998-2019'
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Baseline GHG emissions and removals

Data / Parameter	$\overline{Prec}_m$
Data unit	mm
Description	Average precipitation per month
Source of data	Local weather records: Chipata, Lundazi, Mfuwe, and Petauke meteorological stations
Value applied:	Monthly data are compiled in the Excel file 'monthly Rainfall_1998-2019'
Justification of choice of data or description of	n/a

measurement methods and procedures applied	
Purpose of Data	Baseline GHG emissions and removals
Data / Parameter	$\overline{Evap}_m$
Data unit	mm/month
Description	Average evapotranspiration per month
Source of data	Calculated from local climate data
Value applied:	See RothC models, worksheet 'Meteo'
Justification of choice of data or description of measurement methods and procedures applied	The calculation of PET from climate data applies the modified Hargreaves method.
Purpose of Data	Baseline GHG emissions and removals
Comments	-

4.1.2 REDD+ Component

Data / Parameter	Forest Cover 2020
Data unit	Map
Description	Digital map showing the location of forest within the project area at the project start
Source of data	LANDSAT satellite images of 2020
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Supervised image classification. See details of procedures applied in PD section 2.4 (Step 2: Analysis of historical land-use and land-cover change).
Purpose of Data	Calculation of project deforestation for the purpose of determining project emissions
Comments	-

Data / Parameter	Reference region
Data unit	Map
Description	Digital map showing the boundary of the reference region
Source of data	Mapping by government

Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	The reference is the boundaries of twenty-eight chiefdoms in the project area. Why this spatial scale is suitable to be the reference region is justified in the PD (see section 2.3)
Purpose of Data	Calculation of project deforestation for the purpose of determining reference emissions
Comments	-

Data / Parameter	Project area
Data unit	Map
Description	Digital map showing the boundary of the project area
Source of data	Analyses of LANDSAT satellite images of 2007 and 2017
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Mobility analysis to determine how far away communities in the project area would shift their pre-project agricultural activities.
Purpose of Data	Calculation of leakage
Comments	-

Data / Parameter	Leakage belt
Data unit	Map
Description	Digital map showing the boundary of the leakage belt
Source of data	Leakage analysis (see PD section 2.3.2)
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Mobility analysis to determine how far away communities in the project area would shift their pre-project agricultural activities.
Purpose of Data	Calculation of leakage
Comments	-

Data / Parameter	Annual areas of baseline deforestation in the reference region
Data unit	ha
Description	Annual areas projected to be deforested each year from 2013 to 2022 in the reference region, and from 2017 to 2020 for this monitoring period

Source of data	Analysis of future deforestation (see PD section 3.1.2, Methodology Step 4: Projection of future deforestation)
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Annual locations of deforestation have been modelled using TerrSet Land Change Modeler.
Purpose of Data	Calculation of baseline reference region emissions
Comments	-

Data / Parameter	Annual areas of baseline deforestation in the project area
Data unit	ha
Description	Annual areas projected to be deforested each year from 2013 to 2022 in the project area, and from 2017 to 2020 for this monitoring period
Source of data	Analysis of future deforestation (see PD section 3.1.2: Step 4: Projection of future deforestation)
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Annual locations of deforestation have been modelled using Land Change Modeler, then overlaid over the project area.
Purpose of Data	Calculation of baseline emissions in the project area
Comments	-

Data / Parameter	Annual areas of baseline deforestation in the leakage belt
Data unit	ha
Description	Annual areas projected to be deforested each year from 2013 to 2022 in the leakage belt, and from 2017 to 2020 for this monitoring period
Source of data	Analysis of future deforestation (see PD section 3.1.2: Step 4: Projection of future deforestation)
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Annual locations of deforestation have been modelled using Land Change Modeler, then overlaid over the leakage area.
Purpose of Data	Calculation of baseline emissions in the leakage area
Comments	-

Data / Parameter	Carbon stocks per hectare of initial forest classes, icl
Data unit	tCO2e/ha
Description	Average carbon stock per hectare in all carbon pools before deforestation
Source of data	Existing forest inventory study (Kamelarczyk (2009)
Value applied:	See Excel file: COMACO ER calculations_REDD
Justification of choice of data or description of measurement methods and procedures applied	Existing inventory has been used as allowed by the methodology (see PD section of 3.1: Step 6: Estimation of baseline carbon stock changes and non-CO2 emissions).
Purpose of Data	Calculation of carbon stocks per forest class before deforestation
Comments	-

Data / Parameter	Carbon stocks per hectare of final classes, fcl
Data unit	tCO2e/ha
Description	Average carbon stock decay rate for all carbon pools before deforestation
Source of data	Existing forest inventory study (Kamelarczyk (2009)
Value applied:	See Excel file: COMACO ER calculations_REDD
Justification of choice of data or description of measurement methods and procedures applied	Existing inventory has been used as allowed by the methodology (see PD section of 3.1: Step 6: Estimation of baseline carbon stock changes and non-CO2 emissions).
Purpose of Data	Calculation of carbon stocks per land-use classes after deforestation
Comments	-

Data / Parameter	Carbon stock changes factors for initial forest class, icl
Data unit	tCO2e/ha
Description	Average carbon stock decay rate for all carbon pools before deforestation
Source of data	Calculation, according to the methodology – section 6.1.2.
Value applied:	See Excel file: COMACO ER calculations_REDD
Justification of choice of data or description of measurement methods and procedures applied	Calculation followed the methodology; see PD section of 3.1.2: Estimation of baseline carbon stock changes and non-CO2 emissions.
Purpose of Data	For estimation of the carbon stock changes
Comments	-

Data / Parameter	Carbon stock changes factors for final forest class, fcl
Data unit	tCO ₂ e/ha
Description	Average carbon stock decay rate for all carbon pools after deforestation
Source of data	Calculation, according to the methodology – section 6.1.2.
Value applied:	See Excel file: COMACO ER calculations_REDD
Justification of choice of data or description of measurement methods and procedures applied	Calculation followed the methodology; see PD section of 3.1.2: Estimation of baseline carbon stock changes and non-CO ₂ emissions.
Purpose of Data	For estimation of the carbon stock changes
Comments	-

Data / Parameter	Carbon fraction, CF
Data unit	Unitless
Description	Average carbon content of dry matter
Source of data	IPCC 2006
Value applied:	0.5
Justification of choice of data or description of measurement methods and procedures applied	n/a
Purpose of Data	Determination of carbon content in dry matter
Comments	IPCC default value

Data / Parameter	Average proportion of mass burnt in the carbon pool p in the forest class, icl
Data unit	%
Description	Proportion mass burned in the carbon pool in the forest
Source of data	Published study ¹
Value applied:	60%
Justification of choice of data or description of measurement methods and procedures applied	The main deforestation activity, i.e., conversion of forest to agriculture is always associated with fires (slash and burn)

¹Minishi et al., 2010. The role of the Miombo Woodlands of the Southern Highlands of Tanzania as carbon sinks. Accessed [here](#).

Purpose of Data	Determination of carbon emissions from fires in the forest class
Comments	-

Data / Parameter	Average combustion efficiency of the carbon pool p in the forest class, icl
Data unit	%
Description	Proportion of available fuel burnt
Source of data	IPCC 2003 Table 3.A.14 (Combustion efficiency of Tropical dry mixed forests)
Value applied:	90%
Justification of choice of data or description of measurement methods and procedures applied	Forest loss is always associated with fires (slash and burn)
Purpose of Data	Determination of the amount of Biomass which is actually burnt
Comments	-

4.2 Data and Parameters Monitored

4.2.1 SALM Component

Data / Parameter	PSN_t
Data unit	kg/season
Description	Synthetic fertilizer use per season
Source of data	COMACO annual post-harvest survey
Description of measurement methods and procedures to be applied	A sample survey of project participating farmers, and for each sampled farmer and crop field, amount of fertilizers applied in the crop yield is obtained from farmer interview/records.
Frequency of monitoring/recording	Annually
Value applied:	See Project MIS: Project Summary >> Emissions
Monitoring equipment	Digital data logger/tablet

QA/QC procedures to be applied	During monitoring survey, the team leader randomly checks the data reported and recorded by the survey team. In future, data will be collected by farmer groups, with the support of the group leaders after they have been fully trained and equipped with adequate data gathering knowledge. COMACO survey team will cross-check the values reported by the farmers at each data collection procedure – in addition to cross-checking by the farmer group leader.
Purpose of data	Project GHG emissions and removals
Calculation method	Where values are reported in local units (e.g. bag), convert to kg using information from local markets on weight content of different fertilizer bags
Comments	Since in the 2015 and 2015 monitoring surveys, quantities of fertilizers were not recorded, the baseline values are conservatively applied for the two years. The value for 2017 has been obtained from the 2017 post-harvest survey.

Data / Parameter	$PA_{C,t}$
Data unit	ha/season
Description	Areas in cropland
Source of data	COMACO annual post-harvest surveys
Description of measurement methods and procedures to be applied	A sample survey and interviews of project participating farmers.
Frequency of monitoring/recording	Annually
Value applied:	See Project MIS: Project Summary >> Area Statistics PH Survey
Monitoring equipment	Digital data logger/Tablet, GPS, Quantum GIS, MIS
QA/QC procedures to be applied	The values reported by the farmers are cross-checked by the survey team together with the farmer group leader. GPS boundary tracking is used to assess conformity of farmers' estimates. A standard guideline and field instructions on how to calibrate and use the GPS in the field and how to process and analyze the GPS data using open-source Quantum GIS software is used.
Purpose of data	Project GHG emissions and removals
Calculation method	Farmers report cropland areas in lima. Conversion to ha is done automatically in the Project MIS

Comments	-
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Data / Parameter	$PA_{G,t}$
Data unit	ha/season
Description	Areas in grassland
Source of data	COMACO annual post-harvest surveys
Description of measurement methods and procedures to be applied	A sample survey and interviews of project participating farmers.
Frequency of monitoring/recording	Annually
Value applied:	n/a
Monitoring equipment	n/a
QA/QC procedures to be applied	n/a
Purpose of data	Project GHG emissions and removals
Calculation method	n/a
Comments	No SALM activities are implemented on grassland in this monitoring period.

Data / Parameter	PF_t
Data unit	USD/kg
Description	the price of inorganic fertilizer
Source of data	Market assessment
Description of measurement methods and procedures to be applied	The prices are assessed using regional statistics or market survey
Frequency of monitoring/recording	Annually
Value applied:	n/a
Monitoring equipment	n/a

QA/QC procedures to be applied	n/a
Purpose of data	Project GHG emissions and removals
Calculation method	n/a
Comments	Not applied in this monitoring period

Data / Parameter	$Crop_{i,t}$
Data unit	kg d.m./ha/season
Description	Harvested annual dry matter yield for crop i
Source of data	COMACO annual post-harvest survey
Description of measurement methods and procedures to be applied	A sample survey of project participating farmers, and for each sampled farmer and crop field, yield estimates are obtained from farmer interview/records.
Frequency of monitoring/recording	Annually
Value applied:	See the Project MIS: Project Summary >> Crop Residue (Group) Project (All)
Monitoring equipment	Digital data logger/tablet
QA/QC procedures to be applied	During monitoring survey, the team leader randomly checks the data reported and recorded by the survey team. In future, data will be collected by farmer groups, with the support of the group leaders after they have been fully trained and equipped with adequate data gathering knowledge. COMACO survey team will cross-check the values reported by the farmers at each data collection procedure – in addition to cross-checking by the farmer group leader.
Purpose of data	Project GHG emissions and removals
Calculation method	Farmers report the crop yields of different crops in local units, which are converted into kg by COMACO survey team based on local knowledge of the equivalences of the local units. The dry matter yield is then calculated as a combined step for calculating $PP_{C,m_C,t}$ & $PR_{C,m_C,t}$
Comment	-

Data / Parameter	$Area_{i,t}$
Data unit	Ha/season
Description	Total seasonal area harvested of crop i or N-fixing trees i
Source of data	COMACO annual post-harvest survey
Description of measurement methods and procedures to be applied	A sample survey of project participating farmers. Values are reported by farmers.
Frequency of monitoring/recording	Annually
Value applied:	See Project MIS: Project Summary >> Crop Residue (Group) Project (All)
Monitoring equipment	Digital data logger/Tablet, GPS, Quantum GIS, MIS
QA/QC procedures to be applied	Pre-testing data collection tool, and random cross-checking by survey team leader.
Purpose of data	Project GHG emissions and removals
Calculation method	Sum functions in the project MIS.
Comments	-

Data / Parameter	$Areaburnt_{i,t}$
Data unit	Ha/ season
Description	Seasonal area of crop i or N-fixing trees i burnt
Source of data	COMACO annual post-harvest survey
Description of measurement methods and procedures to be applied	A sample survey of project participating farmers, and for each sampled farmer and crop field, practice of no-burning is recorded.
Frequency of monitoring/recording	Annually
Value applied:	See Project MIS: Project Summary >> Emissions
Monitoring equipment	Digital data logger/tablet
QA/QC procedures to be applied	The values reported by the farmers are crosschecked by COMACO survey team at each data collection procedure.

Purpose of data	Project GHG emissions and removals
Calculation method	Database calculation functions
Comments	-

Data / Parameter	$MB_{C,t}$
Data unit	t d.m./year
Description	Mass of crop residues burnt
Source of data	COMACO annual post-harvest survey
Description of measurement methods and procedures to be applied	A sample survey of project participating farmers, and for each sampled farmer and crop field, practice of no-burning is recorded, and residues burnt estimated from area and crop yield.
Frequency of monitoring/recording	Annually
Value applied:	See section 4.2.1
Monitoring equipment	Digital data logger/tablet
QA/QC procedures to be applied	QC/QA procedures for estimating $Area_{burnt_{i,t}}$ and crop yield $Crop_{i,t}$ apply.
Purpose of data	Project GHG emissions and removals
Calculation method	Calculated from area burnt and dry matter yield of crops
Comments	-

Data / Parameter	$MB_{G,t}$
Data unit	t d.m./year
Description	Mass of grasslands residues burnt
Source of data	n/a only activities on agricultural land included in this project
Description of measurement methods and procedures to be applied	n/a only activities on agricultural land included in this project

Frequency of monitoring/recording	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Monitoring equipment	n/a only activities on agricultural land included in this project
QA/QC procedures to be applied	n/a only activities on agricultural land included in this project
Purpose of data	n/a only activities on agricultural land included in this project
Calculation method	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	C_F
Data unit	Unitless
Description	Combustion factors that depend on vegetation type
Source of data	IPCC 2006, Table 2.6
Description of measurement methods and procedures to be applied	n/a
Frequency of monitoring/recording	Project start
Value applied:	0.8
Monitoring equipment	n/a
QA/QC procedures to be applied	n/a
Purpose of data	Project GHG emissions and removals
Calculation method	n/a
Comments	-

Data / Parameter	$FC_{j,t}$
Data unit	Liters
Description	Fossil fuel consumed in vehicle or equipment recorded by vehicle and fuel type
Source of data	COMACO annual post-harvest survey

Description of measurement methods and procedures to be applied	A sample survey of project participating farmers, and for each sampled farmer and crop field, information on energy source for agricultural production is obtained from farmer interview/records. Only monitored if there is increase in the use of machinery compared to the baseline
Frequency of monitoring/recording	Annually
Value applied:	0
Monitoring equipment	Digital data logger
QA/QC procedures to be applied	The values reported by the farmers are crosschecked by the COMACO survey team at each data collection.
Purpose of data	Project GHG emissions and removals
Calculation method	Farmers report the use of machinery on cropland.
Comments	-

Data / Parameter	$PA_{C,m_c,t}$
Data unit	ha
Description	Project areas in cropland with management practice, mC
Source of data	COMACO annual post-harvest survey.
Description of measurement methods and procedures to be applied	A sample survey of project participating farmers done for each sampled farmer and crop field, area under practice is obtained from farmer interview or observations when visible.
Frequency of monitoring/recording	Annually
Value applied:	See Project MIS: Project Summary >> SALM Practices Project(All)
Monitoring equipment	Digital data logger/tablet, GPS, Quantum GIS
QA/QC procedures to be applied	The values reported by the farmers are cross-checked by the survey team. Further, GPS boundary tracking is used to assess conformity of farmers' estimates. A standard guideline and field instructions on how to calibrate, use the GPS in the field and how to process and analyze the GPS data using open source Quantum GIS software is used.
Purpose of data	Project GHG emissions and removals
Calculation method	Farmers report all management practices on their farmland as well as the area, and those visible are verified instantaneously.

Comments	-
Data / Parameter	$SOC_{C,m_C,t}$
Data unit	tC/ha
Description	Soil organic carbon density, to a depth of 30 cm, at equilibrium for cropland with management practice, mC
Source of data	Modeling with Roth C model
Description of measurement methods and procedures to be applied	Modeling using Excel-based RothC model
Frequency of monitoring/recording	Modeled at each verification event separately for each year within in the monitoring period.
Value applied:	See Roth C model worksheet 'Results'
Monitoring equipment	Excel version of the RothC model
QA/QC procedures to be applied	A version of the RothC model has been developed in which only the input values are entered for each season/ year. Automatic calculation of $SOC_{C,m_C,t}$ Including baseline $SOC_{C,m_C,t=0}$ uncertainty analysis and deduction of $SOC_{C,m_C,t}$ if required.
Purpose of data	Project GHG emissions and removals
Calculation method	Modeled with RothC using input values for: Modeled with RothC using input values for: Baseline $BR_{C,m_C,t=0}$ $BA_{C,m_C,t=0}$ $BM_{C,m_C,t=0}$ Project: $PR_{C,m_C,t}$ $PA_{C,m_C,t}$ $PM_{C,m_C,t}$ $\overline{Temp}_m$ $\overline{Prec}_m$ $\overline{Evap}_m$ $PT_{C,t}$
Comment	-

Data / Parameter	$PP_{C,m_C,t}$
Data unit	t/ha/season
Description	Production in cropland per season with management practice from within the project, mC
Source of data	COMACO annual post-harvest survey

Description of measurement methods and procedures to be applied	The calculation of production is based on the crop yields and converted using default equations from the Volume 4 of the 2006 IPCC Guidelines (See table 11.2 Volume 4 of the 2006 IPCC Guidelines)
Frequency of monitoring/recording	Annually
Value applied:	See the Project MIS: Project Summary >> Crop Residue (Group) Project (All)
Monitoring equipment	Digital data logger/tablet; Project MIS
QA/QC procedures to be applied	The values of $Crop_{i,t}$ reported by the farmers are crosschecked by the COMACO survey team at each data collection procedure. The MIS automatically converts crop yields into $PP_{C,m_c,t}$ and automatically analyzes uncertainty for each crop separately. The MIS has some automatic quality control checks to minimize error sources.
Purpose of data	Project GHG emissions and removals
Calculation method	Derived from crop yields using default equations from Table 11.2 of Volume 4 of the 2006 IPCC Guidelines
Comments	-

Data / Parameter	$PR_{C,m_c,t}$
Data unit	tC/ha/season
Description	Project fraction of production returned as residues per season in cropland with management practice, m_c (Calculated from $PP_{C,m_c,t}$)
Source of data	COMACO annual post-harvest survey Default equations from table 11.2 of Volume 4 of the 2006 IPCC Guidelines See the project web-based MIS for 2012-2020.
Description of measurement methods and procedures to be applied	Estimated from residues yield obtained using default equations from Volume 4 of the 2006 IPCC Guidelines to convert crop yields into $PR_{C,m_c,t}$ and % of cropland with management practice, m_c
Frequency of monitoring/recording	Annually

Value applied:	See the Project MIS: Project Summary >> Crop Residue (Group) Project (All)
Monitoring equipment	Project MIS
QA/QC procedures to be applied	The values of $Crop_{i,t}$ and the area $PA_{C,m_c,t}$ under residue management reported by the farmers are crosschecked by the COMACO survey team/extension staff at each data collection procedure. The MIS database converts crop yields into $PP_{C,m_c,t}$ and then automatically calculates $PR_{C,m_c,t}$. The database automatically analyzes uncertainty for each crop separately and has some automatic quality control checks to minimize error sources.
Purpose of data	Project GHG emissions and removals
Calculation method	Calculated from $PP_{C,m_c,t}$ and $PA_{C,m_c,t}$ for management practice.
Comments	-

Data / Parameter	$PM_{C,m_c,t}$
Data unit	tC/ha/season
Description	Project composted manure input in cropland per season with management practice, mc
Source of data	COMACO annual post-harvest survey
Description of measurement methods and procedures to be applied	Calculation of manure yield using default values for volatile solids production values defined in Tables 10A-4 to 10A-9 in Volume 4 of the 2006 IPCC Guidelines to derive estimate of manure yield depending on livestock category, and number, and use of post-harvest survey of SALM practice to estimate extent of manure management practice
Frequency of monitoring/recording	Annually
Value applied:	See section 4.2.6
Monitoring equipment	Digital data logger/tablet
QA/QC procedures to be applied	The livestock numbers and the area under compost management reported by the farmers are crosschecked by the COMACO survey team at each data collection procedure. The project MIS database converts livestock numbers into applying IPCC animal solids defaults and local decomposition equation and then automatically calculates the database automatically analyzes uncertainty and has some automatic quality control checks to minimize errors.

Purpose of data	Project GHG emissions and removals
Calculation method	Calculation of manure yield using default values for volatile solids production values defined in Tables 10A-4 to 10A-9 in Volume 4 of the 2006 IPCC Guidelines to derive estimate of manure yield depending on livestock category, and number, and use of post-harvest survey of SALM practice to estimate extent of manure management practice.
Comments	For this monitoring period, monitoring data have not been collected; hence, baseline values estimated from a national survey (ILUA) have been used.

Data / Parameter	$PCC_{C,m_C,t}$
Data unit	tC/ha/season
Description	Project cover crop flag per month in cropland per month with management practice, mC
Source of data	COMACO annual post-harvest survey
Description of measurement methods and procedures to be applied	Residue management and cover crops are not easily separable in this project, so are combined, since beans are used as the cover crop. A sample of farmers is interviewed, and residue management practice recorded from the interviews and field assessments where possible.
Frequency of monitoring/recording	Annually
Value applied:	See Project MIS: Project Summary >> SALM Practices Project(All)
Monitoring equipment	Digital data logger
QA/QC procedures to be applied	The areas reported by the farmers are crosschecked by the COMACO survey team/extension staff at each data collection procedure. The project-MIS automatically calculates The database analyzes uncertainty for each crop separately, and has some automatic quality control checks to minimize error sources.
Purpose of data	Project GHG emissions and removals
Calculation method	n/a

Data / Parameter	$PA_{G,m_G,t}$
Data unit	ha

Description	Project areas in grassland with management practice, m_G
Source of data	n/a only activities on agricultural land included in this project
Description of measurement methods and procedures to be applied	n/a only activities on agricultural land included in this project
Frequency of monitoring/recording	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Monitoring equipment	n/a only activities on agricultural land included in this project
QA/QC procedures to be applied	n/a only activities on agricultural land included in this project
Purpose of data	n/a only activities on agricultural land included in this project
Calculation method	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$SOC_{G,m_G,t}$
Data unit	tC/ha
Description	Soil organic carbon density, to a depth of 30 cm, at equilibrium for grassland with management practice, m_G
Source of data	n/a only activities on agricultural land included in this project
Description of measurement methods and procedures to be applied	n/a only activities on agricultural land included in this project
Frequency of monitoring/recording	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Monitoring equipment	n/a only activities on agricultural land included in this project
QA/QC procedures to be applied	n/a only activities on agricultural land included in this project
Purpose of data	n/a only activities on agricultural land included in this project
Calculation method	n/a only activities on agricultural land included in this project

Comments	n/a only activities on agricultural land included in this project
Data / Parameter	$PP_{G,m_G,t}$
Data unit	t/ha/month
Description	Production in grassland per month with management practice, from within the project, m_G
Source of data	n/a only activities on agricultural land included in this project
Description of measurement methods and procedures to be applied	n/a only activities on agricultural land included in this project
Frequency of monitoring/recording	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Monitoring equipment	n/a only activities on agricultural land included in this project
QA/QC procedures to be applied	n/a only activities on agricultural land included in this project
Purpose of data	n/a only activities on agricultural land included in this project
Calculation method	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$PR_{G,m_G,t}$
Data unit	t/t prod/month
Description	Project fraction of production returned as residuals per month (calculated from) in grassland with management practice, m_G
Source of data	n/a only activities on agricultural land included in this project
Description of measurement methods and procedures to be applied	n/a only activities on agricultural land included in this project
Frequency of monitoring/recording	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Monitoring equipment	n/a only activities on agricultural land included in this project

QA/QC procedures to be applied	n/a only activities on agricultural land included in this project
Purpose of data	n/a only activities on agricultural land included in this project
Calculation method	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$PM_{G,m_G,t}$
Data unit	t/ha/month
Description	Project manure input in grassland per month with management practice, mG
Source of data	n/a only activities on agricultural land included in this project
Description of measurement methods and procedures to be applied	n/a only activities on agricultural land included in this project
Frequency of monitoring/recording	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Monitoring equipment	n/a only activities on agricultural land included in this project
QA/QC procedures to be applied	n/a only activities on agricultural land included in this project
Purpose of data	n/a only activities on agricultural land included in this project
Calculation method	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$PCC_{G,m_G,t}$
Data unit	
Description	Project cover crop flag per month in grassland per month with management practice, mG
Source of data	n/a only activities on agricultural land included in this project

Description of measurement methods and procedures to be applied	n/a only activities on agricultural land included in this project
Frequency of monitoring/recording	n/a only activities on agricultural land included in this project
Value applied:	n/a only activities on agricultural land included in this project
Monitoring equipment	n/a only activities on agricultural land included in this project
QA/QC procedures to be applied	n/a only activities on agricultural land included in this project
Purpose of data	n/a only activities on agricultural land included in this project
Calculation method	n/a only activities on agricultural land included in this project
Comments	n/a only activities on agricultural land included in this project

Data / Parameter	$\overline{Temp}_m$
Data unit	°C
Description	Average temperature per month
Source of data	Local weather records: Chipata, Lundazi, Mfuwe, and Petauke meteorological stations
Description of measurement methods and procedures to be applied	5-year-averages are used in the RothC model
Frequency of monitoring/recording	For each modeled year, the previous 5-year records are used.
Value applied:	See the Excel file "Monthly Max-Min Temp_1998-2020"
Monitoring equipment	Excel
QA/QC procedures to be applied	Uncertainty analysis. Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of $SOC_{C,m_c,t}$
Purpose of data	Project GHG emissions and removals
Calculation method	A five year average of monthly means are used
Comments	-

Data / Parameter	$\overline{Prec}_m$
Data unit	mm
Description	Average precipitation per month
Source of data	Local weather records: Chipata, Lundazi, Mfuwe, and Petauke meteorological stations
Description of measurement methods and procedures to be applied	5-year-averages are used in the RothC model
Frequency of monitoring/recording	For each modeled year, the previous 5-year records are used
Value applied:	See Excel table “monthly Rainfall_1998-2020”
Monitoring equipment	Excel
QA/QC procedures to be applied	Uncertainty analysis. Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of
Purpose of data	Project GHG emissions and removals
Calculation method	A five-year average of monthly means are used

Data / Parameter	$\overline{Evap}_m$
Data unit	mm/day
Description	Average evapotranspiration per month
Source of data	Calculated from local climate parameters and solar radiation
Description of measurement methods and procedures to be applied	The calculation of PET from climate data applies the modified Hargreaves method. See RothC models, worksheet ‘meteo’. The average solar radiation is calculated based simple geometry
Frequency of monitoring/recording	For each modeled year, the previous 5-year records are used
Value applied:	See RothC models, worksheet ‘Meteo’.
Monitoring equipment	Excel
QA/QC procedures to be applied	Uncertainty analysis. Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of
Purpose of data	Project GHG emissions and removals

Calculation method	The calculation of PET from climate data applies the modified Hargreaves method. See RothC models, worksheet 'meteo'
Comments	-

Data / Parameter	D
Data unit	Years
Description	Transition period
Source of data	IPCC default value
Description of measurement methods and procedures to be applied	Used in RothC Excel based modeling
Frequency of monitoring/recording	The Methodology stipulates a IPCC default value of 20 years
Value applied:	20 years.
Monitoring equipment	Excel
QA/QC procedures to be applied	The RothC models are standardized and semi-automatic, this is to ensure that only input values for a specific monitoring period are entered and that the parameterized models are not accidentally changed.
Purpose of data	Project GHG emissions and removals
Calculation method	Automatic calculation using the RothC Excel models
Comments	-

Data / Parameter	$B_{Biomass,t}$
Data unit	tonnes/year
Description	Quantity of biomass from outside the project that replaces biomass used for cooking/heating diverted to agricultural system in year t
Source of data	COMACO energy sources survey
Description of measurement methods and procedures to be applied	The use of different fuelwood materials, i.e., charcoal, fuelwood, manure, grasses and kerosene used for agricultural production and cooking/ heating is recorded

Frequency of monitoring/recording	Annually
Value applied:	0
Monitoring equipment	Data logger
QA/QC procedures to be applied	The values reported by the farmers are crosschecked by the COMACO survey team at each data collection procedure together with the farmer group leader.
Purpose of data	Project GHG emissions and removals
Calculation method	Valued quoted in local quantities are converted to tonnes according to locally known conversions
Comments	As the energy sources survey indicate, the project does not result into diversion of on-farm biomass, since farmers do not used crop residues for agricultural production and cooking/ heating; neither does it reduce biomass supply on the farm. Hence, there is no likelihood of any leakage, hence, $B_{Biomass,t}$ has been taken as 0 for this monitoring period.

Data / Parameter	$B_{Fossilfuel,t}$
Data unit	tonnes/year
Description	Quantity of fossil fuel that replaces the biomass used for cooking / heating diverted to agricultural system in year t
Source of data	COMACO energy sources survey
Description of measurement methods and procedures to be applied	The use of different fuelwood materials, i.e., charcoal, fuelwood, manure, grasses and kerosene used for cooking/ heating is recorded
Frequency of monitoring/recording	Annually
Value applied:	0
Monitoring equipment	Data logger
QA/QC procedures to be applied	The values reported by the farmers are crosschecked by the COMACO survey team at each data collection procedure together with the farmer group leader.
Purpose of data	Project GHG emissions and removals

Calculation method	Valued quoted in local quantities are converted to tonnes according to locally known conversions
Comments	As the energy sources survey indicate, the farmers do not used fossil fuel for agricultural production and cooking/ heating. Hence, there is no likelihood of any leakage, hence, $B_{Fossilfuel,t}$ has been taken as 0 for this monitoring period.

Data / Parameter	$fNRB$
Data unit	Dimensionless
Description	Fraction of non-renewable biomass from outside the project in year t
Source of data	Conservative default value provided by the methodology
Description of measurement methods and procedures to be applied	See leakage section in the SALM methodology
Frequency of monitoring/recording	Start of the project
Value applied:	1
Monitoring equipment	n/a
QA/QC procedures to be applied	n/a
Purpose of data	
Calculation method	See leakage section in the SALM methodology
Comments	There is no likelihood of any leakage from the project for this monitoring period, therefore $fNRB$ has not been calculated

Data / Parameter	$NCV_{Biomass}$
Data unit	TJ / tonne
Description	Net calorific value of the non-renewable biomass from outside the project
Source of data	IPCC defaults, national or regional studies
Description of measurement methods	See leakage section in the SALM methodology

and procedures to be applied	
Frequency of monitoring/recording	Start of the project
Value applied:	-
Monitoring equipment	n/a
QA/QC procedures to be applied	n/a
Purpose of data	
Calculation method	See leakage section in the SALM methodology
Comments	There is no likelihood of any leakage from the project for this monitoring period, therefore $NCV_{Biomass}$ has not been calculated
Data / Parameter	$NCV_{Fossilfuel}$
Data unit	TJ / tonne
Description	Net calorific value of the fossil fuel that is substituted
Source of data	IPCC defaults, national or regional studies
Description of measurement methods and procedures to be applied	See leakage section in the SALM methodology
Frequency of monitoring/recording	Start of the project
Value applied:	-
Monitoring equipment	n/a
QA/QC procedures to be applied	n/a
Purpose of data	
Calculation method	See leakage section in the SALM methodology
Comments	There is no likelihood of any leakage from the project for this monitoring period, therefore $NCV_{Fossilfuel}$ has not been calculated
Data / Parameter	$EF_{Fossilfuel}$

Data unit	tCO ₂ / TJ
Description	Emission factor of fossil fuel as a substitution for non-renewable biomass
Source of data	Default value as per AMS I.E.
Description of measurement methods and procedures to be applied	See leakage section in the SALM methodology
Frequency of monitoring/recording	Start of the project
Value applied:	Default value of 81.6 tCO ₂ / TJ
Monitoring equipment	n/a
QA/QC procedures to be applied	n/a
Purpose of data	
Calculation method	See leakage section in the SALM methodology
Comments	There is no likelihood of any leakage from the project for this monitoring period.

4.2.2 REDD+ Component

Data / Parameter	Forest Cover Maps
Data unit	Map
Description	Digital maps showing the location of forest within the project area at the project start and during the fixed baseline period
Source of data	LANDSAT satellite images of 2017 and 2020
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Supervised image classification. See details of procedures applied in section 4.2.2.
Frequency of monitoring/recording	Annually
Value monitored	See supporting documentation
Monitoring equipment	Landsat Satellite

QA/QC procedures to be applied	1) Collection of appropriate data sources 2) Definition of classes of land-use and land-cover 3) Pre-processing – to remove clouds and shadows 4) Developing training samples and classification 5) Post-processing – filtering to remove sand, masking and merging classes 6) Accuracy assessment – determination of confusion matrix
Purpose of the data	Calculation of project emissions
Calculation method	Maximum likelihood classification and determination of forest areas using Terrset software
Comments	-

Data / Parameter	Annual areas of deforestation in the project area
Data unit	ha
Description	Areas deforested between start and end of this monitoring period in the project area
Source of data	LANDSAT Satellite images of 2017 and 2020
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Analysis of satellite images
Frequency of monitoring/recording	Annually
Monitoring equipment	Landsat Satellite
QA/QC procedures to be applied	1) Collection of appropriate data sources 2) Definition of classes of land-use and land-cover 3) Pre-processing – to remove clouds and shadows 4) Developing training samples and classification 5) Post-processing – filtering to remove sand, masking and merging classes 6) Accuracy assessment – determination of confusion matrix
Purpose of the data	Calculation of project emissions
Calculation method	Maximum likelihood classification and determination of forest areas using Terrset software
Comments	-

Data / Parameter	Annual areas of deforestation in the leakage belt
Data unit	ha
Description	Areas deforested between start and end of this monitoring period in the leakage belt
Source of data	LANDSAT Satellite images of 2017 and 2020
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Analysis of satellite images
Frequency of monitoring/recording	Annually
Monitoring equipment	Landsat Satellite
QA/QC procedures to be applied	1) Collection of appropriate data sources 2) Definition of classes of land-use and land-cover 3) Pre-processing – to remove clouds and shadows 4) Developing training samples and classification 5) Post-processing – filtering to remove sand, masking and merging classes 6) Accuracy assessment – determination of confusion matrix
Purpose of the data	Calculation of leakage emissions
Calculation method	Maximum likelihood classification and determination of forest areas using Terrset software
Comments	-

Data / Parameter	Carbon decrease due to catastrophic events
Data unit	tCO2e
Description	Carbon decrease occurring in the project area as a result of catastrophic events in the project
Source of data	Monitoring of catastrophic events
Value applied:	0
Justification of choice of data or description of measurement methods and procedures applied	No catastrophic event registered
Frequency of monitoring/recording	Every Season

Monitoring equipment	Depends on the nature of events
QA/QC procedures to be applied	Depends on the nature of events
Calculation method	Varies depending on the nature of events
Comments	Catastrophic events are recorded on a seasonal basis and assess their impacts on carbon stock changes

4.3 Monitoring Plan

COMACO uses annual compliance audit for assessing compliance levels on SALM farmers as well as community members on the implementation of the community conservation plan for REDD+. The results of these audits are communicated back to the community members via a report called annual compliance audit report indicating their performance. The high performing communities are incentivized with conservation dividends and premium prices for their farm produce while the low performing chiefdom get normal price for their farm produce and are engaged on next action plans to implement for improvement in the next audit. See section 4.3.1 and 4.3.2 for the details of SALM compliance and REDD+ surveys respectively.

The monitoring plan aims to primarily generate data/information necessary for estimating the project GHG emissions and removals. The data/parameters monitored are detailed in section 4.2. The monitoring tasks specific to the SALM and REDD+ components are described separately – though some aspects of the monitoring are combined:

4.3.1 Monitoring tasks of the SALM component

There are two aspects of monitoring undertaken for the SALM component:

1. Monitoring of the implementation of the project activity, i.e., the adoption of SALM practices, and other sustainable land management practices implemented by the registered project farmers.
2. Monitoring of the performance outcomes of the project, e.g., crop yields.

Both aspects are captured in two monitoring surveys, namely: the compliance survey (CS), and the post-harvest survey (PHS). The purpose of the CS is primarily to gather data on adoption of SALM practices (e.g., alley cropping, composting, reduced tillage, etc.). It involves both interviews, and physical observations of the SALM practices being undertaken, and is done during the cropping season. The PHS is conducted at the end of the crop calendar/season, (at/after harvest, hence, the name post-harvest) to gather information such as crop yields, and areas under adoption of different SALM practices. It is largely interview-based since some practices undertaken during the cropping season may no longer be observable. The PHS is the primary source of information for the GHG emissions estimation, while the CS is meant to gather information for comparing with the information from the PHS. Both surveys are conducted annually.

The sample frame for both surveys is the list of farms of specific project activity instances. As the entire project area falls within one major AEZ, stratification is initially not considered. However, if in the future large variability is detected in the estimates of sampled parameters, appropriate strata may be defined. Strata may be defined based on criteria, which are deemed responsible for the variation, e.g., soil types (if detailed soil maps are available); year of inclusion into project; chiefdoms, etc.

Sampling and sample size

The sampling unit is the farm, and the approach for drawing samples (selecting the farms) is simple random sampling. The sampling frame for each project activity instance is the list of all farms recruited into that period. The farms included in this monitoring period constitute the third project activity instances. This list has been compiled into what is known the SALM Farmer Register, in which each farm has a unique identification (ID). The farmer too has a unique ID. Note that several farms recruited into the project can belong to the same farmer.

In this monitoring period, the unique IDs for farms had not been fully developed. Hence, the list of farmers, and not farms has been used for sampling. Once, a farmer was selected, data were enumerated for all his/her farms that are in the project. As the entire project area falls within one AEZ, stratification is initially not considered. However, if in the future large variability is detected in the estimates of sampled parameters, appropriate strata will be defined.

The project carbon accounting methodology requires that the mean estimates of parameters used to model SOC sequestration should achieve a margin of error of 15% at 95% confidence level. If there are specific sampling uncertainty guidance/requirement set by national institutions, it may be used. Since a sampling uncertainty guidance/requirement is not defined for Zambia, the margin of error of 15% at 95% confidence level is applied.

The sample size needed to achieve this uncertainty level is estimated according to Equation 1 below. Since crop yield – after converting into crop residue yield – is one of the principle inputs for the RothC carbon model, it is a suitable parameter to determine the variability and the required sample size. After calculating the mean value of the yield and the standard deviation, the sample size (number of farms) is then calculated as:

$$n = \left[\frac{1.7}{15} * CV \right]^2 \quad \text{Equation 1.}$$

Where: n is the number of sample farms (sample size)

1.7 is the t-number of standard deviations needed to achieve the desired confidence level, obtained from a T-table.

15 is the allowable error (or uncertainty) in percent, and CV is the coefficient of variation in percent.

Further guidance on the sampling and the survey procedures can be obtained from the Activity Baseline and Monitoring Survey (ABMS) Guideline for Sustainable Agricultural Land Management practices², which is also referred to as ABMS Guidelines in short.

Detailed procedures

The compliance surveys

Each year, a representative sample of farmers is interviewed based on a structured questionnaire. The sampling unit is the farm, and once a farm is selected, the farm owner or manager is automatically selected and is interviewed. This sample-based survey is designed based on the SALM Farmer Register and follows the CDM 'General Guidelines for Sampling and Surveys for Small-Scale CDM Project Activities'³. It uses a simple random sampling approach. First, the number of sample farms needed is determined according to equation 1. Then the farms are randomly selected. The sampled farms are monitored annually. In this monitoring period, however, since the system of unique IDs for registered farms was not fully operational, the farmer and not the farm has been randomly selected from the SALM Farmer Register. Then the farms/crop field of the selected farmer automatically included as sampled farm.

Post-harvest survey

In this monitoring period, the PHS survey too has been undertaken by COMACO on a sample of farms. The procedures for sampling have been the same as for the compliance survey. Hence, the description in the paragraphs that follow will apply in future monitoring periods. Figure 3 below shows the distribution of the PHS survey samples⁴.

²Seebauer and Tennigkeit, 2012. Activity baseline and monitoring survey guideline for Sustainable Agricultural Land Management practices (SALM), Version 2 (developed for the World Bank)

³ http://cdm.unfccc.int/EB/050/eb50_repan30.pdf

⁴ Note that the locations shown in this map is not always on the sampled farm. This is because the interview may be conducted on the farm or at a place where the farmer is.

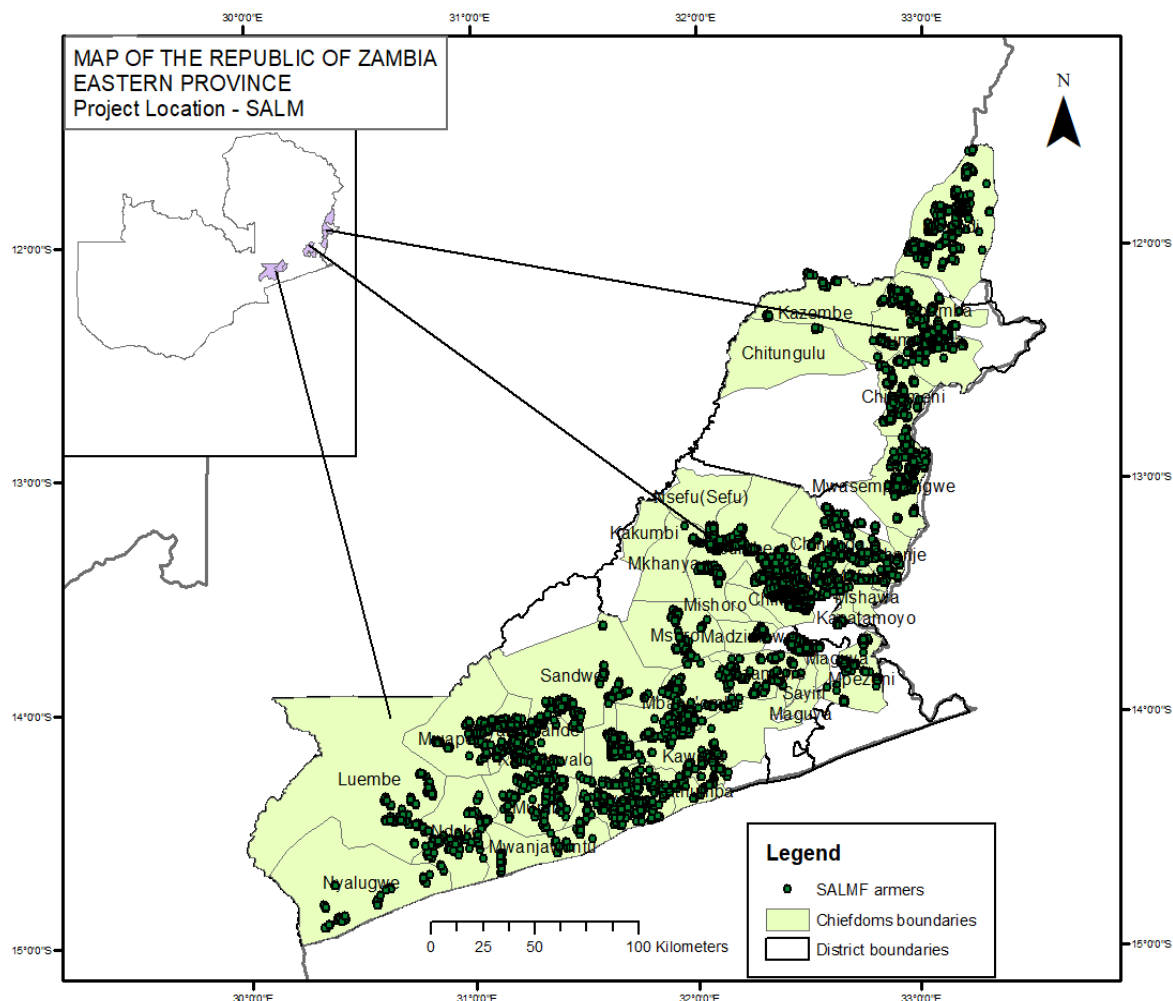


Figure 3: Locations of 2017 PHS samples

The PHS is a full inventory of all farms and farmers participating in the project⁵. It is undertaken annually. Each registered farmer group is trained to conduct a farmer self-assessment on an annual basis by filling the SALM pledge forms and survey questionnaire. Each registered group democratically elects one farmer/member as their Farmer Group Resource Person (FGRP). The FGRP receives extra training from COMACO on how to conduct the farmer self-assessment using the survey questionnaire to collect specific farm data – considering the specific data requirements (e.g. units of crop yields, etc.) and how to manage potential error sources. His/her role is to assist the group members to correctly record their data. He/she also cross-checks and aggregates the data to group level, then submits to

⁵ The full sampling approach was not selected due to the carbon monitoring system; however, the data collected are an important component of the whole project information and implementation system. Based on these data, the group or even farmer specific training needs on different agricultural interventions are assessed and the agricultural extension system essentially designs all specific interventions based on these data. Further, the data monitored within the farm are highly welcome by the farmers themselves since it drastically improves the whole self-management structures in the project area.

COMACO extension/survey team. The aggregated data are summaries from the farms of individual group members, i.e., group records.

The aggregated data are submitted to COMACO survey team, who further cross-checks the data before submitting for analyzing and archiving at the central project monitoring and evaluation unit at the COMACO field office.

Data collection, recording, and analysis

In both surveys, the data are obtained as interview responses and direct observations/measurements. They are recorded using a tablet/data logger; then transferred, stored and analyzed using the project web-based Management Information System (Project MIS).

The Project MIS has been developed – to accelerate the data entry on a more standardized basis. The web-based system includes a data entry module which can work offline, and data can be synced to the project server when internet is available. The module has several mathematical and logical validations to avoid data entry mistakes as well as control mechanisms to ensure data quality. The data sent to the server is immediately available for further processing using different web-based interfaces. The Project MIS data flow concept is illustrated in Figure 4. All the calculations to monitor the project performance, and to provide the parameters needed for the RothC soil modelling and other calculations related to the methodology are integrated into the MIS.

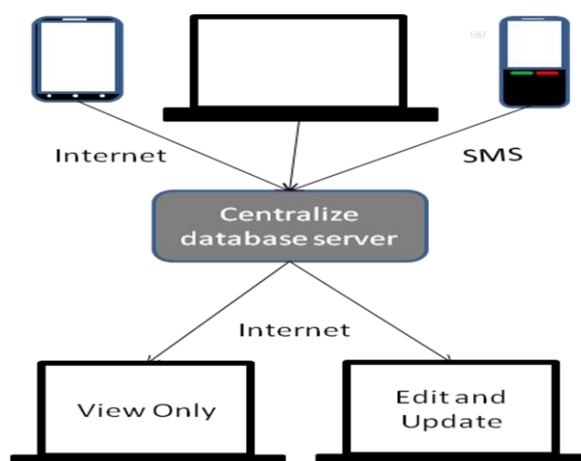


Figure 4: Project MIS data flow concept

The key features of the Project MIS are:

- Centralized online database
- Dashboard to monitor the progress
- Login options specific use rights for data view and editing
- Log of edited records - old value, new value, edited by, time and reason
- Restrict data editing by setting deadlines
- Summary analysis of data on single click (no need of Excel based tools)
- Random selection of a farmer group sample for QA/QC is done by system
- Provision to send comments to lower admin unit

- Export data to excel
- Login management for changing password and setting deadlines for editing
- Create new farmer groups where MIS system designs ID (no scope of duplicate ID)
- Data validation (mathematical and logical)

The web-based MIS has internal quality controls, which ensures that only realistic data are entered into the system. Apart from the internal controls of the MIS, additional quality assurance procedures are implemented, i.e.:

- COMACO staff, FGRPs, and farmers are trained in participatory planning, data collection and record-keeping. Individual farmers are also supported by the FGRPs, who receive extra training on data recording and entry by COMACO staff. Evidence and records of trainings will be documented/archived, e.g., training memos, training theme records, training attendance lists and training program records.
- The FRGP verifies/cross-checks data and assists farmers to fill the questionnaire/SALM pledge forms.
- The FRGP aggregates group monitoring data, hence, ensuring data quality.
- COMACO extension/survey team support the entire process and makes a follow up if there are inconsistencies/errors in the documentation/data. For this, the extension extension/survey/M&E team cross-checks about of 5-10% sample of the field data.
- Pre-testing and re-testing of the data collection procedures and tool is continually done to ensure the data collection tool is always reliable.

The PHS monitors all data required to estimate GHG emissions, e.g.:

- Input values for the SOC modeling, i.e., crop yields and yield increase over time. Only the most dominant crops are used for the modeling to reduce uncertainty of the modeling.
- SALM practices adoption, i.e., residue management, composting, cover crops, etc.
- Activities related to project emissions/leakage, e.g., cooking with fossil fuels.

In addition, the PHS monitors relevant data for overall project implementation and performance including,

- SALM training needs assessment of individual farmer groups/ farmers
- Overall farm development monitoring (e.g., farm enterprise)
- Extension performance monitoring

Another important purpose of the PHS is to establish the benefit distribution system to the different farmer groups. The system has to be simple, transparent and robust.

4.3.2 Monitoring tasks of the REDD+ component

The tasks of monitoring for the REDD+ component are as follows:

- Monitoring of project implementation.
- Monitoring of land use and land-cover change within the project area.
- Monitoring of carbon stock changes and non-CO2 emissions from forest fires.
- Monitoring of natural disturbances and other catastrophic events.

- Monitoring of leakage.
- Monitoring for revisiting the baseline projections for future fixed baseline period.

Monitoring of project implementation

This involves recording of REDD+ project activities and their progresses. Such activities include creation of CCAs, developing and implementing CCPs, patrols of activities causing deforest/degradation, undertaking of forest protection activities; and undertaking of activities to promote non-consumptive forest uses. These are recorded/documented in form of plans, maps, and reports, and other forms of records.

Monitoring of land use and land-cover change within the project area

Monitoring land use and land-cover change within the project area is done through remote sensing analysis. The procedures for the analyses are the same as those described in the PD (refer to section to 2.4: Step 2: Analysis of historical land-use and land-cover change). In this monitoring period, the LANDSAT satellite images used were for 2017 and 2020. The steps are summarized as follows:

1. Obtaining satellite images of good quality, i.e., medium to high resolution, free from cloud cover, and other quality issues – acquired within the monitoring period;
2. Pre-processing the images, i.e., cloud and shadow removal, Ortho-rectification, etc.
3. Interpreting/classifying the images, e.g., into forest and non-forest classes, and producing relevant maps;
4. Further classifying (where possible) the forest/non-forest classes into classes with homogenous carbon density, using any criteria relevant for distinguishing carbon stock density, e.g., forest types, and producing relevant maps.
5. Map accuracy assessment to determine the quality of the classification.

The project uses primarily use LANDSAT images of good quality, unless they are not available – in which case alternatives are to be sought. The images acquisition dates will be as close as possible to the reporting date – subject to availability of high-quality images.

Monitoring of land use and land-cover change within the project area is undertaken at least once in a monitoring period.

Monitoring of carbon stock changes and non-CO2 emissions from forest fires

The project monitors carbon stock changes due to unplanned deforestation and catastrophic events only (see Table 11).

Table 11: Carbon stock changes included/excluded from monitoring

Monitoring of carbon stocks	Methodology requirement	Project monitoring	Justification
Within the project area			
Area of forest land converted to non-forest land	Mandatory	Yes	Area subject to unplanned deforestation activity identified in the baseline is the core of the project monitoring and carbon accounting
Areas subject to significant carbon stock decrease in the project scenario according to the ex-ante assessment. These will be areas subject to controlled deforestation and planned harvest activities, such as logging, fuel wood collection and charcoal production. In these areas, carbon stock changes must be estimated at least once after each harvest event.	Optional	No	There are no controlled or planned deforestation or harvest activities
Areas subject to unplanned and significant carbon stock decrease, e.g. due to uncontrolled forest fires and other catastrophic events. In these areas, carbon stock losses must be estimated as soon as possible after the catastrophic event.	Mandatory	Yes	Areas subject to carbon stock decrease due to catastrophic events only. Fire is not considered a catastrophic event as it is part of the forest ecological process.
Areas subject to carbon stock increase after planned harvest activities, such as logging, fuelwood collection and charcoal production. In these areas, the carbon stock increase occurring after the harvest event can be measured and accounted, when significant.	Optional	No	There are no controlled or planned deforestation or harvest activities, and the project does not seek to be credited for this.
Areas recovering after disturbances, such as unplanned forest fires and other catastrophic events. In these areas, the carbon stock increase occurring after the catastrophic event can be measured and accounted, when significant	Optional	No	There are no controlled or planned deforestation or harvest activities, and the project does not seek to be credited for this.

Within the leakage management areas			
Areas subject to planned and significant carbon stock decrease in the project scenario according to the ex-ante assessment. In these areas, carbon stocks must be estimated at least once after the planned event that caused the carbon stock decrease	Optional	No	There are no controlled or planned event in the leakage management area likely to cause significant carbon stock decrease
Areas subject to carbon stock increase due to leakage prevention measures. In these areas, the carbon stock increase can be measured and accounted only up to the amount necessary to offset any carbon stock decrease caused by leakage prevention measures in other leakage management areas or in previous years	Optional	No	The project does not seek to be credited for carbon stock increase due to leakage prevention measures.
Within the leakage belt			
Areas undergoing significant changes in carbon stock may be measured at the end of each fixed baseline period in order to update carbon stock information for the subsequent period.	Optional	No	Carbon stock are assumed to remain constant over a fixed baseline period, and values are obtained from existing studies.

During the fixed baseline period, average carbon stock and average carbon stock factors are assumed not to change. Hence, monitoring of carbon stocks are not planned or undertaken in this monitoring period.

Monitoring carbon stock changes due to unplanned deforestation involve two main steps:

- Monitoring of land use/cover change to determine quantity of unplanned deforestation. The land use/cover analysis procedures applied are described in the preceding section.
- Combining the quantity of unplanned deforestation with average carbon stock/average carbon stock factors to determine the carbon stock changes. Refer to section 4.2.2: Estimation of carbon stock changes for the calculation of carbon stock changes.

Monitoring of carbon stock changes due to fires is undertaken by:

1. Estimating the area affected by the fires;
2. Estimation the non-CO2 emissions per unit area, i.e., per ha (emission factor) of fires; and
3. Estimating non-CO2 emissions as a product of the quantities in 1 and 2.

For the calculations of non-CO2 emissions, refer to section 5.2.2: Estimation of non-CO2 emissions due to fires.

Monitoring of carbon stock changes and non-CO2 emissions from forest fires is to be undertaken at least once in a monitoring period.

Monitoring of natural disturbance and catastrophic event

Monitoring of carbon stock changes due to natural disturbance and catastrophic events is undertaken by:

1. estimating the area affected by the natural disturbance catastrophic event;
2. Estimating the carbon stock per unit area, i.e., per ha (emission factor) of the catastrophic event; and
3. Estimating carbon stock changes as a product of the quantities in 1 and 2.

Monitoring is undertaken as and when the natural disturbance/catastrophic event occurs. In this monitoring period, no catastrophic event occurred, so no monitoring has taken place.

Monitoring of leakage

Leakage is monitored in the leakage belt only - using land use/cover analysis. Monitoring land use and land-cover change involves remote sensing analysis. The procedures for the analyses are the same as those described in the PD (refer to section 2.4 of the PD), except that satellite images acquired in this monitoring period have been used, i.e., 2017 and 2020 Landsat images. At least one monitoring is undertaken in a monitoring period.

Leakage is determined as difference in the quantity of deforestation estimated in the baseline case and in the respective monitoring period in the leakage belt.

Carbon stock changes due to leakage are then calculated according to equation 10 of the methodology. Since the deforestation in the project is associated with the use of fires, the non-CO2 emissions from fires are estimated according to equations 11, 12 and 13 of the methodology.

Monitoring for revisiting the baseline projections for future fixed baseline period

These monitoring tasks are undertaken to obtain data/information to be used to updating baselines after expiry of the previous first fixed period (e.g., 2012-2022). At least one monitoring will be undertaken within this fixed baseline period. The tasks involved are:

1. Updating information on agents, drivers and underlying causes of deforestation

The variables used to project future deforestation from the reference region are reviewed, and the information regarding the biophysical variables, agents, vectors, and the underlying causes of deforestation updated. This is done by collecting new information via project specific social studies/survey, new studies, expert discussions, etc. The information is used to create new factor maps, underlining the factors that are the key determinants for locating future deforestation. The results are applied in task 2.

2. Adjust the component of land use and land cover change of the baseline.

If an applicable sub-national or national baseline becomes available during the fixed baseline period, it will be used for the subsequent fixed baseline period.

Otherwise step 4 of Part 2 of the methodology will be repeated to consider the 10-year period in the reference region (2012-2022). In doing so, both the location and quantity of annual projected baseline deforestation in that fixed baseline period will be determined. The process involves the modelling component of the system dynamics (which defines the amount of deforestation), and the spatial component that defines the distribution of deforestation. Key variables that will be used to recalculate the baseline in the subsequent fixed baseline periods include:

- Socio-economic dynamics, e.g., population.
- Biophysical spatial features: road map, distance to urban areas and distance to new sites of deforestation, etc.

These variables are obtained from task 1.

3. Adjusting the carbon component of the baseline.

If improved carbon stock data become available, they will be used subject to verification by a verifier. Otherwise, the carbon stock data used in the preceding fixed baseline period will continue to be used.

4.3.3 Institutional structure for monitoring of the project

Both surveys, Post-harvest (PHS) and Compliance, for the SALM component are conducted by COMACO. This is applicable for the first, second and the current monitoring periods. During this time COMACO has been training and building the technical capacity of the farmer groups/cooperatives to conduct the surveys on their own. In the future, the PHS will be conducted entirely by the farmer groups/cooperatives. COMACO will retain the role of conducting the Compliance Surveys only, and overall responsibility for both surveys. Hence, the PHS will become a farmer-self assessment, which is cross-checked against the Compliance Survey. The farmer groups/cooperatives will choose democratically a Farmer Group Resource Person (FGRP) from among the members – to be responsible for supporting the PHS and helping group members to record the data correctly. The farmer field data is cross-checked first by the FGRP, then by COMACO extension/survey team, and Monitoring and Evaluation (M & E) officer on a sample of the farmers/groups to ensure farmers are self-reporting genuine responses.

Data from both surveys are then cross-checked, cleaned and aggregated for farmers of specific project activity instances. Processing is then done centrally by COMACO. In addition to the locally monitored field data, locally or globally available datasets i.e., climate data and soil data⁶ are sourced for modelling of soil carbon sequestration with the Roth C model.

⁶ For example data from Climate Information Portal of the Climate Systems Analysis Group (CSAG): <http://cip.csag.uct.ac.za/webclient2/app/>; and FAO Harmonized World Soil Database: <http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/>

For the REDD+ component, all monitoring tasks, except monitoring of project implementation is planned to be undertaken solely by COMACO since they are largely technical analyses, i.e., remote sensing, modelling and calculations. The local communities/chiefdoms do not have the technical capacity to undertake them. However, project implementation will involve participatory monitoring for project activities, e.g., developing and implementing CCPs, patrols of activities causing deforest/degradation, and undertaking of activities to promote non-consumptive forest uses.

Roles and responsibilities for monitoring of the project

COMACO has the overall responsibility for monitoring of the project, hence, is wholly responsible for ensuring quality data collection, aggregation, processing, analysis, management and storage (archiving). This must be conducted in accordance with best practices to meet the requirement of the project at a realistic cost. All data files including analyses are stored centrally by COMACO. The results are presented to the participating farmer groups/cooperatives/chiefdoms to inform them of their performance and used to determine the amount/nature of incentives that they receive in return for undertaking the project activities, i.e., adopting SALM practices and forest conservation activities. In Table 12 below, the entities involved and their roles and responsibilities in implementing the monitoring surveys are described.

Table 12: Entities and their roles in the project monitoring

Entity	Component	Roles/Responsibility
Participating farmer/groups/chiefdoms	Both	1) Implements project activities 2) Participatory monitoring – particularly of forest management activities 3) Conducts self-assessment (PHS) monitoring
Farmer Group Resource Persons (FGRP)	SALM	1) Ensures individual farmer group members implement SALM activities on land to which they have title or right of use 2) Facilitates review of progress by groups, and in the process identifies capacity building gaps within the groups, and presents to COMACO extension staff during review meetings to ensure that they are included in the project plans 3) Participates in monitoring and evaluation of the project activities and cooperates in implementing the monitoring plan for the project and the applicable safeguard measures:

		• Trains farmers to fill the SALM pledge forms/questionnaires • Assists in mapping and tracking of farms and recording accurate GIS acreages, • Facilitates the transfer of information from the SALM pledge forms/questionnaires to the group records • Verify data reported by farmers by randomly sampling and visiting individual farmers on their farms • Ensure that the information in the group record is up to date and that it reaches the COMACO extension/ field advisors promptly
COMACO field extension/survey team	Both	1) Implements project activities, mainly: training on SALM and forest management, distributing support/inputs, and empowering community for participatory planning and monitoring and leadership 2) Trains farmer groups on enterprise selection, business planning, marketing and financial services 3) Facilitate organizational assessment and development 4) Enhance group capacity to develop the benefit distribution scheme within the farmer group members 5) Ensure that grievances between individual members of the group or between members and their groups are resolved expeditiously 6) Facilitate and/or train groups on SALM pledges to assist the groups to sign the pledge forms and implement their obligations effectively 7) Facilitate monitoring and evaluation process at field level, including:

		- Ensuring that all farmers, through their group leaders and resource persons are trained on data collection and quality assurance procedures - Verifying the monitoring information recorded by the farmer group leaders (PHS) by random sampling a number of groups and cross-checking the information - Verifying that farmers are recording the right information by random sampling from the group record, and cross-checking the information entered in the SALM pledge forms with the situation on the farm including verifying area acreages using the GPS - Carrying out the data collection for compliance survey monitoring - Giving feedback to groups on progress and planning with them
COMACO Monitoring and Evaluation Officer & Carbon Manager	Both	- Trains field extension/survey team on project implementation and monitoring - Plans and undertakes monitoring including mobilizing human and financial resources for monitoring - Participates in and facilitates monitoring and evaluation: - Ensure that all staff are adequately trained and are kept in touch with any new developments - Ensure that all monitoring are planned and implemented promptly and the data entered, analyzed and archived securely - Verify information entered in group records by sampling a number of groups to cross-check the information from the

		SALM pledge form, also the situation on the farm • Hold review meetings with staff to assess progress, identify challenges and capacity building gaps, and arrange for the necessary support for monitoring and evaluation 4) Provide technical advice and backstopping to the field activities 5) Coordinate project activities 6) Plan and budget for projects activities 7) Appraise field officers 8) Compile progress reports 9) Link and network with stakeholders/collaborators including feedbacks from monitoring results 10) Review and evaluate project activities
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4.3.4 Quality control and quality assurance

The project applies best-practice guidance in its monitoring, e.g., IPCC GPG Guideline, which requires provisions for quality assurance (QA) and quality control (QC) to be implemented via a QA/QC plan. The QC/QA procedures for monitoring in this project comprise three parts, namely:

1. Ensuring reliable field measurements.
2. Verifying data entry and analysis.
3. Data maintenance and archiving. This point is especially important as the time scales of project activities are much longer than technological improvements of electronic data archiving.

Ensuring reliable field measurements

Collecting reliable field survey data is an important step in the quality assurance.

Those responsible for the monitoring surveys must be trained in all aspects of the field data collection and data analyses. For the SALM, the project used the *ABMS Guideline* as Standard Operating Procedures (SOPs), to be undertaken during the field surveys, field verification, etc., and contains provisions for documentation for verification purposes so that future field personnel can check past results and repeat the surveys in a consistent fashion. For the REDD+ component, the project makes use of the guidance regarding satellite image acquisition, quality, and analyses provided in the methodology, and other best-practice guides such as IPCC 2006 GL AFOLU and in GOF-C-GOLD sourcebook on REDD.

To ensure the collection and maintenance of reliable field data, the project emphasizes that:

- a) Field-team members and those who eventually analyse the data are made fully aware of all procedures and the importance of collecting data as accurately as possible.
- b) Pre-test of the survey is conducted before the main survey, and the survey is re-tested. The pretesting phase of the surveys is crucial and absolutely compulsory in order to check the quality and reliability of data collection. The main tasks of the pre-testing include:
 - Test the questionnaire design in an iterative process
 - Check the wording of the questionnaire (clarity of questions)
 - Calculate the variance (standard deviation) of certain parameters
 - Check and identify all difficulties and potential errors sources during the interview situation
- During the project implementation, conduct a re-test of the survey

The re-test monitoring serves to control potential bias of the survey over the lifetime of the project. It will be checked to ensure that the sample of farms of the compliance survey remains representative for all farms in the project area. For the re-tests, select 10% of the compliance monitoring sample size, and compare the mean values of parameters used for GHG emission estimation, with those derived from the compliance monitoring sample size.

- c) Adequately train everyone involved in data collection and analysis and document the training. The documentation will list all names of the field team and the project leader will certify that the team is trained.
- d) Train new staff adequately before they get involved in data collection and/or analysis.

COMACO has set up a strong internal communication, training and implementation system to support the monitoring survey and ensure standard operational procedures including quality control (QC) and quality assurance (QA) procedures are implemented. For this, a series of standard guidelines/SOPs have been developed and are used, namely:

- 'SALM Pledge',
- 'COMACO Landscape Management Project - Operations Plan'
- 'ABMS technical guidelines for SALM projects'
- 'Guidelines on GPS farm boundary tracking and GIS data processing instruction'

The strength of this project approach is that project implementation as well as monitoring of the SALM is seen as a holistic system with a clear sense of ownership among the participating farmers in the project. The guideline documents outline the standard project implementation procedure including:

- Sensitization and awareness among farmers' groups,
- Contracting farmer groups based on standard criteria and forms,

- Defining the rollout procedure including definition of trainings, responsibilities of all stakeholders – from the field levels (farmers), groups (group leaders), COMACO field extension officers, M & E staff, up to the project office in Lusaka.

The whole monitoring system is strongly tied to this implementation procedure with SALM pledge forms and groups summaries/records forming part of the farmer group formation and contracting process with multiple objectives including from the ‘carbon’ related monitoring. Therefore, the defined roles and responsibilities as well as the technical guidance in data monitoring, verification of survey data, data analysis and record keeping is part of the day-to-day project implementation at all levels:

The extension officers are responsible for sensitization, contracting, training and capacity building of farms in SALM practices. For this, the annual PHS data from the farmer groups represents a crucial instrument to identify specific training needs and to design a farmer led sustainable implementation system and leadership on SALM within the farmer groups. Therefore, a large emphasis is placed on the effective and high-quality performance of the post-harvest monitoring throughout the project. Furthermore, the farmer driven approach of the PHS guarantees that farmers understand the monitoring system and are clearly aware of the immediate benefits of the system for their sustainable farm management apart from the benefits/incentives they receive from COMACO for SALM practices adopted.

The guiding documents listed above represent a compilation of standard rules of the holistic monitoring system. The guidelines are used on a day-to-day basis at all levels in the COMACO extension and monitoring system; in particular, at the COMACO Farmer Support Centre offices, the guidelines are used to produce various visual working flow charts, posters and stepwise hand-outs which are used in in-house training as well as during the sensitization and training interactions with the farmers.

The following examples describe how the standard guidelines are used to support data monitoring, QA/QC and record keeping:

- The SALM pledge forms, and ‘Operations Plan’ are used in interacting with farmers and farmer groups. In particular, during the initial phase, sensitization, recruitment and contracting process where farmers commit themselves to implement SALM practices, the roles and responsibilities for each farmer and the group with regard to data collection, data provision, data aggregation, record keeping and data verification are introduced and clarified based on these guidelines. This is a very important step towards a transparent, standardized and effective monitoring system since farmers get familiar with the data requirements and the process of data collection. Already during this process, the farmer acknowledges their commitment to adopting and implementing the project activity.
- The ‘ABMS technical guidelines for SALM projects’ is used as guidance for the implementing the monitoring surveys. It also first serves as guidance on how to establish the baseline as per the requirements of the SALM Methodology. The guideline has been developed in a participatory process based on the first survey experiences among selected field extension staff, and reflects the findings of several pretest surveys done to identify the most optimal procedure for the project monitoring surveys. It is used as standard guidance

throughout the project in order to ensure consistent undertaking of the survey, and deals with different quality aspects:

- The whole standard procedure of the survey in the field, each step during the survey is being described.
 - How to deal with systematic and random errors sources during the interview/ survey situation in the field, e.g. by paraphrasing questions for farmers to make sure the data required is understood. Also, the standard procedures of retesting a defined % of farms and cross-checking between the two surveys to validate all data coming from the field.
 - The parameters to be collected from the field are clearly defined including the way and unit the parameter needs to be collected. It is conceptualized in a way to get sufficiently precise information on agricultural practices and at the same time accounting for the diverse conditions among the smallholder farmers in the project.
- In addition to the technical guidelines, the 'Guidelines on GPS farm boundary tracking and GIS data processing instruction' is used as a stepwise guidance on how to track farm boundaries using simple GPS devices (normally GPS Garmin etrex) and how to use open source GIS software applications (Quantum GIS) to process, analyze and store the data. A standard coding system has been developed to efficiently assign the tracks to individual farms/farmer groups. The 'Operations Plan' then defines the in-house procedures and roles and responsibilities on how the field data enter the COAMCO project monitoring system including collection of data from the field (farmer groups), quality checks, entering data into databases, record keeping of hard and soft copies, processing, analyzing and reporting. A standard process is described until the field data are finally stored in the respective databases and data analysis spreadsheets at the central processing unit. This document will be continuously updated also including the new web-based data collection and Project MIS system.

For the REDD+ component, reliable field measurement is ensured by:

- Following the methodology and best-practice guidance of satellite image acquisition
- Sourcing satellite from known and recommended platforms, e.g., Landsat
- Selecting images of good quality, e.g., free from cloud cover.

Verifying data entry and analysis

Reliable carbon estimates require correct entry of data into the data analyses tools. Possible errors in this process can be minimized if the entry of field data is cross-checked and, where necessary, internal tests incorporated to ensure that the data are realistic. The Project-MIS system, including standardized data collection and web-based data management, has inbuilt data quality checks to deal duplicate entries, wrong entries, conversion factors (IPCC crop yield-to-residue conversion factors). The calculations are programmed automatically to avoid accidentally changing the values. In

addition, uncertainty is calculated for the relevant parameters following the guidance of the methodology to determine the overall uncertainty of the model response.

The excel version of the RothC model has been developed in a user-friendly way in order to copy all relevant data (input values) from the MIS into the model including baseline and project values. The model automatically calculates the overall soil carbon benefit for a specific cropping season/year. The databases and model versions available for this monitoring period and values and parameters shown in sections 3.1 and 3.2 are found in the respective files available to the verifier.

For the REDD+ component, the main tasks here involve: pre-processing and post-processing tasks of the satellite images and land use classes respectively. They are described in section the PD (refer to section to 2.4: Step 2: Analysis of historical land-use and land-cover change. The pre-processing tasks ensure the data are of high quality at the start of the analysis, while the post-processing is used to verify the quality of the results.

Desired Precision/Expected Variance

Quantifying SOC sequestration in the SALM project involves basic statistics, primarily for two reasons. Firstly, it helps to design an effective strategy for assessing the carbon benefits of adopting certain SALM practices and –once the monitoring is complete for a particular year- to calculate the input variables for the model to finally determine the amount of carbon sequestered. Secondly, statistics are needed to calculate the uncertainty of the estimate.

Generic guidance to assess uncertainty of estimates is provided in the IPCC Good Practice Guidance (i.e. Chapter 3, Volume 1) and in most of the carbon standards. The following list of criteria refers to the general criteria defined by the carbon offset quality initiative that have to be considered in the VCS projects:

- Offsets Should Be Real: Project-based offset credits should represent actual emission reductions and not simply be artifacts of incomplete or inaccurate accounting.
- Offsets Should Be Additional: Because offsets are used to compensate for emission reductions that an entity would otherwise has to make itself, the reductions resulting from off-set projects must be shown to be “in addition to” reductions that would have occurred without the incentive provided by offset credits. The revenue from selling the project’s emission reductions should be reasonably expected to have incentivized the project’s implementation for an offset project to be considered additional.
- Offsets Should Be Based on a Realistic Baseline: A GHG emission baseline must be established in order to quantify an offset project’s GHG reductions. Offsets are only as credible as their baselines.
- Offsets Should Be Quantified & Monitored: Emission reductions from offset projects must be accurately quantified. Each project must have a unique monitoring plan that defines how, when, and by whom data will be collected and emissions quantified. These plans

should be developed with experts familiar with the specifics of a project and should use established standards.

- **Offsets Should Be Independently Verified:** All GHG reductions should be verified by an independent, qualified, third-party verifier according to approved methodologies and regulations. Verifiers should be entities whose compensation is not in any way dependent on the outcomes of their decisions. Regulatory regimes should have an approved list of offset project verifiers and should have procedures in place to ensure that conflicts of interest are avoided. Ex post monitoring and verification reports should be used as the basis for issuing offset credits.

The SALM methodology stipulates these criteria and generally requires with regard to the ABMS monitoring approach that:

If the project area is stratified, the sampling effort should represent the relevant strata in the sample frame. Where there is no specific survey guidance from national institutions, the project proponent shall use a precision of 15% at the 95% confidence level as the criteria for reliability of sampling efforts. This reliability specification shall be applied to determine the sampling requirements for assessing parameter values. The sampling intensity could be increased to ensure that the model parameters estimated from the ABMS lead to the achievement of a de-sired precision of 15% at the 95% confidence level) for the estimate of greenhouse gas emission reductions from the project.

With regard to the specific uncertainty of the soil model response used for the quantification of the soil organic carbon stock change in the project, the methodology provides a stepwise tool where project proponents should calculate the soil model response using the model input parameters with the upper and lower confidence levels. The range of model responses then demonstrates the uncertainty of the soil modeling. Practically, the methodology allows an uncertainty of <30% of the soil model response with a simple carbon deduction factor if the uncertainty is between 15 and 30%. If the uncertainty of soil models is greater than 30% of the mean value, then the project proponent should increase the sample size of the input parameters until the soil model uncertainty is better than $\pm 30\%$.

All data are fed into an Excel based COMACO Carbon Database in which the input values required for the Roth-C soil carbon model as well as other outputs (e.g. carbon from Gliricidia trees, fertilizer use, etc.) are automatically calculated. For each of the parameters the precision level of the sampling is calculated.

Data maintenance and storage

Because of the relatively long-term nature of the project activities, data archiving (maintenance and storage) will be an important component of quality assurance. Data archiving is taking several forms and copies of all data are made easily accessible to project participants. Copies (electronic and/or paper) of data, data analyses, and models; estimates of the changes in carbon stocks and corresponding calculations and models used; GIS products; and copies of the measuring and

monitoring reports are stored in a dedicated and safe place at the COMACO central processing unit in Lusaka.

Given the time frame over which the project activity will take place and the pace of production of updated versions of software and new hardware for storing data, the electronic copies of the data and reports are updated periodically or converted to a format that could be accessed by any future software application. Copies of all raw data, reports of analysis and supporting spreadsheets are being stored in a dedicated long-term electronic archive and would be available for at least 2 years after the last day of the crediting period: in 2032.

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.1 Baseline Emissions

5.1.1 SALM Component

Baseline emissions have been estimated using baseline survey data collected in the 2012 PHS, and other data sources as referenced. The baseline survey data have been analyzed using the Project MIS⁷.

Baseline emissions due to inorganic fertilizer use

The 2012 baseline survey recorded whether farmers used inorganic fertilizers or not. Fertilizers were applied on 41.78% of total agricultural land. Since, the types and application rates were not recorded, this information was obtained from relevant studies, i.e., a study by Jha and Hojjati, 1993⁸, and Ariga, 2013⁹. According to the second study, the amount of fertilizers supplied per household by the Fertilizer Input Support Program (FISP) having 1.0 - 1.99 ha of agricultural land, which correspond to the range of average farm size in the baseline in this project (0.9-1.8 ha), was reported to be 69 kg. This represents only 48% of the fertilizer need of the households - the remaining being purchased¹⁰. From these figures, the total application rate was estimated at 120 kg/ha. D-compound (10-20-10), a fertilizer made of Nitrogen, Phosphorus, Potassium (N, P, K), is the most common type of fertilizers used in the Eastern Province. Therefore, BEF_t was calculated using the reported fertilizer type and estimated application rate by applying equations (1) and (2) of the CDM A/R Tool “*Estimation of direct nitrous oxide emission from nitrogen fertilization*”, version 01. This resulted into annual per ha baseline emissions due to inorganic fertilizer use of 0.05 tCO₂e for the farmers recruited in 2012. Thus,

⁷ The project MIS can be accessed [here](#).

⁸ Jha and Hojjati, 1993. Fertilizer use on smallholder farms in eastern province, Zambia. Accessed [here](#).

⁹ Ariga, 2013. Zambia Fertilizer Assessment. Accessed [here](#).

¹⁰ Ariga, 2013. Zambia Fertilizer Assessment. Accessed [here](#).

$$BEF_t = 0.05 \text{ tCO}_2\text{e} / \text{ha/year}.$$

For the new farmer instances recruited in 2017, fertilizers were applied on 39% of the total agricultural land. Accordingly, the common type of fertilizer used in Eastern province is D-Compound. Likewise, BEF_t was calculated using the reported fertilizer type and estimated application rate using equations (1) and (2) of the CDM A/R Tool “*Estimation of direct nitrous oxide emission from nitrogen fertilization*”, version 01. Thus, the baseline emissions due to inorganic fertilizer use was;

$$BEF_t = 0.065 \text{ tCO}_2\text{e} / \text{ha/year}.$$

The total baseline emissions due to inorganic fertilizer use in this monitoring period is presented in Table 13.

Table 13: Baseline emissions due to inorganic fertilizer use in this monitoring period

Year	Agricultural land using inorganic fertilisers (ha)	BEF t (tCO ₂ e)
2018	18,872	1,063
2019	18,872	1,063
2020	18,872	1,063
Total		3,189

Baseline emissions due to the use of N-fixing species

The baseline emissions from the use of N-fixing species (BEN_t) are not calculated as specified in the methodology; see Section II.4.2 of SALM methodology. However, as required by the methodology, the baseline area under N-fixing species was estimated as the % of agricultural land under alley-cropping¹¹ at 0.1%. The baseline emissions due to the use of N-fixing species are accounted for as zero as per the methodology.

Thus,

$$BEN_t = 0.$$

Baseline emissions due to burning of biomass

Analysis of the 2012 baseline survey showed that no-burning¹² was practiced on only 3.4% of total agricultural land. Hence, burning of biomass (crop residues) was conversely assumed to be occurring on the remaining 96.6% of the agricultural land in the project area, and 96.6% of the crop residues

¹¹ In alley-cropping, farmers plant rows of *Gliricidia sepium* in alternate rows with crops.

¹² No-burning means burning was not practiced on the farm.

assumed to be burnt. The related GHG emissions have been estimated using equation 20 of the Tool “*Estimation of non-CO₂ emissions from the burning of crop residues*” (Section VI.3 of the SALM methodology). This resulted into annual per ha baseline emissions due to burning of biomass of 0.05 tCO₂e.

Thus,

$$BEBB_t = 0.05 \text{ tCO}_2\text{e per ha per year.}$$

Also, data from the 2017 post-Harvest survey was analyzed for the baseline case. Analysis showed that only 51.07% of the total agricultural land was burned. Hence, 51.07% of the crop residues are assumed to be burnt. The related GHG emissions have been estimated using equation 20 of the Tool “*Estimation of non-CO₂ emissions from the burning of crop residues*”. This resulted into the annual per ha baseline emissions due to biomass burning of 0.03 tCO₂e per ha per year.

Thus, for the new farmer instances, $BEBB_t = 0.03 \text{ tCO}_2\text{e per ha per year}$

The total baseline emissions due to burning of biomass in this monitoring period are presented in Table 14.

Table 14: Baseline emissions due to Biomass burning in this monitoring period

Year	Agricultural land experiencing burning (ha)	BEBB t (tCO ₂ e)
2018	30,759	1,254
2019	30,759	1,254
2020	30,759	1,254
Total		3,762

Baseline removals from existing woody perennials

According to the methodology, baseline removals from existing woody perennials are estimated by applying the latest CDM A/R Tool “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*”. However, the project present plan is not to account for removals from woody perennials tree/shrub both in the baseline and project cases since planting woody perennial is not currently considered among the main project activities. In addition, the quantities of trees in the baseline were very low, hence, the baseline removals from existing woody perennials have been accounted for as zero. Analysis of the baseline survey indicated that, the average number of tree was less than 1 tree/ha. In any case if the project would like to consider removals from woody perennials in the future, baseline trees would not be inventoried as part of the project; only trees planted in the project (“project trees”) will be monitored. Therefore, baseline removals from woody perennials, $BRWP_t$, has been accounted as zero.

Thus,

$$BRWP_t = 0.$$

Baseline emissions from use of fossil fuels in agricultural management

The project is in a typical rural area, and according to the baseline survey, the farmers use manual hand tools and animal draught power for agricultural production. Even at the country level, use of machinery which consumes fuel (diesel/petrol/electricity) is a preserve of large commercial agricultural farms. Zambia is estimated to have an average of only 32 tractors for every 100 square kilometre¹³. Large commercial farms are not present in the project area, and would in any case be excluded from the project as they do not represent the average baseline scenario. Therefore, emissions from use of fossil fuels in agricultural management are conservatively excluded.

Thus,

$$BEFF_t = 0.$$

Baseline removals due to changes in soil organic carbon

Among all SALM management practices promoted by the project, the following would soil organic carbon (SOC) resulting in GHG removals:

- Residue management – including both residue mulching, and cover crops (beans).

The residues of only the most dominant crops: maize, beans/pulses, root crops (potatoes), and tubers (cassava) are considered.

- Composted manure application

As per the methodology, removals due to changes in soil organic carbon should be modelled using RothC Carbon model, or a similar appropriate model.

The goal of modelling soil organic carbon is to estimate increase or decrease in SOC, and not the absolute SOC in the baseline. Hence, modelling soil organic carbon is only feasible when differences between baseline and project scenarios result in changes in SOC. This happens in two cases:

1. When the model input parameter, which increases soil carbon is changing, e.g., due to increasing crop residues yields.

¹³ FAO, 2013 quoted in Stubbs, 2013. Energy usage of agricultural machinery for corn and soybean production in Brazil, India, USA and Zambia. Accessed [here](#).

2. When the area under the SALM practice is changing, e.g., due to increasing adoption of the soil carbon-enhancing practice.

Since both cases are not occurring in the baseline, there is no expected increase in SOC in the baseline. The applicability conditions limit the project to lands that are under agricultural pressure and are degrading, so it can be conservatively assumed that the baseline removals due to changes in SOC are zero. Hence, as per the methodology, baseline removals due to changes in SOC are accounted for as zero.

Thus,

$$\text{BRS } t = 0.$$

Total baseline emissions and removals for SALM component

Total baseline emissions and removals in this monitoring period, BE_t, have been calculated according to the equation 3 of the methodology, and presented in Table 15.

Note that for the sake of estimating VCS Buffer, the values are further divided into GHG emissions and carbon stock change, where by BEF_t, BEFF_t, and BEBB_t are emissions, and BRWP_t is removals also referred to as carbon stock change.

$$\text{BE } t = \text{BEF } t + \text{BEFF } t + \text{BEBB } t - \text{BRWP } t$$

Where:

BE_t = Baseline emissions in year *t*, t CO₂e

BEF_t = Baseline emissions due to nitrogen fertilizer use in year *t*, t CO₂e

BEFF_t = Baseline emissions due to use of fossil fuels in agricultural management in year *t*, t CO₂e

BEBB_t = Baseline emissions due to biomass burning in year *t*, t CO₂e

BRWP_t = Baseline removals due to changes in woody perennials in year *t*, t CO₂e

BRS_t = Baseline removals due to changes in soil organic carbon in year *t*, t CO₂e

Table 15: Total baseline emissions and removals for the monitoring period

Year	BEF _t (tCO ₂ e)	BEFF _t (tCO ₂ e)	BEBB _t (tCO ₂ e)	BRWP _t (tCO ₂ e)	BE _t (tCO ₂ e)	GHG emissions (tCO ₂ e)	Carbon stock changes (tCO ₂ e)
2018	1,063	0	1,254	0	2,317	2,317	0
2019	1,063	0	1,254	0	2,317	2,317	0

2020	1,063	0	1,254	0	2,317	2,317	0
Total	3,189	0	3,762	0	6,950	6,950	0

5.1.2 REDD+ Component

The steps/procedures applied in the quantification of baseline emissions and removals are described in the subsequent sections. For ease of referencing to the methodology, the steps have been titled according to the methodology.

For details of the procedures used to analyze satellite images for projecting the quantity of future deforestation, refer to the PD, section 2.4: Step 2: Analysis of historical land-use and land-cover change.

Actual deforestation analyses in this monitoring period have been done using 2017 and 2020 Landsat images. Hence, for conservativeness, baseline emissions as well as project emissions and leakage emissions for the REDD+ component are also calculated over the three years, i.e., 2018, 2019 and 2020 of the monitoring period.

Methodology Step 4: Projection of future deforestation

Projection of the quantity of future deforestation

The methodology proposes stratifying the reference region accordingly if deforestation drivers, agents or underlying causes have distinct patterns across the reference region. This is not the case in this project: the deforestation driver, small-scale agriculture, is distributed across the entire reference region, leading to a mosaic deforestation pattern observed in the region. Therefore, stratification is not applied. A baseline deforestation rate is projected specifically for the project because no baseline has been established in a jurisdictional program encompassing the project area at the time of preparing this report. The entire reference region is, therefore, considered as one unit (Table 16).

Table 16: Reference region

ID	Name	Description	Area (ha)
n/a.	Reference region	Area enclosed within the physical boundaries of nine chiefdoms	1,444,088

Selection of the baseline approach

The historic average approach is used – referred to as approach “a” in the methodology. The rate of baseline deforestation is assumed to be a continuation of the average annual rate measured during the historical reference period within the reference region. Based on LULC change analysis, deforestation rate was estimated at 3.5% between 2003 and 2008, and 4.5% between 2008 and 2013. From the analyses of agents and drivers of deforestation, deforestation is related to population increase resulting from increasing demand for farmland and settlements. Average deforestation over the whole period (2003-2013) was estimated at about 2.3%. Data from population census 2010 indicates that the Eastern Province population growth rate is almost constant, compared to other Provinces with a clear increasing/decreasing trend. It was estimated at about 2.7% between 1990 and 2000, and 2000 and 2010¹⁴. Hence, the increasing deforestation rate cannot be clearly explained by the population dynamics; hence, approach “a” is selected.

Quantitative projection of future deforestation

Projection of the annual areas of baseline deforestation in the reference region

The historic average approach is used. Annual rate of deforestation in the reference region over the reference period has been estimated at 2.3%. This is derived from forest cover change from 2003 and 2013 Landsat satellite image analyses. Annual areas of baseline deforestation in the Reference region were calculated according to the formula below. The figures are presented in Table 17.

$$ABSLRR_{i,t} = ARR_{i,t-1} * RBSLRR_{i,t}$$

Where:

$ABSLRR_{i,t}$ is annual area of baseline deforestation in stratum i within the reference region at time t ; ha yr⁻¹

$ARR_{i,t-1}$ is area with forest cover in stratum i within the reference region at year $t-1$; ha

$RBSLRR_{i,t}$ is deforestation rate applicable to stratum i within the reference region at year t ; %

t 1, 2, 3 ... T , a year of the proposed crediting period; dimensionless

i 1, 2, 3 ... I_{RR} , a stratum within the reference region; dimensionless

Projection of the annual areas of baseline deforestation in the project area and leakage belt

The annual area deforested in the project area has been estimated by overlaying the annual deforestation maps of the reference region over the project area in GIS system. Deforested areas, which fall within the project area were then extracted to obtain values of the annual areas of baseline deforestation in the project area. The detailed steps followed to project the annual areas of baseline deforestation are presented in the subsequent section on the Projection of the location of future

¹⁴ Central Statistics Office, 2000; and Central Statistics Office, 2010. Accessed [here](#) and [here](#)

deforestation. The same approach has been applied to the leakage belt. The annual areas of baseline deforestation are presented in table 17 for reference region. For the project area, the annual baseline deforestation in the CCAs, which are subject to verification in this monitoring period (see Table 8) are presented in Table 18. The annual baseline deforestation for the leakage belt is presented in Table 19.

Table 17: Annual areas of baseline deforestation in the reference region

Project year t	Stratum i in the reference region $ABSLRR_{i,t}$ (ha)	Total	
		Annual $ABSLRR_t$ (ha)	Cumulative $ABSLRR$ (ha)
2018	10,884	10,884	10,884
2019	10,581	10,581	21,465
2020	10,275	10,275	31,740
Total	31,740	31,740	31,740

Table 18: Annual areas of baseline deforestation in the project area

Project year t	Stratum i in the project area $ABSLPA_{i,t}$ (ha)	Total	
		Annual $ABSLPA_t$ (ha)	Cumulative $ABSLPA$ (ha)
2018	4,683	4,683	4,683
2019	4,901	4,901	9,583
2020	4,935	4,935	14,519
Total	14,519	14,519	14,519

Table 19: Annual areas of baseline deforestation in the leakage belt

Project year t	Stratum i in the project area ABSLLK $_{i,t}$ (ha)	Total	
		Annual ABSLLK $_t$ (ha)	Cumulative ABSLLK (ha)
2018	505	505	505
2019	513	513	1018
2020	500	500	1,518
Total	1,518	1,518	1,518

Projection of the location of future deforestation

The steps described in this section have been undertaken to determine where future deforestation would most likely occur in the baseline case and the annual areas of baseline deforestation in the project area. They are a prediction of future deforestation, based on the guidance provided in the methodology.

The prediction of future deforestation has been done using Terrset Land Change Modeller (LCM) as described in the following steps:

Preparation of factor map

The main geospatial variables that influence the likelihood of deforestation were identified as:

- Distance to roads
- Topography / Elevation

For each of these variables, a factor map is prepared.

The influence of the individual factors/variable to the deforestation potential was performed using an eventuality likelihood algorithm which is a part of the LCM. Other variables were tested but found not to be suitable and were discarded due to the quality of the data e.g. distance to settlements.

The list of variables used is presented in Table 20.

Table 20: List of variables, maps, and factor maps

			Variable represented	Meaning of the categories or pixel value
--	--	--	----------------------	--

ID	File Name	Source	Unit	Description	Range	Meaning
1	_roads_dist_mask	Forestry Department	Meters	Road network	1 – Primary roads	Transition potential that the road network has on the forest to non-forest change
	_roads_dist_mask	ASTER	Meters	Digital elevation model	0 – 1405	Transition potential that the elevation has on the forest to non-forest change

Preparation of deforestation risk map

Several factors were tested as part of the process for producing a deforestation risk map. Among them were: distance to previous deforested areas, distance to roads, distance to rivers/streams, slope and distance to settlements.

The factors were then individually and in groups tested in order to see which of them is producing the highest accuracy for the deforestation risk map.

From the tested factors, distance to previous deforested areas, distance to roads, and topography/elevation shown the biggest significance for the projected deforestation and were thus selected.

This analysis, performed using the Terrset Land Change Modeller, determines the transition potential from forest to non-forest using the group of factors. The maps generated in the process present the deforestation risk in percentage, indicating increasing risk from 0, meaning no risk and up to 1 meaning highest risk.

Selection of most accurate deforestation risk map

The factors/combinations that produced the most accurate deforestation risk map were distance to roads, and topography/elevation.

Mapping of locations of future deforestation

The prediction of locations of future deforestation was done using the Land Change Modeler (LCM). The prediction is based on all areas defined from the land use/cover analysis as forest in 2013 for the initial areas and 2017 for the new chiefdoms added to the project. The LCM assigns deforestation sequentially to the pixels of greatest deforestation risk. The deforested areas after 5 years and 10 years are shown in Table 21 and Table 22 as examples. Annual deforestation maps are not presented as the differences are less noticeable in form of maps, but the GIS files are available to the verifier.

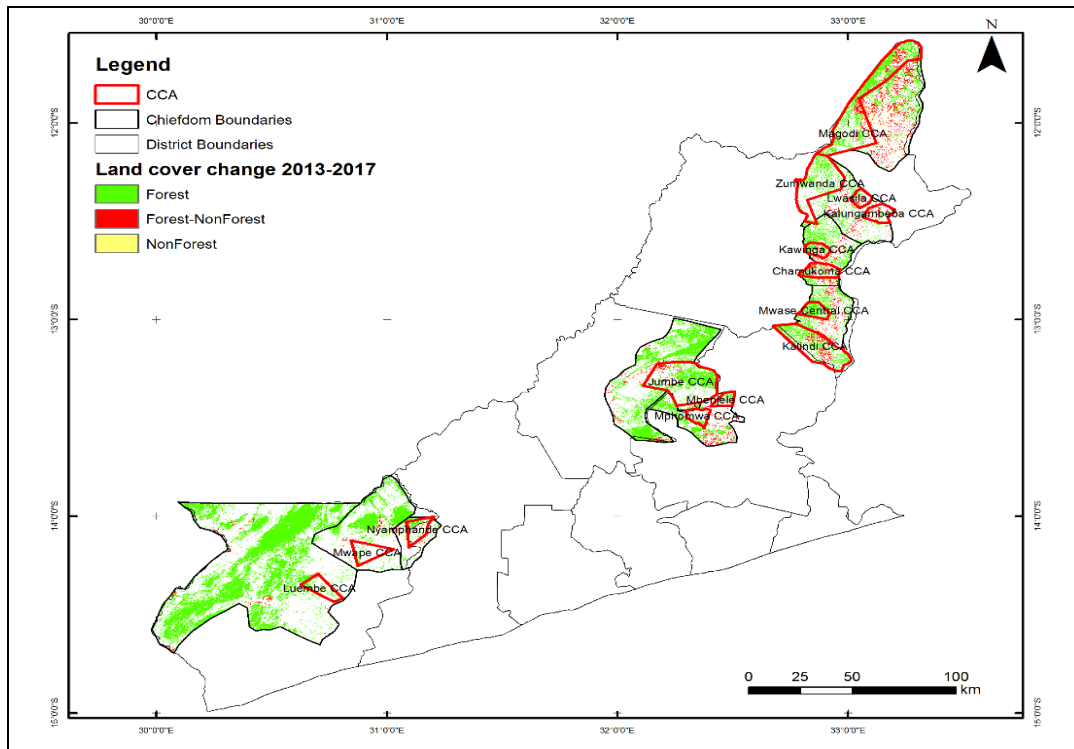


Figure 5: Deforestation areas in 2021 - 5 years into project

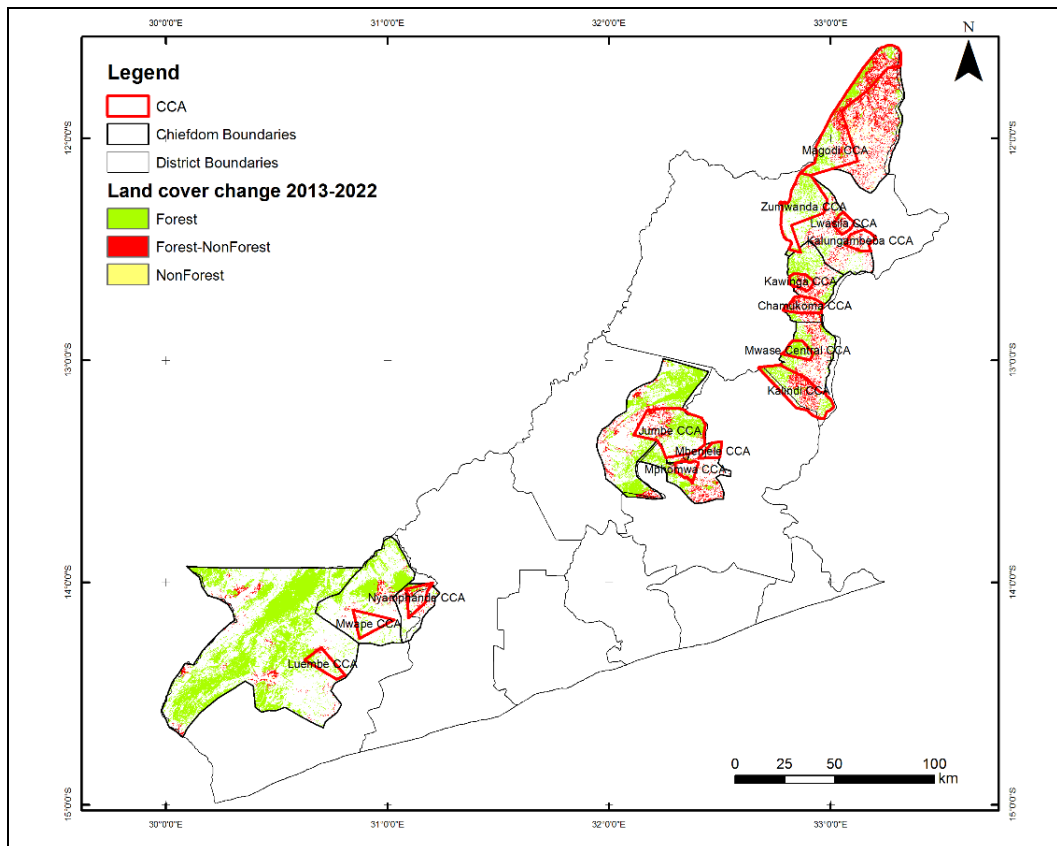


Figure 6: Deforestation areas in 2022 - 10 years into project

Methodology Step 5: Definition of the land-use and land-cover change component of the baseline

Calculation of baseline activity data per forest class

To estimate the areas that would be deforested in the project area and the leakage belt the map of forests in the project area and leakage belt produced through LULC analysis 2013 for the initial areas, was overlaid on the annual deforestation maps, and the forest areas predicted to be deforested were extracted. The resultant figures are presented in Table 21 and Table 22 below for the project area, which are subject to verification in this monitoring period, and the leakage belt respectively. During the fixed baseline period, the carbon stocks and boundaries of forest class within the project area and leakage belt are assumed to remain constant as per the methodology.

Table 21: Annual areas deforested within the project area in the baseline case (baseline activity data of the forest class)

Area deforested within the project area		Total baseline deforestation in the project area	
IDicl> Name> Project year	Forest (ha)	ABSLPA annual (ha)	ABSLPA cumulative (ha)
2018	4,683	4,683	4,683
2019	4,901	4,901	9,583
2020	4,935	4,935	14,519
Total	14,519	14,519	14,519

Table 22: Annual areas deforested within the leakage belt in the baseline case (baseline activity data)

Area deforested within the leakage belt		Total baseline deforestation in the leakage belt	
IDicl> Name> Project year	Forest (ha)	ABSLKt annual (ha)	ABSLKt cumulative (ha)
2018	505	505	505

2019	513	513	1018
2020	500	500	1,518
Total	1,518	1,518	1,518

Method 1 (historical LU/LC-change) of the methodology has been used to estimate baseline activity data per post-deforestation forest class. In this approach historical LU/LC-change changes are assumed to be representative for future trends. The post deforestation land-use comprises only cropland since when forests are converted, the resultant land use is cropland/ agriculture. The methodology proposes zonation of the reference region if there are different combinations of post-deforestation land uses. In this project, the post-deforestation land use class is small-scale agriculture; therefore, zonation is not applied. The annual areas of post-deforestation forest class figures are presented in Table 23, Table 24 and Table 25 below for the reference region, the project area, which are subject to verification in this monitoring period, and the leakage belt respectively.

Table 23: Annual areas of post-deforestation class fcl within the reference region in the baseline case

IDz > Name> Project year	ha	Total baseline deforestation in the reference region	
		ABSLRRt annual ha	ABSLRR cumulative ha
2018	10,884	10,884	10,884
2019	10,581	10,581	21,465
2020	10,275	10,275	31,740
Total	31,740	31,740	31,740

Table 24: Annual areas of post-deforestation class fcl within the project area in the baseline case

IDz > Name> Project year	ha	Total baseline deforestation in the project area	
		ABSLPA annual ha	ABSLPA cumulative ha
2018	4,683	4,683	4,683
2019	4,901	4,901	9,583
2020	4,935	4,935	14,519
Total	14,519	14,519	14,519

Table 25: Annual areas of post-deforestation class fcl within the leakage belt in the baseline case

IDz > Name> Project year	ha	Total baseline deforestation in the project area	
		ABSLPA annual ha	ABSLPA cumulative ha
2018	505	505	505
2019	513	513	1018
2020	500	500	1,518
Total	1,518	1,518	1,518

Methodology Step 6: Estimation of baseline carbon stock changes and non-CO2 emissions

Estimation of baseline carbon stock changes

Estimation of the average carbon stocks of each LU/LC class

Estimates of the average carbon stocks of forest and non-forest classes were obtained from data derived from a national forest inventory conducted between 2005 and 2008 in Zambia under the Integrated Land Use Assessment phase I program (ILUA I). The data have been analyzed and reported in a study by Kamelarczyk (2009)¹⁵, hence, average carbon stock values were taken from this study.

The methodology allows the use of existing inventories and studies subject to the following conditions:

- The data are less than 10 years old;
- The data are derived from multiple measurement plots;
- All species above a minimum diameter are included in the inventories;
- minimum diameter for trees included is 30 cm or less at breast height (DBH);
- Data are sampled from good coverage of the classes over which they will be extrapolated.

The data used satisfy the above conditions as the inventory was undertaken between 2005 and 2008; hence, the data are less than 10 years old. A total of 221 plots were measured, each with 4 sub-plots, and all species down to 7 cm DBH were measured covering forest, agricultural land, and other land use classes defined for the inventory purpose. The classes defined in this monitoring report correspond to the classes shown below in the inventory.

Classes defined in this monitoring report	Corresponding classes in inventory
Forest	Forest – main land-use category
Small-scale agriculture	Annual crops

As per the methodology's uncertainty requirement and for conservativeness, the lower boundary of the 90% confidence interval of mean carbon stocks have been used where the class is an initial forest class in the project area or a final non-forest class in the leakage belt, and the higher boundary of the 90% confidence interval where the class is an initial forest class in the leakage belt or a final non-forest class in the project area. This approach is applied for all carbon pools, except for soil carbon, where IPCC default has been applied. For soil carbon, a default approach proposed in the methodology has been applied, which states: "when defaults are used, the lowest value of the range given in the literature source (or the value reduced by 30%) must be used for the forest classes, and the highest value (or the value augmented by 30%) for non-forest classes." Hence, the IPCC default reduced by 30% has been

¹⁵ Kamelarczyk, K. B. F., 2009. Carbon Stock Assessment and Modelling in Zambia. A UN-REDD programme study. Accessed [here](#).

used for SOC for the forest classes, and the value increased by 30% for SOC for the non-forest class (agricultural land).

The carbon stock values used are shown in Table 26 and Table 27 for the project area and leakage belt respectively. The initial forest class will have constant carbon stock values over the fixed baseline period.

Table 26: Carbon stocks per hectare of initial forest class, existing in the project area

<i>ID_{icl}</i>	Initial forest class							
	Name: Forest							
	<i>ID_{icl}</i> 1							
	Average carbon stock per ha $\pm$ 90% CI							
	<i>Cab_{icl}</i>		<i>Cbb_{icl}</i>		<i>CsoC_{icl}</i>		<i>Ctot_{icl}</i>	
	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI
	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹
Forest	89.5	8.6	25.0	2.4	128.3	-	242.9	11.0

Table 27: Carbon stocks per hectare of initial forest class existing in the leakage belt

<i>ID_{icl}</i>	Initial forest class							
	Name: Forest							
	<i>ID_{icl}</i> 1							
	Average carbon stock per ha $\pm$ 90% CI							
	<i>Cab_{icl}</i>		<i>Cbb_{icl}</i>		<i>CsoC_{icl}</i>		<i>Ctot_{icl}</i>	
	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI
	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹
Forest	89.5	8.6	25.0	2.4	128.3	-	242.9	11.0

Long-term (20 years) average carbon stocks of post-deforestation class

When the forests are converted, the post-deforestation land use class is annual croplands. In the typical shifting system that used to exist, after cultivation for some time, forestlands converted to agriculture would be left alone for up to 20-25 years, and regain its vegetation. This typical shifting cultivation system is no longer possible. Studies and expert and common knowledge in the region indicate that most farmers do not fallow, rather continuously cultivate their lands. For those practicing

it, the fallow period is very short: one to three years, and generally below 5 years¹⁶. Therefore, the average carbon stocks of post-deforestation classes have been taken as the average carbon stock of annual crops derived from the ILUA I inventory data (Table 28) for all carbon pools except soils. Hence, average soil carbon stocks after forest conversion to cropland were estimated using IPCC default reference soil organic carbon (SOC_{REF}) for mineral soils (IPCC, 2006); and relative soil stock change factors for land use, management regime, and level of inputs listed in Table 5.5 of IPCC (2006). The project area's climate is classified as tropical dry, and the soils are both High Activity Mineral (HAC), and Low Activity Mineral (LAC) (refer to PD section 2.2 Figure 4). Although the first soil class is predominant, to be conservative, we used SOC_{REF} for LAC (35 tC/ha as opposed to 38 tC/ha for HAC). The farming system has been defined as cropland continuously managed for more than 20 years, to predominantly annual crops, with low input, and full tillage. The following equation of the IPCC has been used for the estimation:

$SOC = SOC_{REF} * F_{LU} * F_{MG} * F_I$, Where:

SOC = soil organic carbon stock, tons C ha⁻¹

SOC_{REF} = the reference carbon stock, tons C ha⁻¹ (value used: 35; Source: IPCC, 2003¹⁷, Table 3.3.3)

F_{LU} = stock change factor for land use or land-use change type; dimensionless (value used: 0.58; Source: IPCC, 2006¹⁸, Table 5.5)

F_{MG} = stock change factor for management regime, dimensionless (value used: 1.00; Source: IPCC, 2006, Table 5.5)

F_I = stock change factor for input of organic matter, dimensionless (value used: 0.95; Source: IPCC, 2006, Table 5.5).

Note that, since a default value for SOC has been used, it has been augmented by 30% as per the methodology¹⁹.

Table 28: Long-term (20-years) average carbon stocks per hectare of post-deforestation LU/LC class present in the reference region.

¹⁶ Kwesiga et al., 2005. Improved fallows in Eastern Zambia: History, Farmer Practice and Impacts. Accessed [here](#).

Kwesiga, (n.d). The Sesbania sesban Improved Fallow Model in Eastern Zambia. Accessed [here](#).

¹⁷ IPCC 2003 LUCF Sector Good Practice Guidance. Accessed [here](#).

¹⁸ IPCC 2006 Guidelines for National Greenhouse Gas Inventories. Accessed [here](#)

¹⁹ The methodology states that "When defaults are used, the lowest value of the range given in the literature source (or the value reduced by 30%) must be used for the forest classes, and the highest value (or the value augmented by 30%) for non-forest classes."

ID_{fcl}	Post deforestation class fcl							
	Name:				Annual crop			
	ID_{fcl}				4			
	Average carbon stock per ha $\pm$ 90% CI							
	Cab_{icl}		Cbb_{icl}		$CsoC_{icl}$		$Ctot_{icl}$	
	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI	Cstock	$\pm$ 90% CI
	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹	tCO ₂ -e ha ⁻¹
Annual crop	22.7	7.1	9.1	2.8	70.7	-	102.4	9.9

Calculation of carbon stock change factors

The method stipulated in the methodology is applied to calculate and account for the decay of carbon stock in initial forest classes (icl) and increase in carbon stock in post-deforestation class. It applies default linear functions as described below.

Above-ground biomass: immediate release of 100% of the carbon stock is assumed to happen in the year in which deforestation occurs (t^*).

Below-ground biomass: an annual release of 1/10th of the initial carbon stock is assumed to happen each year between the year in which deforestation occurs (t^*) and year t^*+9 .

Soil organic carbon: it is assumed that in a 20-year period, the carbon stock changes from the level estimated for the initial forest classes (icl) to the level estimated for the post-deforestation class fcl . The change occurs linearly.

The carbon stock change factors are presented in Table 29 for the initial forest class, and Table 30 for final (post-deforestation) class. Litter, deadwood and wood product pools are not accounted for in this project.

Table 29: Carbon stock changes factors for initial forest class, icl

Dense forest - Initial forest class

Year after deforestation		$\square Cab_{icl,t}$	$\square Cbb_{icl,t}$	$\square CsoC_{icl,t}$	$\square CTot_{icl,t}$
1	t^*	-80.9	-2.3	0.1	-83.0
2	t^*+1	0.0	-2.3	0.1	-2.2
3	t^*+2	0.0	-2.3	0.1	-2.2
4	t^*+3	0.0	-2.3	0.1	-2.2
5	t^*+4	0.0	-2.3	0.1	-2.2
6	t^*+5	0.0	-2.3	0.1	-2.2
7	t^*+6	0.0	-2.3	0.1	-2.2
8	t^*+7	0.0	-2.3	0.1	-2.2

9	$t^{*}+8$	0.0	-2.3	0.1	-2.2
10	$t^{*}+9$	0.0	-2.3	0.1	-2.2
11	$t^{*}+10$	0.0	0.0	0.1	0.1
12	$t^{*}+11$	0.0	0.0	0.1	0.1
13	$t^{*}+12$	0.0	0.0	0.1	0.1
14	$t^{*}+13$	0.0	0.0	0.1	0.1
15	$t^{*}+14$	0.0	0.0	0.1	0.1
16	$t^{*}+15$	0.0	0.0	0.1	0.1
17	$t^{*}+16$	0.0	0.0	0.1	0.1
18	$t^{*}+17$	0.0	0.0	0.1	0.1
19	$t^{*}+18$	0.0	0.0	0.1	0.1
20	$t^{*}+19$	0.0	0.0	0.1	0.1

Method 1 of the methodology has been used for $\Delta C_{ab_{icl,t}}$ and $\Delta C_{bb_{icl,t}}$, and Method 2 for $\Delta C_{soc_{icl,t}}$.

Table 30: Carbon stock change factors for final class (Method 1)

Final Class:

Year after deforestation		$\square C_{ab_{icl,t}}$	$\square C_{bb_{icl,t}}$	$\square C_{soc_{icl,t}}$	$\square C_{Tot_{icl,t}}$
1	t^{*}	3.0	1.2	0.0	4.2
2	$t^{*}+1$	3.0	1.2	0.0	4.2
3	$t^{*}+2$	3.0	1.2	0.0	4.2
4	$t^{*}+3$	3.0	1.2	0.0	4.2
5	$t^{*}+4$	3.0	1.2	0.0	4.2
6	$t^{*}+5$	3.0	1.2	0.0	4.2
7	$t^{*}+6$	3.0	1.2	0.0	4.2
8	$t^{*}+7$	3.0	1.2	0.0	4.2
9	$t^{*}+8$	3.0	1.2	0.0	4.2
10	$t^{*}+9$	3.0	1.2	0.0	4.2
11	$t^{*}+10$	0.0	0.0	0.0	0.0
12	$t^{*}+11$	0.0	0.0	0.0	0.0
13	$t^{*}+12$	0.0	0.0	0.0	0.0
14	$t^{*}+13$	0.0	0.0	0.0	0.0
15	$t^{*}+14$	0.0	0.0	0.0	0.0
16	$t^{*}+15$	0.0	0.0	0.0	0.0
17	$t^{*}+16$	0.0	0.0	0.0	0.0
18	$t^{*}+17$	0.0	0.0	0.0	0.0

19	$t^{*}+18$	0.0	0.0	0.0	0.0
20	$t^{*}+19$	0.0	0.0	0.0	0.0

Method 1 of the methodology has been used for $\Delta Cab_{icl,t}$ and $\Delta Cbb_{icl,t}$, and Method 2 for $\Delta Csoc_{icl,t}$. The spreadsheet used for the calculation is available to the verifier.

Calculation of baseline carbon stock changes

Equation 10 of the methodology has been used:

$$\begin{aligned} \Delta CBSLPA_t = & \sum_{p=1}^P \left(\sum_{icl=1}^{Icl} ABSLPA_{icl,t} * \Delta Cp_{icl,t=t^*} - \sum_{z=1}^Z ABSLPA_{z,t} * \Delta Cp_{z,t=t^*} \right. \\ & + \sum_{icl=1}^{Icl} ABSLPA_{icl,t-1} * \Delta Cp_{icl,t=t^*+1} - \sum_{z=1}^Z ABSLPA_{z,t-1} * \Delta Cp_{z,t=t^*+1} \\ & + \sum_{icl=1}^{Icl} ABSLPA_{icl,t-2} * \Delta Cp_{icl,t=t^*+2} - \sum_{z=1}^Z ABSLPA_{z,t-2} * \Delta Cp_{z,t=t^*+2} + \dots \\ & \left. + \sum_{icl=1}^{Icl} ABSLPA_{icl,t-19} * \Delta Cp_{icl,t=t^*+19} - \sum_{z=1}^Z ABSLPA_{z,t-19} * \Delta Cp_{z,t=t^*+19} \right) \end{aligned}$$

Where:

$\Delta CBSLPA_t$ = Total baseline carbon stock change within the project area at year t ; tCO₂-e.

$ABSLPA_{icl,t}$ = Area of initial forest class icl deforested at time t within the project area in the baseline case; ha

$ABSLPA_{icl,t-1}$ = Area of initial forest class icl deforested at time $t-1$ within the project area in the baseline case; ha

...

$ABSLPA_{icl,t=t-19}$ = Area of initial forest class icl deforested at time $t-19$ within the project area in the baseline case; ha

$\Delta Cp_{icl,t=t^*}$ = Average carbon stock change factor for carbon pool p in the initial forest class icl applicable at time t ; tCO₂-e ha⁻¹

$\Delta Cp_{icl,t=t^*+1}$ = Average carbon stock change factor for carbon pool p in the initial forest class icl applicable at time $t=t^*+1$ (= 2nd year after deforestation); tCO₂-e ha⁻¹

...

$\Delta Cp_{icl,t=t^*+19}$ = Average carbon stock change factor for carbon pool p in the initial forest class icl applicable at time $t=t^*+19$ (20th year after deforestation) tCO₂-e ha⁻¹.

$ABSLPA_{z,t}$ = Area of the zone z “deforested” at time t within the project area in the baseline case; ha

$ABSLPA_{z,t-1}$ = Area of the zone z “deforested” at time $t-1$ within the project area in the baseline case; ha

...

$ABSLPA_{z,t-19}$ = Area of the zone z “deforested” at time $t-19$ within the project area in the baseline case; ha

$\Delta Cp_{z,t=t^*}$ = Average carbon stock change factor for carbon pool p in zone z applicable at time $t = t^*$; tCO₂e ha⁻¹

$\Delta Cp_{z,t=t^*+1}$ = Average carbon stock change factor for carbon pool p in zone z applicable at time $t = t^*+1$ (2nd year after deforestation); tCO₂-e ha⁻¹

...

$\Delta Cp_{z,t=t^*+19}$ = Average carbon stock change factor for carbon pool p in zone z applicable at time $t = t^*+19$ (20th year after deforestation); tCO₂-e ha⁻¹

$icl = 1, 2, 3 \dots$ icl initial (pre-deforestation) forest classes; dimensionless

$z = 1, 2, 3 \dots Z$ zones; dimensionless

$p = 1, 2, 3 \dots P$ carbon pools included in the baseline; dimensionless

$t = 1, 2, 3 \dots T$, a year of the proposed project crediting period; dimensionless

t^* = the year at which $ABSLPA_{icl,t}$ is deforested in the baseline case.

The total baseline carbon stock changes in the project area in Table 31.

Table 31: Total baseline carbon stock change in the project area

Project year	Total net carbon stock change in the project area	
	ΔC BSLPA icl,t Annual tCO ₂ -e)	ΔC BSLPA icl Cumulative tCO ₂ -e
2018	-408,389	-408,389
2019	-490,986	-899,375

2020	-525,005	-1,424,380
Total	-1,424,380	-1,424,380

Baseline non-CO2 emissions from fires

Baseline emissions from fires is considered to be significant – as conversions of forests to agricultural lands are associated with burning, i.e., slash-and-burn. When the forest is cleared, the stem wood is removed and used for fuelwood and/or charcoal, while the branches and twigs are left on site and burnt. Hence, only this fraction of above-ground biomass is considered for the calculations of the baseline non-CO₂ emissions from forest fires. In miombo woodlands, branches constitute about 60% of the total tree biomass²⁰. Hence, this has been taken as the fraction of biomass that is burnt. Other biomass carbon pools are conservatively excluded; also they constitute very small fractions of the total biomass (section 2.3). For the average percentage of the deforested area in which fire is used, it is taken as 100% since conversion is always associated with burning. Baseline non-CO₂ emissions from forest fires have been calculated according to following equations 11, 12 and 13 of the methodology. The parameters used for the calculations are shown in Table 32, and the estimated non-CO₂ emissions from forest fires are presented in Table 33.

$$EBB_{tot_{icl,t}} = EBB_{N2O_{icl,t}} + EBB_{CH4_{icl,t}}$$

Where:

$EBB_{tot_{icl,t}}$ = Total GHG emission from biomass burning in forest class *icl* at year *t*; tCO₂e ha⁻¹

$EBB_{N2O_{icl,t}}$ = N₂O emission from biomass burning in forest class *icl* at year *t*; tCO₂e ha⁻¹

$EBB_{CH4_{icl,t}}$ = CH₄ emission from biomass burning in forest class *icl* at year *t*; tCO₂e ha⁻¹

$$EBB_{N2O_{icl,t}} = EBB_{CO2_{icl,t}} * 12/44 * NCR * ER_{N2O} * 44/28 * GWP_{N2O}$$

$$EBB_{CH4_{icl,t}} = EBB_{CO2_{icl,t}} * 12/44 * ER_{CH4} * 16/12 * GWP_{CH4}$$

Where:

$EBB_{CO2_{icl,t}}$ = Per hectare CO₂ emission from biomass burning in slash and burn in forest class *icl* at year *t*; tCO₂-e ha⁻¹

$EBB_{N2O_{icl,t}}$ = Per hectare N₂O emission from biomass burning in slash and burn in forest class *icl* at year *t*; tCO₂-e ha⁻¹

$EBB_{CH4_{icl,t}}$ = Per hectare CO₂ emission from biomass burning in slash and burn in forest class *icl* at year *t*; tCO₂-e ha⁻¹

²⁰ Minishi et al., 2010. The role of the Miombo Woodlands of the Southern Highlands of Tanzania as carbon sinks. Accessed [here](#).

NCR = Nitrogen to Carbon Ratio (IPCC default value = 0.01); dimensionless

NCR = Nitrogen to Carbon Ratio (IPCC default value = 0.01); dimensionless

ER_{N2O} = Emission ratio for N_2O (IPCC default value = 0.007)

ER_{CH4} = Emission ratio for CH_4 (IPCC default value = 0.012)

GWP_{N2O} = Global Warming Potential for N_2O (IPCC default value = 310 for the first commitment period)

GWP_{CH4} = Global Warming Potential for CH_4 (IPCC default value = 21 for the first commitment period)

$$EBBCO2_{icl,t} = Fburnt_{icl} * \sum_{p=1}^P (C_{p,icl,t} * Pburnt_{p,icl} * CE_{p,icl})$$

Where:

$EBBCO2_{icl,t}$ = Per hectare CO_2 emission from biomass burning in the forest class icl at year t ; $tCO_2e \text{ ha}^{-1}$

$Fburnt_{icl}$ = Proportion of forest area burned during the historical reference period in the forest class icl ; %

$C_{p,icl,t}$ = Average carbon stock per hectare in the carbon pool p burnt in the forest class icl at year t ; $tCO_2-e \text{ ha}^{-1}$

$Pburnt_{p,icl}$ = Average proportion of mass burnt in the carbon pool p in the forest class icl ; %

$CE_{p,icl}$ = Average combustion efficiency of the carbon pool p in the forest class icl ; dimensionless

p = Carbon pool that could burn (above-ground biomass, dead wood, litter)

$icl = 1, 2, 3, \dots, icl$ (pre-deforestation) forest classes

$t = 1, 2, 3 \dots T$, a year of the proposed project crediting period; dimensionless

Table 32: Parameters used to calculate non- CO_2 emissions from forest fires

Initial forest class		Parameters								
$IDicl$	Name	% $Fburnt_{icl}$	$tCO_2-e \text{ ha}^{-1} Cab$	% $Pburnt_{ab,icl}$	% $CE_{ab,icl}$	$tCO_2-e \text{ ha}^{-1} ECO2-ab$	$tCO_2-e \text{ ha}^{-1} EBBCO2-tot$	$tCO_2-e \text{ ha}^{-1} EBBN2O-tot$	$tCO_2-e \text{ ha}^{-1} EBBCH4-tot$	$tCO_2-e \text{ ha}^{-1} EBBtot_{icl}$
1	Forest	100%	89.5	60%	90%	48.3	48.3	0.4494	4.4	4.4

Note that $\text{tCO}_2\text{-e ha}^{-1}$ EBB_{total} is 4.4 because only CH_4 is considered in the calculation since both CO_2 and N_2O are excluded as per the methodology.

Table 23: non-CO2 emissions from forest fires

Project year	Emission of non-CO2 emissions from baseline forest fires		Total baseline non-CO2 emissions from forest fires in the project area	
	IDicl = 1		Annual EBBBSLPAt tCO2-e	Cumulative EBBBSLPA tCO2-e
	ABSLPAicl,t ha	EBBBSLtotal tCO2-e ha-1		
2018	4,683	4.4	20,740	20,740
2019	4,901	4.4	21,704	42,444
2020	4,935	4.4	21,858	64,303
Total			64,303	64,303

Total baseline emissions and removals for REDD+ component

Total baseline emission and removals of the REDD+ component have been estimated as the sum of baseline carbon stock change and non-CO₂ emissions due to fires in the project area and are presented in Table 34. The values are further split into GHG emissions and carbon stock changes.

Table 34: Total baseline emissions and removals for REDD+ component

Year	Carbon stock changes (tCO2e)	Non-CO2 emission due to fires (tCO2e)	Total (tCO2e)
2018	-408,389	20,740	429,129
2019	-490,986	21,704	512,691
2020	-525,005	21,858	546,864
Total	-1,424,380	64,303	1,488,683

5.2 Project Emissions

5.2.1 SALM Component

The ex-post project emissions and removals have been determined based on analyses of the data recorded in the annual post-harvest surveys conducted during this monitoring period. The data analysis has been done using the web-based project MIS system²¹.

Project emissions due to fertilizer use

The project is not promoting increased use of fertilizers, but the adoption of SALM practices that are expected to improve soil fertility, hence, reducing the need to maintain or increase fertilizer application rates.

Comparing the baseline data with those of the monitoring period indicates that the area under fertilizer use has decreased though not in a consistent manner (Table 35).

Table 35: Agriculture land applying fertilizer

Year	Agricultural land applying fertilizers (%)
2012 (Baseline)	41.78%
2013	23.29%
2014	20.65%
2015	32.76%
2016	38.76%
2017	39.00%
2018	34.33%
2019	36.93%
2020	25.32%

The average use of fertilizer for the years 2018, 2019 and 2020 were 73.9kg/ha, 79.4kg/ha and 63.3kg/ha respectively and were based on the total area under fertilizer for the years, 2018, 2019 and 2020. This information is found in the MIS ([MIS link](#)). Therefore, the annual per ha project emissions due to fertilizer use are 0.032 tCO₂e/ha/year for 2018, 0.035tCO₂e/ha/year for 2019 and

²¹ The project MIS can be accessed [here](#).

0.028tCO₂e/ha/year for 2020 respectively. These annual per ha project emissions due to fertilizer use have been estimated from quantities reported in the 2018, 2019 and 2020 monitoring surveys, applying equations (1) and (2) of the CDM A/R Tool “Estimation of direct nitrous oxide emission from nitrogen fertilization”, version 01. This data is available in the MIS and the EF were determined for each year.

The total project emissions due to fertilizer use are reported in Table 36.

Table 36: Project emissions due to fertilizer use for this monitoring period

Year	Share of agricultural land that applied fertilizer (ha)	Total (tCO ₂ e)
2018	15,429	494
2019	16,598	581
2020	11,380	319
Total		1,393

Project emissions due to the use of N-fixing species

The N-fixing species planted in the project is *Gliricidia sepium*, which is planted in an agroforestry technique known as alley-cropping. According to the project methodology, emissions due to the use of N-fixing species is estimated if the area cropped with N-fixing tree species in the project is more than 50% larger than the area under N-fixing species in the baseline. The area cropped with N-fixing crops (beans & pulses) has not increased (see project MIS); hence, only *Gliricidia sepium* is considered for estimation of project emissions due to the use of N-fixing species.

The project emission from the use of N-fixing species has been calculated applying equations 18 and 19 of the tool “Estimation of direct nitrous oxide emission from N-fixing species and crop residues” (Section VI.1 of the SALM Methodology).

The density and area under *Gliricidia sepium* (trees/ha) have been derived from 2018, 2019 and 2020 Post Harvest survey data (refer to the MIS).

To determine the aboveground biomass, a conservative estimate of 5 kg dry mass per tree is applied – based on a study in Eastern Zambia by Kaonga (2012)²² which measured 2-year-old trees. This value is assumed for each year during the verification period and multiplied by the number of trees planted per ha²³. The number of hectares under agroforestry was determined from PHS survey data in the MIS.

²² Kaonga 2012. Fractal analysis of canopy architectures of *Acacia angustissima*, *Gliricidia sepium*, and *Leucaena collinsii* for estimation of aboveground biomass in a short rotation forest in eastern Zambia. Journal of Forestry Research (2012) 23(1): 1–12.

²³ See Excel file ‘COMACO_Monitoring Report ER summaries’

The estimated project emissions due to the use of N-fixing species are presented in Table 37.

Table 37: Project emissions due to N-fixing species in this monitoring period

Year	Agricultural land with Gliricidia (ha)	PEN t (tCO ₂ e)
2018	17,034	1,937
2019	16,791	1,910
2020	12,562	1,429
Total		5,276

Project emissions due to the burning of biomass

The project is promoting no-burning as one of the sustainable agricultural management practices. Compared to the baseline, there has been significant reduction in the practice of biomass burning, as determined by the percentage of agricultural land practicing no-burning (Table 38).

Table 38: Trends in no-burning practice in this monitoring period

Year	% Of agricultural land not burnt (ha)
2018	38.18%
2019	44.92%
2020	73.88%

Project emissions from biomass burning have been estimated using equation 20 of the Tool “*Estimation of non-CO₂ emissions from the burning of crop residues*” (Section VI.3 of the SALM methodology), and the values are presented in Table 39.

Table 39: Project emissions due to burning of biomass for the monitoring period

Year	Share of total agricultural land burnt (ha)	PEBB t (tCO ₂ e)
2018	27,784	834
2019	24,755	743
2020	11,739	235

Total	1,811
-------	-------

Project removals from woody perennials

Removals from woody perennials are not accounted for since planting woody perennials is not currently considered among the main project activities. The project is promoting alley cropping with *Gliricidia* species, which is accounted for in terms of soil carbon sequestration. In case the project would like to consider removals from woody perennials in the future, only trees planted in the project (“project trees”) will be monitored. Therefore, project removals from existing woody perennials are accounted for as zero in this monitoring period.

Project emissions due to use of fossil fuels for agricultural management

The small-scale subsistence farmers in the project area have very low financial capacities; they cannot afford use of gas- or diesel-powered machinery in agricultural management, which would otherwise cause GHG emissions.

According to the monitoring surveys conducted in this monitoring period, the farmers use only manual hand tools and animal draught power for agricultural production. Hence, project emissions due to use of fossil fuels for agricultural management are accounted for as zero.

Thus,

$$PEFF_t = 0$$

Project removals due to changes in soil organic carbon

Project removals due to changes in soil organic carbon has been estimated by modelling soil organic carbon change using the RothC Carbon model. The model estimates changes in SOC as a result of inputs of plant residues into the soil. Details of the model, the data required for its parameterization, and modelling procedures can be obtained from the Rothamsted Research webpage link [here](#).

Climate data used to parameterize the model have been obtained from local meteorological stations in the Eastern Province. Soil data have been obtained from the Harmonized World Soil Database, and plant residue inputs into the soil from monitoring data collected by the project, which are analyzed and presented in the project MIS.

The Roth C carbon model predicts a change in soil organic carbon when:

- The model input parameter is changing, e.g., more plant residues are added into the soil; and/or
- When the area under the SALM practice is changing, e.g., due to increasing area of adoption of residue management practice by farmers.

The modelling processes are described below and the Excel-based version of the models used are available to the verifier as separate files.

Soil carbon inputs

Among the SALM practices promoted by the project, the following have been considered for project removals due to changes in soil organic carbon since they return carbon into the soil:

1. Compost manuring – inputs of carbon from manure, applied and incorporated into the soil.
2. Residue management – inputs of carbon from crop residues applied as mulch and incorporated into the soil.
3. Agroforestry, i.e., alley-cropping with *Gliricidia sepium*.
4. Inputs from other unburnt biomass

Inputs from residue management and composting

Data on plant residues and manure inputs into the soil were derived from the estimates of yields of plant residues and manure, and the area of agricultural land on which farmers practiced residue management, and compost manuring.

The amount of plant residues produced was derived from the reported plant yields using the equations listed in Table 11.2 of Volume 4 of the 2006 IPCC Guidelines. As per the methodology, the area-weighted values are used. For the value used, refer to the project MIS.

The amount of composted manure available for each farm was estimated based on the population and types of livestock, converted to volatile solid production using the equations in Tables 10A-4 to 10A-9 of Volume 4 of the 2006 IPCC Guidelines. The data used came from a national survey (Integrated Land Use Assessment - ILUA). The estimation and value used are contained in the Excel: *COMACO_compost_input*. Since livestock has not been monitored in this monitoring period, the value derived from the ILUA survey has been taken to be equal for each year of this monitoring period.

Inputs from agroforestry

The soil carbon inputs from agroforestry considered in this project is the biomass from *Gliricidia sepium*, a fast-growing tree species that farmers plant to enhance soil fertility. The shrub is grown on croplands in alley-cropping practice, where crops are grown between rows of the nitrogen-fixing shrubs. The shrubs' leafy biomass is harvested and incorporated into the soil.

In this monitoring period, the density of *Gliricidia sepium* (trees/ha) has been estimated using 2020 survey data, and has been assumed to be the same for the previous two years²⁴. The number of *Gliricidia sepium* per ha is presented in the Table 40 below. To determine the above ground biomass, a conservative estimate of 5 kg dry mass per tree is used – based on a study in Eastern Zambia by

²⁴ According to study by Kaonga and Bayliss-Smith, 2012. A Conceptual Model of Carbon Dynamics for Improved Fallows in the Tropics, tree density did not change much in the first 3 years of planting in experimental plots.

Kaonga (2012)²⁵ which measured 2-year old trees. This value is assumed for each year during the verification period and multiplied by the number of trees planted per ha²⁶

Table 40: *Gliricidia sepium* biomass species in this monitoring period

Year	Number of trees per ha	Above ground biomass (kg d.m./ha)
2018	62	310
2019	100	500
2020	327	1,635

The annual amount of biomass returned to the soil as soil carbon inputs has been estimated using a study by Kaonga and Bayliss-Smith (2012), which was conducted in the Eastern Province. The study estimated annual soil carbon inputs of 1.3 tC/ha from *Gliricidia sepium*. The shrubs had been planted at initial density of 10,000 stems/ha, but the density had reduced by about 30% at the time of the study (three years later)²⁷. Hence, the 1.3 tC/ha/year soil carbon inputs, reported in the study, were being contributed by the remaining 7,000 trees.

Using the tree density in this monitoring period (Table 40 above), the annual soil carbon inputs for the project has been estimated by proportion as equal to 0.007 tC/ha/year.

In accordance with the methodology, area-weighted averages of soil carbon inputs have been used. In addition, inputs were used if the precision, measured by the standard error, was $\leq 15\%$ at the 95% confidence level and not zero, in order to reduce the uncertainty of the modelled SOC changes. For the values of residue carbon inputs, refer to the project MIS.

Inputs from other unburnt biomass

Other biomass includes weeds that grow between the time of harvest and commencement of land preparation for the next crop season – when the land is rested from cultivation/weeding. According to a local study conducted in the Eastern Province (Kaonga and Bayliss-Smith, 2012), this weed growth contributes substantial biomass as soil carbon input. This soil carbon input has been accounted for in this monitoring period applying the following value and assumptions:

²⁵ Kaonga 2012. Fractal analysis of canopy architectures of *Acacia angustissima*, *Gliricidia sepium*, and *Leucaena collinsii* for estimation of aboveground biomass in a short rotation forest in eastern Zambia. Journal of Forestry Research (2012) 23(1): 1–12.

²⁶ See Excel file 'COMACO_Monitoring Report ER summaries'

²⁷ Kaonga and Bayliss-Smith, 2012. A Conceptual Model of Carbon Dynamics for Improved Fallows in the Tropics.

- Annual soil carbon input from weed biomass is equivalent to 1.2 tC/ha/year²⁸. This figure already assumed suppressed weed growth, i.e., weed growth on fields having Gliricidia, hence, is conservative.
- Only fields that do not burn (are under no-burning practice) and residue management are accounted for. This is to account for the fact that where there is burning, the biomass will be lost due to that burning, and where there is residue management, weed growth is highly suppressed, hence, weed biomass is negligible.

For the estimation of the weed biomass used as soil carbon inputs in the RothC model, refer to the Excel file 'COMACO Monitoring Report ER summaries'

Project equilibrium soil organic carbon density in management systems

The soil carbon inputs from residue management, agroforestry and compost manure were entered into the Roth C model and the model run to predict equilibrium (20 years) SOC densities and averaged removal factors of SALM practices.

The CDM A/R Methodological Tool "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities, version 01.1.0" is applied to ensure conservative accounting of SOC change. The tool requires that 'considering uncertainties and inherent limitation of the precision of a factor-based estimation used in this tool, value of the rate of change of SOC stock is not accounted as more than 0.8 t C/ha/ year'. Assuming that this default approach is considering a land use change from non-forest land to forest land (as defined by the country forest definitions), this project uses the input values only if the modeled SOC change is below 0.8 in order to be conservative (see the Roth C models – sheet: Results column Y).

The resulting SOC values were used together with areas of adoption of the SALM practices (see project MIS) to estimate project soil organic carbon at equilibrium in the respective years PSequil,1 (year 1), PSequil,2 (year 2), etc. according to equation 4 of the methodology:

$$PS_{equil,t} = \sum_{m_C} PA_{C,m_C,t} \bullet SOC_{C,m_C,t} + \sum_{m_G} PA_{G,m_G,t} \bullet SOC_{G,m_G,t} \quad 4$$

Estimation of project removals due to changes in SOC

The estimation of project removals due to changes in SOC was done using the following equation – the result of combining equation 5 and equation 6 of the methodology²⁹:

$$PRS_t = \frac{1}{20} * (PS_{equil,t} - BS_{equil,0}) * \frac{44}{12}$$

Where

PRS_t Estimate of project removals due to changes in soil organic carbon in year t, t CO₂e

²⁸ Kaonga and Bayliss-Smith, 2012. A Conceptual Model of Carbon Dynamics for Improved Fallows in the Tropics.

²⁹ See Annex for a detailed explanation of the derivation of the equation.

$PS_{equil,t}$ Estimate of the project SOC in equilibrium year t , tC

$BS_{equil,0}$ Baseline SOC in equilibrium year 0, tC

Uncertainty

To address uncertainty of the RothC model outputs, the SALM methodology stipulates that the user calculate the soil model response using the model input parameters with the upper confidence level (P_{max}) and lower confidence level (P_{min}) values as shown in equation 14 of the methodology³⁰:

$$\begin{aligned} PRS_{min,t} &= Model(P_{min}, Temperature_{max}, Precipitation_{max}, ClayContent_{min}) \\ PRS_{max,t} &= Model(P_{max}, Temperature_{min}, Precipitation_{min}, ClayContent_{max}) \end{aligned} \quad 14$$

The range of model responses represents the uncertainty of the soil modeling, which is calculated with equation 15 of the methodology:

$$UNC_t = \frac{|PRS_{max,t} - PRS_{min,t}|}{2 * PRS_t}$$

The Excel-based RothC model used has been designed to automatically calculate the overall uncertainty. Where the uncertainty of the modelled value is below 15%, the estimated project removals due to changes in SOC (PRS_t) are fully counted. Where the uncertainty exceeds 15%, the modeled PRS_t is adjusted by discounting following step 4 of section IV.2.8 of the SALM methodology. In this monitoring period, the uncertainties of the modelled PRS_t have all been below 15%.

Adjustment for tillage

A tillage factor has been included to account for the impact of tillage change on soil carbon sequestration. This has been done by applying the IPCC default coefficients – denoted as K - for estimating the impact of changing tillage specific to climatic zones³¹. The following values from the IPCC are used – treating the project area as falling within the tropical dry climate zone (mean annual temperature of $>25^{\circ}C$, mean annual rainfall $< 1000mm$) classification of the IPCC.

Tillage practice under baseline	Tillage practice in the project	K
Conventional till	Reduced till	1.09

This value is applied only to the share of agricultural land under reduced tillage in the respective year of this project monitoring period: see the Excel file: *COMACO Monitoring Report ER summaries*.

³⁰ See Annex for a detailed explanation on the use of this equation and the calculation of uncertainty

³¹ IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

The PRS_t estimates for this monitoring period are presented in Table 41 below.

Table 41: Project removals due to changes in SOC in the monitoring period

Year	PRS t (tCO ₂ e)
2018	27,576
2019	23,048
2020	36,249
Total	86,873

Details of derivation of the equations for the estimation of PRS_t are presented in Appendix 1.

Total ex post project net GHG emissions and removals by sinks

The ex-post actual net GHG emissions and removals by sinks have been estimated using equation 7 of the methodology:

$$PE_t = PEF_t + PEFF_t + PEN_t + PEBB_t - PRWP_t - PRS_t \quad 7$$

The ex-post estimates of actual net GHG emissions and removals by sinks are presented in Table 42.

Table 42: Ex-post actual net project GHG emissions and removals by sinks

Year	PEF t (tCO ₂ e)	PEFF t (tCO ₂ e)	PEN t (tCO ₂ e)	PEBB t (tCO ₂ e)	PRWP t (tCO ₂ e)	PRS t (tCO ₂ e)	PE t (tCO ₂ e)	GHG emissions (tCO ₂ e)	Carbon stock changes (tCO ₂ e)
2018	494	0	1,937	834	0	27,723	-24,458	3,265	27,723
2019	581	0	1,910	743	0	23,290	-20,057	3,233	23,290
2020	319	0	1,429	235	0	35,253	-33,271	6,498	35,253
Total	1,393	0	5,276	1,811	0	86,266	-77,786	12,995	86,266

5.2.2 REDD+ Component

The quantification of project emissions involved the following tasks:

1. Analysis of deforestation in the project area and leakage belt in this monitoring period. For details of the procedures used to process satellite images for determining the quantity of deforestation, refer to the PD, section 2.4.2: Methodology Step 2: Analysis of historical land-use and land-cover change. The steps are the same as described in the PD, except that the analyses refer to 2017 and 2020 Landsat images. In summary, the steps involved: collecting relevant satellite images, pre-processing, and interpreting/classifying the images, and map accuracy assessment. The satellite images and results of the analyses are available to the verifier.
2. Estimation of carbon stock changes.
3. Estimation of non-CO₂ emissions due to fires.
4. Estimation of emissions due to catastrophic events.

Analysis of deforestation in the project area and leakage belt

The quantity of deforestation in the project area was estimated from the deforestation maps, produced by subtracting the forest cover map at the project start from the forest cover map at the end of the monitoring period in a GIS system. The deforestation map was overlaid over the project area, and deforested areas falling inside the project area were extracted to derive the values of deforestation in the project area in this monitoring period. Similarly, for the leakage belt, the deforestation map was overlaid over the leakage belt and deforested areas falling inside the leakage belt were extracted to get the values of deforestation in the leakage belt in this monitoring period. The results are presented in Table 43 and Table 44 for project area subject to verification in this monitoring period, and the leakage belt respectively. Note that since deforestation analyses in this monitoring period have been done at two points in time, i.e., 2017 and 2020, all annual figures of actual deforestation in this monitoring period are derived by averaging totals over the three-year period.

Table 43: Areas lost forest in the project area in this monitoring period

Project year t	Stratum i in the project area APSLPAt (ha)	Total	
		Annual APSLPAt (ha)	Cumulative APSLPAt (ha)
2018	1,733	1,733	1,733
2019	1,733	1,733	3,467
2020	1,733	1,733	5,200
Total	5,200	5,200	5,200

Table 44: Areas lost forest in the leakage belt in this monitoring period

Project year <i>t</i>	Stratum <i>i</i> in the Leakage region APSLKt (ha)	Total	
		Annual APSLKt (ha)	Cumulative APSLKt (ha)
2018	149	149	150
2019	149	149	299
2020	149	149	449
Total	449	449	150

Areas deforested per forest class

The figures are presented in Table 45 and Table 46 for the project area – subject to verification in this monitoring period, and leakage belt respectively. During the fixed baseline period, which includes this monitoring period, the carbon stocks and boundaries of the forest class within the project area and leakage belt are assumed to remain constant.

Table 45: Areas lost forest per forest class icl within the project area in this monitoring period (activity data per forest class)

IDicl> Name> Project year <i>t</i>	Area deforested per forest class icl within the project area 1 Forest ha	Total deforestation in the project area	
		Annual (ha)	Cumulative (ha)
2018	1,733	1,733	1,733
2019	1,733	1,733	3,467
2020	1,733	1,733	5,200
Total	5,200	5,200	5,200

Table 46: Areas losing forest per forest class icl within the leakage belt in this monitoring period (activity data per forest class)

IDicl> Name> Project year t	Area deforested per forest class icl within the Leakage belt	Total deforestation in the Leakage belt	
	1 Forest ha	Annual (ha)	Cumulative (ha)
2018	149	149	149
2019	149	149	299
2020	149	149	449
Total	449	449	150

Areas per post-deforestation class

The post-deforestation land-use comprises only cropland – since when forests are converted, the resultant land use is cropland/agriculture. The areas of post-deforestation forest class are presented in Table 47 and Table 48 below for the project area that are subject to verification in this monitoring period, and the leakage belt respectively.

Table 47: Annual areas of post-deforestation class fcl within the project area in this monitoring period

Project year	Total deforestation in the project area	
	annual ha	cumulative ha
2018	1,733	1,733
2019	1,733	3,467
2020	1,733	5,200
Total	5,200	5,200

Table 48: Annual areas of post-deforestation class fcl within the leakage belt in this monitoring period

Project year	Total deforestation in the Leakage belt	
	annual ha	cumulative ha
2018	149	149
2019	149	299
2020	149	449
Total	449	449

Estimation of carbon stock changes

The *ex-ante* estimated average carbon stocks and average carbon stock change factors do not change during the fixed baseline, hence, the *ex-ante* estimated average carbon and carbon stock change factors are used both for the baseline case and here for the project case. For the values of average carbon and carbon stock change factors, refer to baseline emissions: section 4.1.

Equation 10 of the methodology was used to calculate carbon stock changes. Note that in this case, all baseline values referred to in that equation are automatically replaced with project case values of this monitoring period. The carbon stock changes in the project area are presented in Table 49.

Table 39: Carbon stock changes in the project area

Project year	Carbon stock change in the project area	
	annual tCO ₂ -e	cumulative tCO ₂ -e
2018	-151,178	-151,178
2019	-200,474	-351,652
2020	-211,435	-563,087
Total	-563,087	-563,087

Estimation of non-CO2 emissions due to fires

Conversions of forests to agricultural lands are associated with burning i.e. slash-and-burn. When the forest is cleared, most of the stem wood is removed for use as fuelwood. The branches and twigs are left and burnt on-site to clear the site for planting. Hence, only the branch and twig biomass have conservatively been considered for the calculations of the baseline non-CO₂ emissions from forest fires. In miombo woodlands, branches constitute about 60% of the total tree biomass³². Other biomass carbon pools have also been conservatively excluded; also they constitute very small fractions of the total biomass (section 2.3). The average percentage of the deforested area in which fire is used has been taken as 100% since clearing of the forests is always associated with burning. The non-CO₂ emissions from fires have been calculated according to following equations 11, 12, and 13 of the methodology (see section 4.1). The parameters used for the calculations are shown in Table 50, and the estimated non-CO₂ emissions from fires are presented in Table 51.

Table 50: Parameters used to calculate non-CO2 emissions from fires

Initial forest class		Parameters								
IDicl	Name	% $F_{burnt,icl}$	tCO ₂ -e ha ⁻¹ C_{ab}	% $P_{burnt,ab,icl}$	% $CE_{ab,icl}$	tCO ₂ -e ha ⁻¹ $ECO2-ab$	tCO ₂ -e ha ⁻¹ $EBBCO2-tot$	tCO ₂ -e ha ⁻¹ $EBBN2O-tot$	tCO ₂ -e ha ⁻¹ $EBBCH4-tot$	tCO ₂ -e ha ⁻¹ $EBBtot,icl$
1	Forest	100%	89.5	60%	90%	48.3	48.3	0.4494	4.4	4.4

Note that tCO₂-e ha⁻¹ EBB_{tot,icl} is 4.4 because only CH₄ is considered in the calculation since both CO₂ and N₂O are excluded as per the methodology.

Table 51: Non-CO2 emissions from fires in the project area in this monitoring period

IDicl> Name> Project year t	Emissions of non-CO2 gases from forest fires		Total non-CO2 emissions from fires in the project area	
	1 Forest ha	tCO ₂ -e ha ⁻¹	Annual tCO ₂ -e	Cumulative tCO ₂ -e
2018	1,733	4.4	7,678	7,678
2019	1,733	4.4	7,678	15,355

³² Minishi et al., 2010. The role of the Miombo Woodlands of the Southern Highlands of Tanzania as carbon sinks. Accessed [here](#).

2020	1,733	4.4	7,678	23,033
Total			23,033	23,033

Estimation of emissions due to catastrophic events

No catastrophic events have been registered in this monitoring period. Hence, ex-post estimation of emissions due to catastrophic events is zero.

Total project emissions of the REDD+ component

The total project emissions for the REDD+ component is presented in Table 52, and further split into GHG emissions and carbon stock changes.

Table 52: Total project emissions in this monitoring period

Year	Carbon stock changes (tCO ₂ e)	Non-CO ₂ emission due to fires (tCO ₂ e)	Emissions due to catastrophic events (tCO ₂ e)	Total project emissions & removals (tCO ₂ e)
2018	-151,178	7,678	0	158,855
2019	-200,474	7,678	0	208,152
2020	-211,435	7,678	0	219,113
Total	-563,087	23,033	0	586,120

5.3 Leakage

5.3.1 SALM Component

Based on the methodology, the only source of leakage that the SALM component of the project could cause is leakage in form of a switch to non-renewable biomass use or fossil fuels.

In the project area, the predominant traditional cooking method makes use of the three-stone open fires. Based on a survey of energy sources in 2015, none of the farmers used manure or crop residues for heating/cooking. Only firewood (99% of farmers) and charcoal (1% of farmers) are used³³. Manure or crop residues have low energy content and produce substantial smoke, therefore, are also not a preferred fuel source.

The project is improving the supply of firewood as the stems of *Gliricidia sepium* planted in alley-cropping provides additional firewood. There is no likelihood of leakage from the project, hence, estimate of

³³ See Fuel-Wood-Data files in supporting documentation.

leakage in this monitoring period is zero. The project will continue to monitor leakage in subsequent monitoring periods.

Thus,

$LHE_t = 0$.

5.3.2 REDD+ Component

As per the methodology, leakage is the quantity of deforestation in the leakage belt that is above the baseline level. Hence, leakage is estimated as actual deforestation in this monitoring period in the leakage belt, which is above the baseline deforestation in the leakage belt. As shown in Table 53 actual deforestation is lower than baseline, hence, no leakage.

Table 53: Areas deforested within the leakage belt in this monitoring period

Project year t	Deforestation in the leakage belt		
	Baseline (ha)	In this monitoring period (ha)	Leakage deforestation (ha)
2018	505	149	None, actual deforestation is below baseline
2019	513	149	„
2020	500	149	
Total	1,518	449	„

Leakage emissions are, thus, zero in this monitoring period.

5.4 Net GHG Emission Reductions and Removals

The ex-post net anthropogenic GHG removals by sinks are estimated separately for each component, then summed up.

5.4.1 SALM Component

The ex-post net anthropogenic GHG removals by sinks are estimated according to equation 8 of the methodology, and the values are presented in Table 54.

$$\Delta R_t = BE_t - PE_t - LHE_t$$

Table 54: Ex-post actual net project GHG emissions and removals by sinks

Year	BE t (tCO ₂ e)	PE t (tCO ₂ e)	LHE t (tCO ₂ e)	ΔR_t (tCO ₂ e)	Net GHG emissions (tCO ₂ e)	Net carbon stock change (tCO ₂ e)
2018	2,317	-24,458	0	26,775	-948	27,723
2019	2,317	-20,057	0	22,374	-916	23,290
2020	2,317	-33,271	0	35,588	335	35,253
Total	6,950	-77,786	0	84,736	-1529	86,266

5.4.2 REDD+ Component

The ex-post net anthropogenic GHG removals by sinks are estimated as baseline emissions minus project emissions minus leakage emissions. The results are presented in Table 55.

Table 55: The ex-post net anthropogenic GHG removals by sinks

Year	Baseline emissions (tCO ₂ e)	Project emissions (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Ex-post actual net project GHG emissions (tCO ₂ e)	Net GHG emissions (tCO ₂ e)	Net carbon stock change (tCO ₂ e)
2018	429,129	158,855	0	270,273	13,062	257,211
2019	512,691	208,152	0	304,539	14,027	290,512
2020	546,864	219,113	0	327,751	14,181	313,570
Total	1,488,683	586,120	0	902,563	41,270	861,293

Total ex-post net anthropogenic GHG removals and sinks

The ex-post net anthropogenic GHG removals by sinks are estimated as the sum of net GHG emissions of the SALM component and REDD+ component (Table 56).

Table 56: Total ex-post net project GHG emissions and removals by sinks

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net Carbon Stock Change (tCO ₂ e)	Buffer Contribution	VCU or Net GHG Emission Reductions	Net GHG emission reductions or removals (tCO ₂ e)
2018	431,445	134,397	0	284,934	31,343	265,706	297,048
2019	515,008	188,095	0	313,802	34,518	292,394	326,912
2020	549,180	185,842	0	348,823	38,371	324,968	363,339
Total	1,495,633	508,334	0	947,559	104,231	883,068	987,300

The total net anthropogenic GHG removals and sinks in this monitoring period are 987,300tCO₂e. Independent assessment of risk has been conducted for each component, resulting in the non-permanence risk rating of 11% – as assessed and documented in the AFOLU non-permanence risk report (provided as a separate document). Applying this risk-rating to the net carbon stock change as per the VCS requirement, the total number of buffer credits that need to be deposited into the AFOLU pooled buffer account is 104,231tco₂e. Hence, the number of GHG credits eligible to be issued as VCUs in this monitoring period is 883,068tco₂e.

APPENDIX I: DERIVATION OF THE EQUATION FOR THE ESTIMATION OF PRS_t

PRS_t is estimated using equation 6 of the methodology. According to this equation PRS_t is the difference between SOC in project year t and SOC in the previous year t – 1.

The estimate of project removals due to changes in soil organic carbon is given by:

$$PRS_t = (PS_t - PS_{t-1}) \bullet \frac{44}{12} \quad 6$$

Where:

PRS_t	Estimate of project removals due to changes in soil organic carbon in year t, t CO ₂ e.
PS_t	Estimate of the project SOC in year t, tC
PS_{t-1}	Estimate of the project SOC in year t-1, tC

The estimation of PS_t and PS_{t-1} is done according to equation 5 of the methodology.

The estimate of soil organic carbon with transitions can be estimated using:

$$PS_t = \frac{1}{D} \sum_{t-D+1}^t PS_{equil,t} \bullet \Delta t \quad 5$$

Where:

PS_t	Estimate of the project SOC in year t, tC
$PS_{equil,t}$	Estimate of the project SOC in equilibrium year t, tC
D	The transition period required for SOC to be at equilibrium after a change in land use or management practice, year
Δt	Time increment = 1 year

Assuming that D = 20 years (default value provided in the methodology)

$$PS_t = \frac{1}{20} * (PS_{equil,t-19} + PS_{equil,t-18} + PS_{equil,t-17} + PS_{equil,t-16} + PS_{equil,t-15} + PS_{equil,t-14} + PS_{equil,t-13} + PS_{equil,t-12} + PS_{equil,t-11} + PS_{equil,t-10} + PS_{equil,t-9} + PS_{equil,t-8} + PS_{equil,t-7} + PS_{equil,t-6} + PS_{equil,t-5} + PS_{equil,t-4} + PS_{equil,t-3} + PS_{equil,t-2} + PS_{equil,t-1} + PS_{equil,t})$$

$$PS_{t-1} = \frac{1}{20} * (PS_{equil,t-20} + PS_{equil,t-19} + PS_{equil,t-18} + PS_{equil,t-17} + PS_{equil,t-16} + PS_{equil,t-15} + PS_{equil,t-14} + PS_{equil,t-13} + PS_{equil,t-12} + PS_{equil,t-11} + PS_{equil,t-10} + PS_{equil,t-9} + PS_{equil,t-8} + PS_{equil,t-7} + PS_{equil,t-6} + PS_{equil,t-5} + PS_{equil,t-4} + PS_{equil,t-3} + PS_{equil,t-2} + PS_{equil,t-1})$$

PS_t values are required if one is trying to estimate the absolute SOC. Since the ultimate goal of the methodology is the increase or decrease in SOC with the project these values are not required. Then PRS_t is directly calculated by applying the two equations above into equation 6 of the methodology.

$$PRS_t = \frac{1}{20} * (PS_{equil,t} - PS_{equil,t-20}) * \frac{44}{12}$$

As indicated in the methodology it can be assumed that

- $PS_{equil,t} = BS_{equil,0}$ for values of $t - D + 1 < 0 \rightarrow$ before the start of the project
- $PS_{equil,0} = BS_{equil,0} \rightarrow$ start of the project

Then for the first 20 years of the project the equation above is equivalent to the following equation, which was used for the estimation of PRS_t in the second verification period.

$$PRS_t = \frac{1}{20} * (PS_{equil,t} - BS_{equil,0}) * \frac{44}{12}$$

This new equation may lead one to think that PRS_t is no longer the difference between PS in year t and PS in year $t - 1$ but only PS in year t , which would mean that cumulative values are being estimated. However, this equation is 100 % equivalent to equation 6, as it is just the result of applying equation 5 together with equation 6, and thus only takes into account the additional SOC corresponding year t . It is important here not to mix up parameters $PS_{equil,t}$ and PS_t as they refer to two different concepts:

- $PS_{equil,t}$ is the SOC at equilibrium reached when practices from year t are implemented during many years (20 years is considered the time to reach equilibrium). This is used to obtain PS values. Actually $PS_{equil,t}$ only considers practices implemented in year t and is completely independent from what happened in previous years (thus not cumulative).
- PS_t is the SOC in project year t and results not only from practices implemented in year t ($PS_{equil,t}$) but also from practices implemented during the last 20 years (time to reach equilibrium).

Estimation of $PRS_{min,t}$ and $PRS_{max,t}$ and calculation of uncertainty

The assessment of uncertainty is done according to the steps indicated in the methodology.

Step 1 - All model input parameters are calculated at the upper and lower confidence limit. Parameters include:

- Temperature, precipitation and clay content
- P_{min} and P_{max} values of soil inputs in the baseline scenario (in our case residues and composted manure recorded in the PFM 2009)
- P_{min} and P_{max} values of soil inputs in the project scenario (in our case residues and composted manure recorded in FGM 2012 to 2014/2015)

Step 2 - $PRS_{min,t}$ and $PRS_{max,t}$ are calculated as indicated in equation 14 of the methodology

The project removals due to changes in soil organic carbon using the minimum and maximum values of the parameters is given by

$$\begin{aligned} PRS_{min,t} &= Model(P_{min}, Temperature_{max}, Precipitation_{min}, ClayContent_{min}) \\ PRS_{max,t} &= Model(P_{max}, Temperature_{min}, Precipitation_{max}, ClayContent_{max}) \end{aligned} \quad 14$$

Where:

$PRS_{min,t}$	The minimum value of project removals due to changes in soil organic carbon at the 95% confidence interval
$PRS_{max,t}$	The maximum value of project removals due to changes in soil organic carbon at the 95% confidence interval

The calculation of $PRS_{min,t}$ and $PRS_{max,t}$ is done in the same as the calculation of PRS_t (see the derivation explained above) but applying the combination of parameters indicated in equation 14.

The calculation of $PRS_{min,t}$ is done as follows:

$$\begin{aligned} PRS_{t,min} &= (PS_{t,min} - PS_{t,min}) * \frac{44}{12} \\ PRS_{t,min} &= \frac{1}{20} * (PS_{equil,t,min} - PS_{equil,t-20,min}) * \frac{44}{12} \\ PRS_{t,min} &= \frac{1}{20} * (PS_{equil,t,min} - BS_{equil,0,min}) * \frac{44}{12} \end{aligned}$$

Where, according to equation 14, SOC density values are the result of running the RothC model with

- P_{min} which refers to the lower confidence limit of soil input parameters (as indicated in Step 1). This includes values in the baseline (for the calculation of $BS_{equil,0,min}$) and in the project (for the calculation of $PS_{equil,t,min}$)
- $Temperature_{max}$

- $Precipitation_{max}$
- $ClayContent_{min}$

In the same way the calculation of $PRS_{max,t}$ is done as follows

$$PRS_{t,max} = (PS_{t,max} - PS_{t,max}) * \frac{44}{12}$$

$$PRS_{t,max} = \frac{1}{20} * (PS_{equil,t,max} - PS_{equil,t-20,max}) * \frac{44}{12}$$

$$PRS_{t,max} = \frac{1}{20} * (PS_{equil,t,max} - BS_{equil,0,max}) * \frac{44}{12}$$

Where, according to equation 14, SOC density values are the result of running the RothC model with

- P_{max} which refers to the lower confidence limit of soil input parameters (as indicated in Step 1). This includes values in the baseline (for the calculation of $BS_{equil,0,max}$) and in the project (for the calculation of $PS_{equil,t,max}$)
- $Temperature_{min}$
- $Precipitation_{min}$
- $ClayContent_{max}$

Step 3 - Uncertainty is estimated using equation 15 of the methodology

Step 3: Calculate the uncertainty in the model output

The uncertainty in the output model is given by:

$$UNC_t = \frac{|PRS_{max,t} - PRS_{min,t}|}{2 * PRS_t} \quad 15$$

The calculation of all three PRS values include soil input parameters estimated from both the baseline and the project scenario. As a consequence the variability of both scenarios is assessed in the uncertainty.

APPENDIX II: POST - HARVEST REPORT 2020

Post-harvest Survey Report 2020

Link: <https://drive.google.com/file/d/1k5MNJ5TcRcKsl-P7yB0mdvAZdtvfxmZy/view?usp=sharing>

APPENDIX III: Results for Sections 5.1, 5.2, 5.3 and 5.4

Electronic spreadsheets for the results in this Monitoring Period can be found [HERE](#) and [HERE](#)