

COMACO LANDSCAPE MANAGEMENT PROJECT



Document Prepared By

Community Markets for Conservation (COMACO)

COMACO Head Office

Light Industrial Area

Plot No: 7223, Kachidza Road

Lusaka, Zambia

Project Title	COMACO Landscape Management Project
Version	2.0
Date of Issue	26 September 2016
Prepared By	COMACO
Contact	COMACO Head Office Light Industrial Area Plot No: 7223, Kachidza Road Lusaka, Zambia Director - Dale Lewis – Tel +260-977-373747 dlewis@itswild.org http://www.itswild.org/

Table of Contents

1	Project Details	4
1.1	Summary Description of the Project	4
1.2	Sectoral Scope and Project Type	5
1.3	Project Proponent	6
1.4	Other Entities Involved in the Project	6
1.5	Project Start Date	7
1.6	Project Crediting Period	7
1.7	Project Scale and Estimated GHG Emission Reductions or Removals	7
1.8	Description of the Project Activity	8
1.9	Project Location	16
1.10	Conditions Prior to Project Initiation	18
1.11	Compliance with Laws, Statutes and Other Regulatory Frameworks	19
1.12	Ownership and Other Programs	23
1.12.1	Right of Use	23
1.12.2	Emissions Trading Programs and Other Binding Limits	24
1.12.3	Other Forms of Environmental Credit	24
1.12.4	Participation under Other GHG Programs	24
1.12.5	Projects Rejected by Other GHG Programs	24
1.13	Additional Information Relevant to the Project	24
2	Application of Methodology	27
2.1	Title and Reference of Methodology	27
2.2	Applicability of Methodology	28
2.2.1	SALM component	28
2.2.2	REDD+ component	34
2.3	Project Boundary	38
2.3.1	SALM component	39
2.3.2	REDD+ component	40
2.4	Baseline Scenario	52
2.4.1	SALM component	53
2.4.2	REDD+ component	54
2.5	Additionality	69
2.5.1	SALM Component	69
2.5.2	REDD+ component	72
2.6	Methodology Deviations	77
3	Quantification of GHG Emission Reductions and Removals	77
3.1	Baseline Emissions	77
3.1.1	SALM component	77
3.1.2	REDD+ component	84
3.2	Project Emissions	104
3.2.1	SALM component	104
3.2.2	REDD+ component	114
3.3	Leakage	120
3.3.1	SALM component	120
3.3.2	REDD+ component	120
3.4	Net GHG Emission Reductions and Removals	124
3.4.1	SALM component	124
3.4.2	REDD+ component	125
4	Monitoring	128
4.1	Data and Parameters Available at Validation	128
4.1.1	SALM component	128
4.1.2	REDD+ component	129
4.2	Data and Parameters Monitored	132
4.2.1	SALM component	132
4.2.2	REDD+ component	140

4.3	Monitoring Plan	142
4.3.1	Monitoring tasks of the SALM component	142
4.3.2	Monitoring tasks of the REED+ component	148
4.3.3	Institutional structure for monitoring of the project – both components	153
5	Environmental Impact.....	161
6	Stakeholder Comments.....	162
APPENDIX: Chiefdoms constituting the outer project boundary		164

1 PROJECT DETAILS

1.1 Summary Description of the Project

The COMACO Landscape Management Project (CLMP) promotes sustainable agriculture and forest conservation. The main objectives of the project are twofold: 1) to sustainably increase smallholder farmer agricultural productivity, income and welfare; and 2) to reduce uncontrolled forest loss and degradation, and increase net forest cover. Hence, the project comprises two components:

1. Sustainable Agricultural Land Management (SALM) component – which aims to promote widespread adoption of agricultural practices including conservation agriculture that increase food production per unit area and farmers' income. The project promotes the adoption by farmers of legume-based alley cropping, residues management (e.g. mulching; cessation of residue burning), and reduced tillage among other SALM practices.
2. REDD+ (Avoided Unplanned Deforestation) component – which aims to reduce forest loss, and protect and expand areas under natural forest, and conserve biodiversity. This is achieved primarily through land use planning and creation of Community Conservation Areas (CCA), coupled with sustainable non-extractive forest use, e.g. honey and mushrooms.

The project stretches across nine chiefdoms in five districts in the Eastern Province of Zambia, namely: Chikomeni, Chikuwe, Jumbe, Luembe, Magodi, Mwasemphangwe, Mwape, Nyamphande, and Zumwanda. It is a grouped project as defined in the VCS Standard (version 3.5); the first project activity instance comprises 7,372 ha of agricultural land for the SALM component, and 116,629 ha for the REDD+ component. The potential project area for the SALM component is estimated to be about 28,972 ha of agricultural land, and for the REDD+ at 288,810 ha of forest.

Prior to the project, poor farming practices such as residue burning led to rapid soil nutrient depletion. There was also a general lack of land use planning and forest management, undertaken in a participatory and coordinated manner – which led to destruction and fragmentation of the forests. The COMACO Landscape Management Project uses market incentives to promote adoption of SALM practices and forest and wildlife conservation. It uses land use planning with traditional leaders and communities to identify and zone areas for conservation and forest management known as Community Conservation Areas (CCA). A Community Conservation Plan (CCP) is developed and implemented for specific CCAs – including activities for sustainable forest management, and rules regarding forest management. These activities will result in increased and sustainable agricultural production, and forest conservation. GHG emission reductions will be generated through improved carbon storage on farms, and avoidance of mosaic deforestation from unplanned agricultural land conversion. Two VCS-approved carbon methodologies are used to account for the project's emissions reductions.

The annual average GHG emission reductions of the project are estimated at 122,047 tCO₂-e, and total GHG emission reductions over 20 years are estimated at 2,440,933 tCO₂-e. This estimate considers only the first 10 years of GHG emission reductions for the REDD+ component.

1.2 Sectoral Scope and Project Type

The project falls under scope 14 of the VCS, Agriculture, Forestry, and Other Land Use (AFOLU).

SALM component

The project activities fall under the category “Agricultural Land Management (ALM) according to the VCS AFOLU Requirements v3.4, 2013. 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 categories:

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, the project focuses on the following:

- 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.
- b) Practices that reduce N₂O emissions by improved fertilizer management through reduction in total nitrogen additions by substitution with compost manure, timely application and improved placement.

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 entire project is a grouped project as defined by the VCS Standard (version 3.5): “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 first project activity instance for the SALM component comprises 6,793 of agricultural land, and for the REDD+ component forest areas totalling 116,629 ha, which are found within 14 Community Conservation Areas in the nine chiefdoms listed in section 1.1. The geographic area for all project activity instances is defined as the boundaries of the nine chiefdoms.

1.3 Project Proponent

Organization name	Community Markets for Conservation (COMACO)
Contact person	Dale Lewis
Title	Director
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

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

1.5 Project Start Date

The project start date is 1 July 2012. This is when COMACO initiated the project idea through consultations with the chiefdoms as part of participatory rural appraisal. A Project Idea Note (PIN) was submitted to the World Bank BioCarbon Fund in May 2012. The detailed justification for setting the project start date as 1 July 2012 is provided in the report: Project start date assessment SALM REDD (contained in supporting documentation). As landscape project, the SALM and REDD+ components are integrated – as the overall goal of the COMACO Landscape Management Project is to improve agricultural productivity in a sustainable way to address nutritional and income needs of communities, and protect and enhance forest resources, soil and allied natural resources. The project start date is, therefore, 1 July 2012, which is also the beginning of the annual crop calendar in the project region.

1.6 Project Crediting Period

The project has a 20-year crediting period.

Start of the crediting period: 1 July 2012

End of the crediting period: 30 June 2032

The REDD+ component has fixed baseline period of 10 years - starting July 2012; it will be renewed every 10 years as per the requirement of the applied methodology.

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

The project scale is shown below. Note that the annual GHG emission reductions for the REDD+ component has been estimated for the first 10 years (fixed baseline period) only.

Project Scale	
Project	x
Large project	

Year	Estimated GHG emission reductions or removals (tCO ₂ e)	Buffer contributions by vintage year (11% buffer) (tCO ₂ e)
2013	-12,542	-1,380
2014	17,780	1,956
2015	65,519	7,207
2016	132,031	14,523
2017	212,362	23,360

2018	301,590	33,175
2019	324,185	35,660
2020	340,512	37,456
2021	360,901	39,699
2022	383,377	42,171
2023	31,535	3,469
2024	31,532	3,469
2025	31,529	3,468
2026	31,526	3,468
2027	31,523	3,468
2028	31,520	3,467
2029	31,517	3,467
2030	31,514	3,467
2031	31,511	3,466
2032	31,508	3,466
Total estimated ERs	2,440,933	
Total number of crediting years	20	
Average annual ERs	122,047	

Based on the Non-permanence Risk Assessment of this project, 11% buffer credits are to be deposited in the AFOLU pooled buffer account.

1.8 Description of the Project Activity

The COMACO Project Model

Community Markets for Conservation Ltd. (COMACO) is a model for rural development in Zambia that links over 107,000 smallholder farmer families to market incentives and value chains to achieve poverty reduction, sustainable land management and conservation impact at a landscape scale.

As a Zambian social enterprise, COMACO interacts through two distinct but interrelated components: 1) a farmer support component that provides inputs and training on effective climate-smart agricultural practices that protect soils and reduce threats to wildlife and habitat, while offering smallholder farmers premium prices for their surplus commodities when local compliance to these practices is demonstrated; and 2) the COMACO business of selling a range of healthy, pesticide-free, value-added food products under the brand *It's Wild!* that sustains the process.

Through its compliance-based premium pricing system, COMACO also encourages community leaders to develop community conservation plans with zoned conservation areas that further reduce threats to forests and important wildlife and watershed resources across Zambia's Luangwa Valley.

The COMACO project model is explained in further detail in the supporting documentation.

SALM component

The project will promote SALM practices to restore soil fertility, improve crop yields, build resilience of the farming system to the impacts of climate change, and reduce/remove greenhouse gas emissions from agricultural activities. The practices promoted include: alley cropping with *Gliricidia sepium* shrub, reduced tillage, the use of crop residues for mulching, use of compost manure, green-manuring, physical structures and biological measures for soil and water conservation, row-planting, cover crops, and the use of improved crop varieties. By applying the COMACO farmer cooperative approach, participating groups of farmers are sensitized, mobilized, registered and trained on a range of these practices. The farmers ultimately choose which practices to adopt, and receive further training and guidance on the same.

Each farmer is estimated to have between 0.9 and 1.8 ha of agricultural land (average 1.2 ha) on which to adopt SALM practices. Adopting the SALM practices will improve the productivity and climate resilience of the farming system, increase crop yields, as well as increase carbon stock storage particularly in the soils.

The project will use the participatory group approach. The farmers are organized into cooperatives, each having an Executive Committee, which is responsible for day-to-day coordination and mobilization of its members. The cooperative members receive training and capacity building to implement SALM practices. The training and guidance is provided by COMACO extension staff, as well as through lead/model farmers from within the group. Additional training may be provided by government extension staff. The adoption of practices among farmers is monitored through annual compliance surveys.

The group approach can be summarized as follows:

- 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. are thoroughly described and discussed;
- Sensitization and trust-building of farmers/farmer groups via follow-up meetings;
- Recruitment and registration of farmer groups (cooperatives);
- Strategic planning with cooperative members, and regular training and advisory services on specific SALM practices;

- Guidance and technical support for bulk crop processing, marketing and input purchase to strengthen the membership and add value to the produce – through existing farmer co-operatives or new ones formed by the farmer groups;
- Compliance monitoring and follow-ups to determine adoption rates and address adoption barriers.
- Further registration of farmers in future project activity instances.

The extension/advisory services promote appropriate SALM practices as well as capacity building on farm-planning, and farm enterprise and home economics.

Below is the summary of practices with potential to sequester carbon that are promoted for adoption (Table 1). A number of them directly contribute to carbon sequestration/emission reductions, but also go beyond the objective of carbon sequestration e.g. they improve climate resilience and agricultural productivity.

Table 1: Practices with direct impact on GHG emissions reductions/removals promoted in the project

Practice	Description
Agroforestry	Planting of <i>Gliricidia sepium</i> in alternate rows with crops. This practice is also known as alley-cropping. Annually, the biomass from the shrub is harvested (with the shrubs cut about knee to waist height) and incorporated into the soil to improve soil organic matter and nutrient content.
Residue management	Residues from crops such as maize, pulses, and sweet potatoes as well as litter fall from <i>Gliricidia</i> are spread on the soil surface as mulch, arranged in strips, etc. This organic matter creates favourable microclimatic conditions that optimize decomposition and mineralization of organic matter and protect soils from erosion. The residues are incorporated into the soils during ploughing or basin digging.
Compost application	Compost is made from plant material and animal dung. Composting entails controlled biological and chemical decomposition that converts the plant material and animal wastes to humus. Compost will be made on-farm or off-farm, then transported, and distributed on crop fields. In both cases, the compost is incorporated into the soils.
Cover crops	Cover crops are planted on bare or short-term fallow farmland (e.g. immediately after harvest of crops) to reduce erosion, excessive moisture loss and mineralization of organic matter.
Green manuring	Green manure is a fast growing cover crop sown in a field several weeks or months before the main crop. Before the main crop is

	planted, the green manure is ploughed into the soil with the objective of improving nutrient and organic matter contents of the soil.
Management of in-organic fertilizer	Improved fertilizer management – through timely application and improved placement of fertilizers, and overall reduction in synthetic fertilizers by substituting with organic fertilizers/compost.

COMACO promotes the adoption of these practices through a set of innovative training techniques designed to enhance content and learning for smallholders who have little or no formal education, as is the case for the majority of small-scale farmers in the region. These training techniques or approaches include:

1. Farmer group learning with a simple picture -friendly training guide on sustainable farming practices, and a range of other life skills;
2. Three 1-hour radio program called COMACO Farm Talk aired weekly in local language to promote the adoption of recommended farming skills through the experiences and lessons as told by other farmers, or as explained by qualified extension staff. The radio program reaches over 800,000 in Eastern Province on Radio Breeze and provides an effective way for rural communities to understand the challenges of climate change and how efforts by CLMP in the targeted chiefdoms help small-scale farmers adapt to them.
3. Community-based extension system organized through three levels of lead farmers: producer group lead farmers, senior lead farmers, and principle lead farmers. For a given chiefdom, their ratio is approximately 40:5:1. Through this organization of lead farmers, farmers participating in the project receive training, input assistance, supervision and technical support to enhance the adoption of recommended practices.
4. An increasingly important component to these efforts in the development and growing leadership of Producer Group Cooperatives that operate at the level of the chiefdom. These cooperatives are a legally registered association of producer group members. COMACO provides an advanced training curricula to the executive leaders of these cooperatives. As their management and leadership skills improve, these cooperatives are demonstrating a critical level of farmer organization for enhancing both soil carbon sequestration and reduced need to clear forests for more farm land. This training approach uses MP3 audio-visual technology that allows COMACO to pre-record an entire module of local language lectures on a given topic for playback on an MP3 radio player. COMACO has demonstrated 2 such radio players to each cooperative for 45 chiefdoms in Eastern Province for automating a low cost training of COMACO leaders.

As a result of the above efforts, and primed with commodity market incentives when farmers demonstrate compliance to low carbon impact land use practices, behavior change is occurring, thus, creating carbon market opportunities for the community. Examples of such behavior change include:

- Cooperative leaders helping to enforce non-burning of farm plots, and the adoption of non-burning practices for capturing field mice by children who regard field mice as a protein delicacy,

- Cooperative leaders consulting with their local chiefs to develop local by-laws for protecting crop residue from grazing by cattle,
- Cooking practices that do not require large pieces of firewood that degrade surrounding forest, but rather requires only small twigs or branches.

REDD+ component

The project uses land use planning and forest conservation activities driven by traditional leaders and local communities to address forest loss and degradation caused by unplanned agricultural land use and charcoal production. The main activities to be 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. Fourteen CCAs have so far been demarcated to constitute the first project activity instances, namely: Nyamphande, Mwape, Jumbe, Mphomwa, Mbenjele, Chamukoma, Kabinga, Magodi, Zumwanda, Lwasila, Kalungambaba, Kalindi, Mwase, and Luembe.
2. Creation of Community Conservation Plans (CCPs) and attendant rules governing permitted activities and sanctions. This is the main means through which forest protection and management is to be achieved.
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.
4. Training farmers on and promoting non-consumptive forest uses such as bee-keeping, and harvesting of non-wood forest products such as mushrooms within well-defined areas, combined with fire control measures i.e. firebreaks to control bush fires.
5. Protecting the forest from fires.
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.

The forest management activities are undertaken by the communities, with COMACO and relevant government institutions playing supportive and advisory roles.

The main management approach to reduce deforestation and enhance forest conservation is the CCP. The CCP process is undertaken in a participatory manner, under the authority of the Royal Highness (head of each chiefdom), indunas (chief's advisors), with the endorsement of concerned communities, and support of COMACO, and government institutions i.e. Forestry Department (FD) and the Department of National Parks and Wildlife (DNPW). The institution of the chiefdom, i.e. the Royal Highness, village headmen, and appointed committees are responsible for the implementation of the CCPs.

The purpose of CCPs is to enhance land and natural resource conservation under community leadership across the entire area of a particular chiefdom, and to promote local leadership and skills in land management through on-going improvement in agricultural and land use practices. This plan provides for the establishment of a community conservation area(s) which are then designated Community Forestry Management Areas upon approval of the Forestry Department with an approved CFMP. The following methodology applied for the creation of CCPs;

1. The first step is a meeting with the Royal Highness of the area. This meeting is conducted by such partners as COMACO and farmer cooperative leaders, and its purpose is to discuss the need for a CCP and to sensitize the Chief on the potential benefits of a CCP to sustain economic benefits. During this meeting the minutes are documented and later signed and stamped by the Chief.
2. If the Chief agrees at this first meeting to proceed with a CCP, the Royal Highness then arranges for another meeting that calls together all other key community leaders, including indunas, headmen, and other influential leaders in the community. The Royal Highness also invites representatives from the Forestry Department, DNPW, Ministry of agriculture and Livestock (MAL), and Community Development and Mother and Child, and COMACO to help explain and provide answers to concerns which may be expressed by community members.
3. At this same meeting, a map is drawn in front of the participants to explain what natural resources are found in the chiefdom. In addition, a technical GIS person from COMACO or the Forestry Department provides a more detailed explanation of how resources, particularly forests and wildlife habitat, have changed over time as a result of human activities. This presentation is critical to making linkages between the way farmers cultivate their land and the pressures they exert on surrounding forests and habitat.
4. Also, at this same meeting, a discussion is facilitated by an appointed person to ask for ideas on ways to harmonize agriculture and other resource uses to achieve greater security for the resources held by the community through their chief. These ideas become the framework for regulations to be set forth in their CCP.
5. Some of the ideas that might be promoted at this meeting include a) the creation of a community conservation area where the community seeks to keep specific areas forested as much as possible, b) zoning of certain areas to help recover the soil with approved practices or to designate areas where farming should take place, c) specific plans that build long-term economic benefits from wildlife or trees, d) resolutions on how to control such activities as charcoal-making, poaching, burning of cropland or livestock control, and e) decisions that affect water supply and development of fisheries or opportunities for irrigation for dry-season crops.
6. Following this second meeting which is fully documented with attendance recorded, the Royal Highness convenes a private meeting with his advisors and headmen to consult internally and have the freedom to decide on their own the specific ideas they wish to adopt and support as their own CCP.
7. Once the local leaders have met privately to agree on what proposals or ideas they wish to adopt, a drafting is undertaken with external help if requested. Such help is available through such institutions as COMACO, FD, DNPW, and Ministry of Chiefs and Cultural Affairs.

8. Once the draft is complete, the document is then presented to the Royal Highness who reviews it with his advisors and unless any changes are made, the Royal Highness provides his signature for its endorsement.
9. Following this step, the headmen throughout the community are instructed by the Royal Highness to present the plan to their respective villages and to ensure all members of their communities are sensitized and educated on the plan, its benefits, and the required regulations to support the plan. In all these meetings, headmen or their representative documents all grievances and general reactions from the people. From these points raised, an addendum may be added to the CCP to reinforce the plan with ideas presented by members of the community. For example, there could be a decision to phase out a specific crop considered harmful to the area and the community-at-large through the village-level meetings may wish to debate such a resolution and allow a consensus to prevail to better support the CCP and to even recommend alternative crops that will bring better economic opportunities.
10. After the above procedures to ensure community-wide support has been demonstrated, other signatures are appended to the CCP, including the farmer cooperative, a senior COMACO representative, and FD representative before the District Commissioner signs the document.
11. Once the document is recognized and supported by local government authorities, the implementation of all agreed tasks and penalties can be executed.

The CFMP formed based on the CCP includes information on the environmental conditions of the community forest to be managed, the socio-economic conditions of the communities adjacent to the designated forest area as well as the forest resources that would be used sustainably. These sections of the CFMP are further developed after the social and forest surveys have been conducted.

The CCP process is summarised in two categories as shown in Figure 1 below. The CCP stipulates activities that are promoted or prohibited which include;

- Adoption of good farming practices, e.g., minimum tillage, rotation with legume, legume cover crop, non-burning of crop residue, use of mulch, crop diversification, composting, firebreaks
- Promotion of honey (bee-keeping).
- No charcoal making for commercial sale
- Adoption of agro-forestry and wood lots
- No bush burning after a given date
- No timber extraction for commercial sale,
- No cultivation of Virginia tobacco, which requires fuelwood for curing

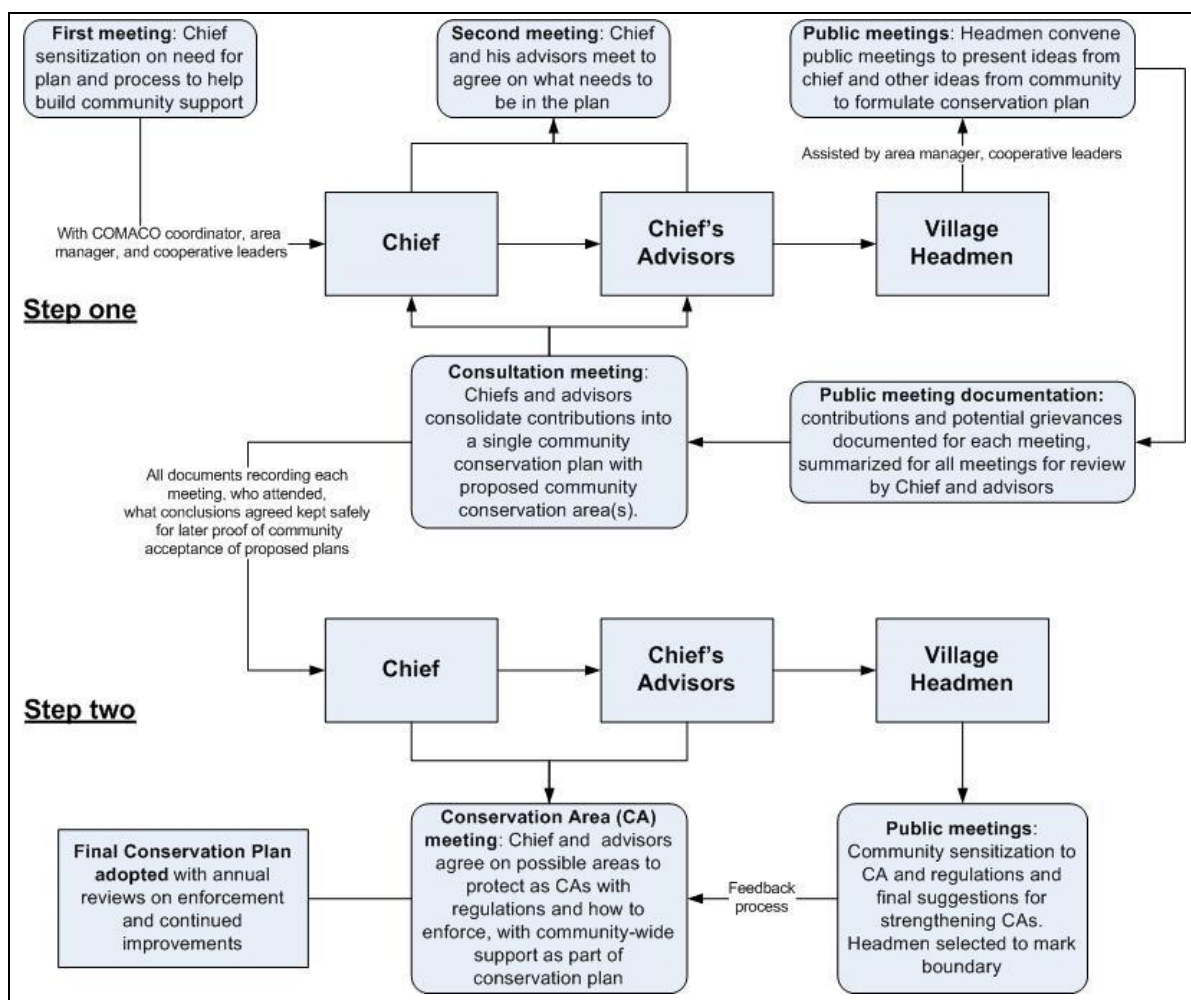


Figure 1: The Community Conservation Plan process

The CCP is further amended through wide consultations among community leaders and residents, with the help and support of the local chief and district government authorities. The outcome the process is the establishment of a long-term zoning of land uses, settlements, land use practices and conservation targets. This forms part of the CCP in form of a map. In all these process, the roles of COMACO and government institutions is to provide technical support e.g. in mapping areas designated to different land uses.

Undertaking and monitoring of forest management activities, fire and use of the forest resources is done by communities under the guidance of clan leaders (indunas), and appointed committees – with COMACO providing technical support.

The implementation of the CCP will result in protection of existing forests from deforestation and degradation pressures, and increase the volume and biomass stock in the forest. GHG emission reductions will, therefore, be generated through the avoidance of mosaic deforestation mainly from unplanned agricultural land use and charcoal production. Furthermore, the CCP will help communities carefully plan the sustainable utilization of natural forest products such as honey, mushrooms and traditional medicine.

1.9 Project Location

The project is located in Eastern Province of Zambia, and stretches across nine chiefdoms in six districts as shown in Table 2 below and Figure 2. These nine chiefdoms and six districts constitute the geographic boundary for the first project activity instances, where both the project proponent and the World Bank (BioCarbon Fund) agreed to start the project from. The project area for the SALM component consists of agricultural lands only. For the REDD+ component it consists of numerous parcels of forested lands found within the chiefdoms. As a grouped project, an additional 23 chiefdoms are planned to be included into the project in the future, and additional project areas from 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 include the first 9 chiefdoms plus the additional 23 chiefdoms (see details in Appendix 1). However, the geographic boundary for the first project activity instances, i.e., the boundaries of the nine chiefdoms is used throughout this PD as the analytical domain since this is where the project has definitely begun.

Table 2: Project chiefdoms and districts

Chiefdom	District	Community Conservation Area for REDD+ component
1. Chikomeni	Lundazi	Chamukoma and Kabinga CCAs
2. Chikuwe	Chipata	Mbenjele and Mphomwa CCAs
3. Jumbe	Mambwe	Jumbe CCA
4. Luembe	Nyimba	Luembe
5. Magodi	Lundazi	Magodi
6. Mwasemphangwe	Lundazi	Kalindi CCA and Mwase Central
7. Mwape	Petauke	Mwape
8. Nyamphande	Nyimba & Petauke	Nyamphande
9. Zumwanda	Lundazi	Zumwanda, Lwasila, and Kalungambeba CCAs

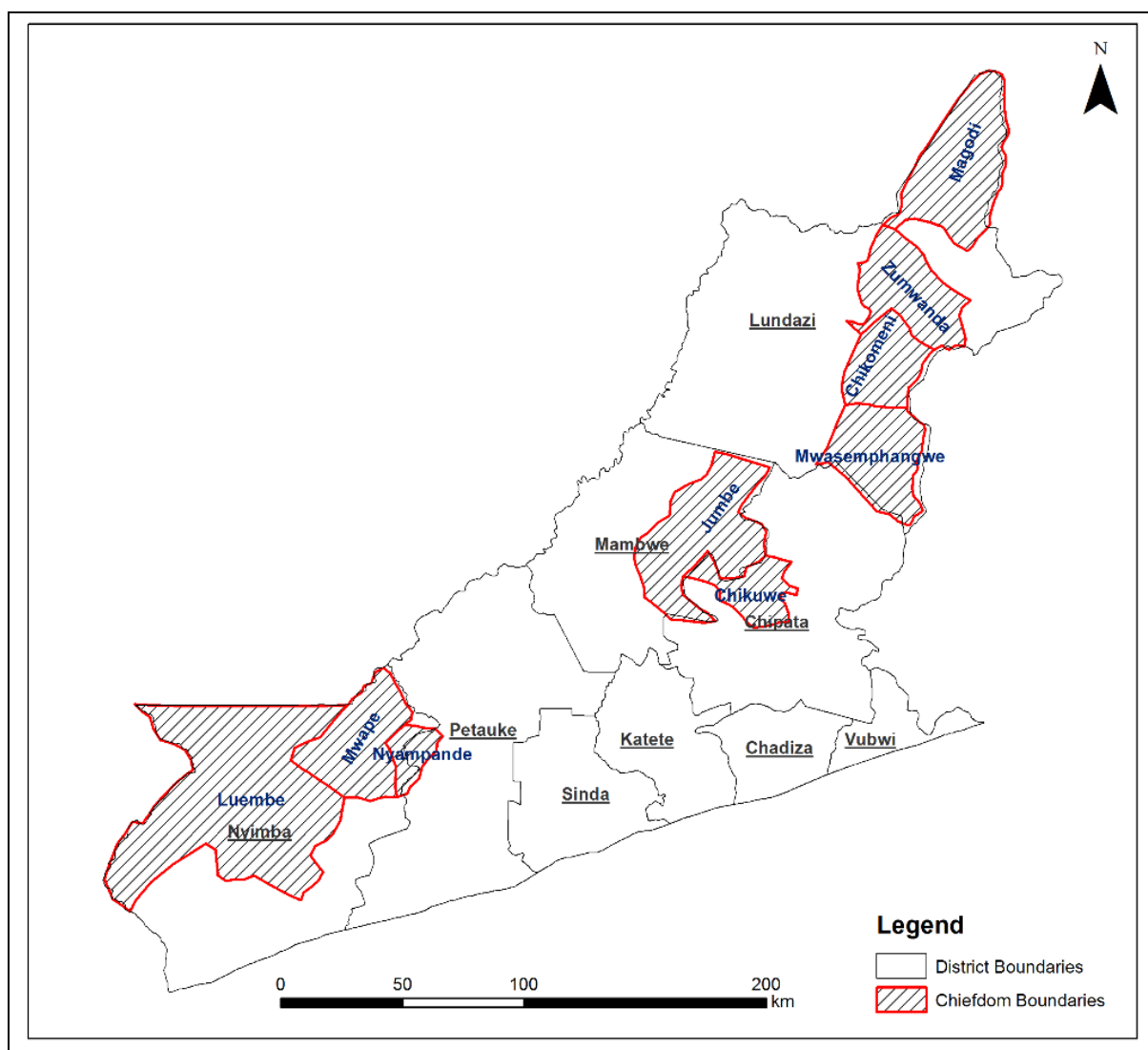


Figure 2: Project location

Figure 2 shows the location map of the project. The biophysical characteristics of the project area are summarised in Table 3. The geographic boundaries are provided as separate KML files. For the SALM component, all farms participating in the project have one set of coordinates taken using GPS to show their locations. The KML files of the GPS points for the SALM first project activity instances are available as separate files.

Table 3: Biophysical characteristics of project location

Characteristics	Description
Agro-ecological zone (AEZ)	The area falls into two nationally-defined agro-ecological zones: AEZ I (Luangwa-Zambezi River Valley Zone), and AEZ IIa (Central Southern and Eastern Plateau Zone). At the global level, the project area falls into AEZ 3 (tropical moist semi-arid), according to the 18 AEZs of the Center for Sustainability and the

	Global Environment (SAGE). This AEZ classification is used for the SALM component.
Soil	The area has both Low Activity Clay and High Activity Clay soils according to the IPCC soil classification system (see section 2.2 for details)
Rainfall	Annual precipitation ranges between <800-1,000 mm. Historical average of 1950-2000 is 980 mm, with a range of 780 – 1,400mm.
Temperature	Temperature ranges between 20-25°C
Elevation	Elevation ranges from 410-1,308 m above sea level.

1.10 Conditions Prior to Project Initiation

The unpredictability of rainfall influences the availability and access components of food security, with both drought and flooding affecting vulnerable communities and families. Rainfall levels in Zambia decrease from the northern to the southern climatic zones. At the same time, crop water requirements, highest in the southwest of the country, increase from the north to the south. The Eastern Province has two distinct physiographic regions: the plateau with elevations ranging from 900 to 1,500 meters, and the Luangwa Valley, with an average elevation of 500 meters. The valley contains a mixture of alluvial soils that are suitable for crops such as rice, cotton, and drought-resistant sorghum and millet. The plateau contains soils that are moderately fertile and suitable for cultivating maize, groundnuts, cotton, sunflower, tobacco, and soybeans. Annual rainfall in the Eastern Province ranges from 850 to 1,050 mm.

Thus, rainfall is lowest in areas where the crop water requirements are highest, exposing rain-fed agriculture in the south and the southeastern part of the Eastern Province to drought risks. Furthermore, variations in rainfall are generally higher in the zones with low rainfall. Despite this massive agricultural potential, Zambian smallholder farm production is often not sufficient to meet household-level nutritional needs, nor is it sufficient to produce a surplus that can be sold in local or other markets. Only 28 percent of rural farmers are net sellers of maize while 49 percent are net buyers.¹⁵ Smallholder agricultural production relies on rainfall, as few have access to irrigation. 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. Even during good years, agricultural production is insufficient. Close to 60 percent of farmers face a hungry season from November through February (USAID, 2013).

In Zambia and the eastern Province, smallholder farmers are vulnerable to a number of factors, including increasingly variable rainfall patterns, limited access to seed inputs, bad roads, and poor farming skills, all impacting negatively on food security and household income while increasing risks of soil degradation and deforestation. The result is a perpetuation of rural poverty and hunger across much of the Luangwa Valley ecosystem, where livelihoods are based largely on farming and subsistence use of natural resources. For example, 65% of all people living in Eastern Province, which falls within the Luangwa Valley watershed, are considered to be

exceedingly poor, a rate well above the national average of 51%, despite an economic growth rate of about 7.6%¹.

See also section Baseline Scenario 2.4 for further details on the conditions prior to project initiation which is also identified as the baseline scenario.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The proposed project activities are all within the existing national legal framework of the Government of the Republic of Zambia as described in the Environmental Project Brief (Greenfield Consultants 2015) and the approval letter by the Zambia Environmental Management Authority.

The project areas for the SALM and REDD+ components of the project is constituted by the land provisions in the draft constitution of the Government of the Republic of Zambia. The Zambian Government as attributor of the constitution, warrants the respect of the legal framework. Furthermore, the project will also be implemented in accordance to Zambia's REDD+ strategy (2015).

The project will not encroach uninvited on private property, community property, or any other government property. Chiefs and community members of respective Chiefdoms have customary land tenure through the land provisions of the new draft constitution.

Zambia realized the need for balancing environmental requirements, economic activities and social needs in the early 80s. The Government therefore adopted the National Conservation Strategy (NCS) in 1985. This was upgraded to the National Environmental Action Plan (NEAP) in 1992 with the same aim of fostering sustainable development. The NCS and NEAP are the foundation pillars of environmental laws in Zambia.

The NCS facilitated development of the Environmental Protection and Pollution Control Act (EPPCA) of 1990. This Act consequently facilitated formulation of the Environmental Council of Zambia (ECZ) in 1992. The EPPCA was repealed in 2011 and became Environmental Management Act No. 12 of 2011, which is the current supreme environmental management law in Zambia. Through provisions of this Act, ECZ was consequently transformed into Zambia Environmental Management Agency (ZEMA) and the institution has the legal mandate to oversee all environmental management issues in Zambia.

¹ See USAID Report (2013) <https://www.usaid.gov/opengov/developer/datasets/Zambia%202013%20FTF%20ZOI%20PBS%20County%20Report%20-%2020140404.pdf> for further details on the socio-economic baseline conditions in the Eastern Province

The Environmental Management Act No. 12 Of 2011

Provisions of the Environmental Management Act require that all new projects begin with an Environmental Impact Assessment (EIA) and thereafter, licensing, auditing and compliance inspections follow.

Applicable Regulations to the proposed project under the Environmental Management Act No. 12 of 2011 are described below.

I. Environmental Impact Assessment Regulations, SI No. 28 of 1997.

These Regulations provides the main framework under which EIAs are conducted, submitted to ZEMA and considered for either approval or rejection.

Relationship with the proposed project: The project will definitely have social and environmental impacts – both negative and positive in nature. It is important to document the project and associated impacts with mitigations measures so that the documented information can be used as a guide. This documentation is a legal requirement and there is prescribed process that should be followed which should be in accordance with these regulations hence the relevance.

Compliance: Preparation of this EIA.

II. Air and Water Pollution: (Licensing Regulations) S.I. 112 of 2013

Enshrined in the Environmental Management Act (2011) these regulations are very important to the proposed project as they prohibit the discharge of waste or wastewater into water bodies. This project is with a view to comply with these regulations as no waste will be discharged in water for whatever reason. These regulations provide for the control of emissions to the environment and specify the statutory discharge limits for respective parameters. The Regulations prohibit unauthorized emission of pollutants into air, sets out licensing requirements and provides long-term emission limits for air pollution.

Relationship with the proposed project: Even though the proposed project will not promote the use of insecticides, herbicides and chemical fertilisers which are the main source air and water pollution, dust shall still be generated from the proposed activities. To ensure environmental protection, the regulations cited above provide long term, point sources, and ambient air pollution limits and guidelines for compliance reason hence the relevance to the project.

Compliance: The project will ensure compliance with the standards set out in the SI.

The National Heritage Conservation Commission Act, Cap 173

The National Heritage Conservation commission Act CAP 173 of 1989 stipulates preservation and protection of ancient cultural and natural heritage resources and objects of aesthetic, historical and archaeological value. In this Act, “Ancient Heritage is defined as being among other things, any structure, settlement previously inhabited, land mark, burial place or any other item designated by the commission which is known or believed to have been erected, constructed or

used before 1st January 1924. The Act also provides for the formation of the National Heritage and Conservation Commission which is the responsible institution.

Relationship with the proposed project: The proposed project sites were checked during site visits and did not indicate any features of interest in terms of archaeology. The management team shall be reminded about the requirement and once such facilities are observed, relevant authorities shall be consulted. This explanation justifies the relevance.

Compliance: Any discoveries of possible ancient cultural, historical and natural heritage features to be found during implementation of the project will be reported to the National Heritage Society as per provisions of this Act.

The Forest Act No. 4 of 2015

The Forest Act No. 4 of 2015 enacted by parliament, in August, 2015, provides for the establishment of Community Forests and Community Forest Groups which are based on the following;

1. members of a village in or near a forest;
2. managing a forest or part of a forest; or
3. Desirous of managing a forest or part of a forest.

The Act further indicates that the Director may provide assistance to persons living in the vicinity of, or deriving their livelihood from, a forest to form a community forest management group to manage a forest. Therefore, a group of persons living in the vicinity of a forest may apply to the Director for recognition as a community forest management group with the consent of the Chief of the area in which the forest is located.

Relationship with the proposed project: the REDD component of the COMACO project advocates for the engagement of communities in conservation of community forests hence the relevance of the Act. Further, the practices of conservation agriculture being promoted guarantee the continued existence of the designated Community Forests as farmers will not open up new fields or burn fields.

Compliance: The Conservation areas are open community forests which have been earmarked for protection in conjunction with the Forestry Department and the communities who are represented by Community Forest Groups. Therefore, compliance with provisions of the Forest Act No. 4 of 2015 is imperative.

The formation of Community Forest Management Groups in the 9 Chiefdoms of the Project area involved the participation of the communities and their local leadership in collaboration with stakeholders which include Forest Department, COMACO, and Department of National Wildlife and Parks. Community sensitization meetings held in the entire targeted Project Chiefdoms, prompted communities to desire for the management of the community forests. The following steps were critical for the creation of Community Forest Management Groups;

1. Communities adjacent to community forests identified versatile members to be part of the Community Management Group whose names were submitted for scrutiny by the Royal

Highness and stakeholders (COMACO, Forest Department, Department of National Wildlife and Parks)

2. Elections were conducted in a transparent manner involving the participation of the community and the Royal Highness for the top five executive members and committee members.

The Zambia Wildlife Act, No. 12 Of 1998

The Zambia Wildlife Act No. 12 of 1998 provides for establishment of the Department of National Parks and Wildlife (formerly Zambia Wildlife Authority (ZAWA)), and provides the enabling legislation for the sustainable management of wildlife resources in Zambia. The Act also provides for regulation of all wildlife activities such as hunting, poaching and keeping of wild animals. The local management of wildlife resources and habitats is partly delegated to Community Resource Boards (CRBs) in designated Game Management Areas (GMAs). The CRBs in turn are given commission for the income generated from GMAs.

Relationship with the proposed project: Most project sites are near Game Management Areas and have the presence of animals that require protection. This shows how the Act relates to the project.

Compliance: The proposed project will follow the requirements of this act to ensure that the wildlife habitats are conserved and ensure that there is minimal disturbance in the project area.

The Water Resources Management Act No. 21 Of 2011

The Act was enacted establish the Water Resources Management Authority; facilitate management of common water, to regulate formation of water users associations and to promote collective protection and efficient use of public waters. Under this Act, a buffer zone of at least 50 meters from a public water facility should be maintained and access to public water should be provided at all times especially for abstracting water for domestic use.

Relationship with the proposed project: There project crosses a number of rivers and streams. These are classified as public water resources and no one should claim ownership, Rivers or misuse these public resources.

Compliance: Protection measures especially regarding effluent discharge is required. This example explains that the Act is related to the project and there are a number of provisions that shall require compliance in order to protect public waters.

Occupational Health and Safety Act No. 36 of 2010

This Act provides for preventing work-related injuries, illness, and death by issuing and enforcing workplace health and safety standards. Hundreds of OSHA safety standards, covering everything from first aid to fire protection, apply to most federal and private workplaces. OSHA allows employees to question unsafe conditions, request inspections, and file lawsuits to correct unsafe conditions without retaliation.

Relevance to the Project: Wherever human activities take place, issues of occupational health are critical. Environmental aspects of the project that shall require adherence to the Act include working in hazardous areas such as waste management facilities, sanitation facilities and tendering problematic animals.

Compliance: COMACO shall ensure that issues of occupational health are understood, implemented and sustained at all times.

The Chief's Act No. 13 of 1994

Provides for the recognition, appointment and functions of Chiefs and Deputy Chiefs; for the exclusion of former Chiefs and Deputy Chiefs from specified areas in the interests of public order; for the appointment and functions of *kapasus*; and for matters incidental to or connected with the foregoing.

Relationship with the proposed project: The project will work in close collaboration with Chiefs and their subjects.

Compliance: COMACO recognises that the project areas fall under nine chiefdoms and will recognise and respect the functions of the Chiefs in accordance with this act.

1.12 Ownership and Other Programs

1.12.1 Right of Use

The evidence of right of use is enshrined in the Chiefdom and Cooperative sub-agreements between COMACO and the community structures in place (as described above in Chapter 1.8). In respect of a GHG emission reduction, the unconditional, undisputed and unencumbered ability to claim that the relevant project will cause such reduction is given through the clauses pertaining to the project activities and monitoring arrangements in the sub-agreements.

SALM: SALM pledges and cooperative sub-agreements that the farms are farming on customary land and agree to the monetisation of emission reductions by and for COMACO.

REDD: Agreements with the Community Forest Management Groups and chiefdoms that stipulate the GHG REDD process and monetisation of emission reductions by and for COMACO.

As per the requirement of the Forest Act, 2015, the communities formed the Community Forest Management Groups to manage the CCAs, and through their Chairpersons applied to the Director of Forestry in the prescribed manner and form to enter into a community forestry agreement with the Department in respect of the forest areas (CCAs) for which the groups have been formed.

The communities have willingly transferred the right to claim and monetise the emission reductions generated in the CCAs as well as on their farms to COMACO through the above-mentioned agreements, which also outline the roles and obligations of both parties.

1.12.2 Emissions Trading Programs and Other Binding Limits

As a developing nation, the country of Zambia has no binding limits on GHG emissions or compliance requirements under international multilateral agreements. GHG removals generated by this project will not be used for compliance with binding limits to GHG emissions since such limits are not enforced in Zambia. There are no emissions trading programs in place in the country. Consequently, this project will only generate net GHG emission reductions/ removals on an additional and voluntary basis.

1.12.3 Other Forms of Environmental Credit

The project is not being used to create other environmental credits.

There is a cookstoves PoA for Zambia², but this project is completely separate.

1.12.4 Participation under Other GHG Programs

The project has not been registered, or is seeking registration under any other GHG programs.

1.12.5 Projects Rejected by Other GHG Programs

The project has not been rejected by any other GHG programs.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

This is grouped project; and as per the VCS Standard, v3.5 guidance on grouped projects, the eligibility criteria in Table 4 below have been defined for the inclusion of new project activity instances.

Table 4: Eligibility criteria for inclusion of new project activity instances

Criteria	Component applicable to	
	SALM	REDD+
The new instances must be located within the boundaries of the chiefdoms listed in Appendix 1.	☒	☒
Participating farmer groups have willingly agreed to adopt and apply SALM practices being promoted, evidenced by pledge/agreement.	☒	
The farming system is typically low-input agriculture.	☒	
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.	☒	

² Available at the UNFCCC CDM webpage [here](#).

The land is either cropland or grassland at the start of the project, and is not a wetland ³ .	☒	
The lands should not have been cleared of native forests 10 years prior to inclusion into the project.	☒	
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.	☒	
The area of land under cultivation in the region is constant or increasing.	☒	
Forest land, according to the national forest definition, in the region is constant or decreasing over time.	☒	
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 ⁴ .	☒	
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.	☒	
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.	☒	
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		☒
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.		☒
The area is subject to unplanned deforestation as defined in the VCS AFOLU Requirements/ VCS Standard.		☒
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.		☒
The project activity is avoided deforestation of secondary forest		☒

³ Wetland is defined according to the 2003 IPCC GPG LULUCF guidance – where a wetland category includes land that is covered or saturated by water for all or part of the year (e.g. peatland) and that does not fall into the forest land, cropland, grassland or settlements categories.

⁴ If another model is used the parameters used by that model must correspond to some or all parameters included in SALM methodology. Use of another model may also require at a minimum, revisions to estimates of uncertainty and activity baseline and monitoring survey specific to the model applied.

The area does not have peat ⁵ .		☒
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.		☒
The area has the same baseline scenario as the first project activity instances identified in section 2.4	☒	☒

Leakage Management

SALM component

The project aims at increasing the organic inputs from plants and manure to the agricultural land. The project intervention considers the whole farm field as a basic unit where biomass is produced to provide organic inputs to the soil. Consequently biomass and organic material is only shifted within a single farm system.

As per the methodology, the one potential source of leakage is an increase in the use of fuel wood and/or fossil fuels from non-renewable sources for cooking and heating purposes due to the decrease in the use of manure and/or residues as an energy source. Leakage due to the increase in the use of fuelwood from non-renewable sources for cooking and heating purposes may be a significant source of leakage if manure or other agricultural residuals used for cooking and heating are transferred to the fields as part of the project. In the project area, the dominant cooking method is cooking on open fires or three-stone fires. According to survey of energy sources for the COMACO cookstove program, firewood and charcoal are the only fuelwood sources used in the project. The project activities do not reduce the supply of these energy sources. Nonetheless, through its whole farm approach, COMACO is improving the supply of fuelwood as the stems of *Gliricidia* grown on the crop fields will supply woodfuel. This leakage management measure is expected to further reduce leakage potential.

REDD+ component

The project is being implemented in one of the provinces of Zambia where there may be a jurisdictional REDD+ program. At present, relevant information about this program, in particular baseline establishment, is, however, not available. Hence, leakage is considered independently for this project. The significant cause of unplanned deforestation is agricultural expansion (through slash and burn methods) by local farmers (see section 2.4 Baseline Scenario). Given the nature of the project activities and that the drivers and agents of deforestation are for subsistence farming, no market leakage, or leakage related to investment in the project area and alternative livelihood programmes is foreseen. The only leakage type likely to occur due to the project activity is activity-shifting leakage. Foreseeable leakage is therefore limited to the displacement of slash-and-burn agriculture by local people to meet their needs. Leakage management in this project involves the following:

⁵ Peat is defined as organic soils with at least 65% organic matter and a minimum thickness of 50 cm.

Leakage belt: A leakage belt has been defined using a mobility analysis in accordance with the methodology to determine which areas are subject to leakage.

Leakage management areas: the project has delimited non-forested leakage management areas that encompass the area of activity of agents of deforestation. Within the leakage management areas a concerted and long-term programme of activities has been put into place to address the long term livelihood needs of the agents of deforestation and to stabilise land-use. The project is undertaking the following measures:

- Market incentives, where local communities are incentivised through premium prices for the agricultural crops; the premiums are paid on evidence of forest conservation actions implemented by the communities;
- Capacity building and support to provide alternative livelihood options for the community members that have traditionally depended on slash and burn agriculture to adopt sustainable agricultural land management SALM;

These activities will be funded from the revenues raised from the sale of VCU's. The leakage management areas are defined as non-forest areas within a 1 km radius of the CCA boundaries. The activities in this leakage management area are therefore directly targeting the individuals who would potentially clear forest in the project area.

The boundaries of the CCAs, as well as the zoning of the protected area into different management areas, and consequently the areas of forest that are to be conserved, has been done with the full participation and agreement of the local stakeholders (see section 1.8). Communities defined the boundaries of the CCAs, the sustainable use forest and the protected forest areas according to their anticipated needs.

Commercially Sensitive Information

No commercially sensitive information is linked to this PD

Further Information

No further information.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

The methodology applied to the SALM component is:

VCS-approved Methodology VM0017 - Adoption of Sustainable Agricultural Land Management, version 1.0⁶.

The methodology applied to the REDD+ component is:

VCS-approved VM0015 Methodology for Avoided Unplanned Deforestation, version 1.1⁷.

The Tools applied are outlined in Table 5 below.

Table 5: Methodological tools

Tools	Component applied to	
	SALM	REDD+
CDM Tool for testing significance of GHG emissions in A/R CDM project activities, version 01	☒	☒
CDM Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities, version 01	☒	
VCS VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, version 3.0	☒	
CDM Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities, version 01	☒	
CDM Tool: Estimation of direct nitrous oxide emission from nitrogen fertilization, version 01	☒	
CDM Tool: Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities", version 04.2	☒	
Tool: Estimation of emissions from the use of fossil fuels in agricultural management (Section VI.2 of the SALM methodology)	☒	

2.2 Applicability of Methodology

2.2.1 SALM component

The SALM methodology is applicable to projects that introduce sustainable agriculture land management practices (SALM) into an agricultural landscape subject to six conditions numbered a) to f) below. Justification of the project activities meeting these conditions is provided under each of the applicability conditions.

a) *Land is either cropland or grassland at the start of the project*

⁶ <http://www.v-c-s.org/methodologies/adoption-sustainable-agricultural-land-management-v10>

⁷ <http://www.v-c-s.org/methodologies/methodology-avoided-unplanned-deforestation-v11>

SALM activities are implemented within the individual farmlands of registered farmers, and no SALM project activity will be implemented on forest land. The landscape within the nine project area chiefdoms is characterized by mosaic vegetation of forests, open woodland, grassland and cropland (Figure 3). As part of the COMACO approach, the cultivated areas under SALM are clearly defined and demarcated. During the periodic baseline and monitoring surveys, these areas are randomly checked and verified as cropland. Furthermore, the locations of the farmlands are cross-checked with land use/cover maps to ensure that they have not been cleared on native forests 10 years prior to inclusion into the project. Farmlands not meeting this criterion are excluded.

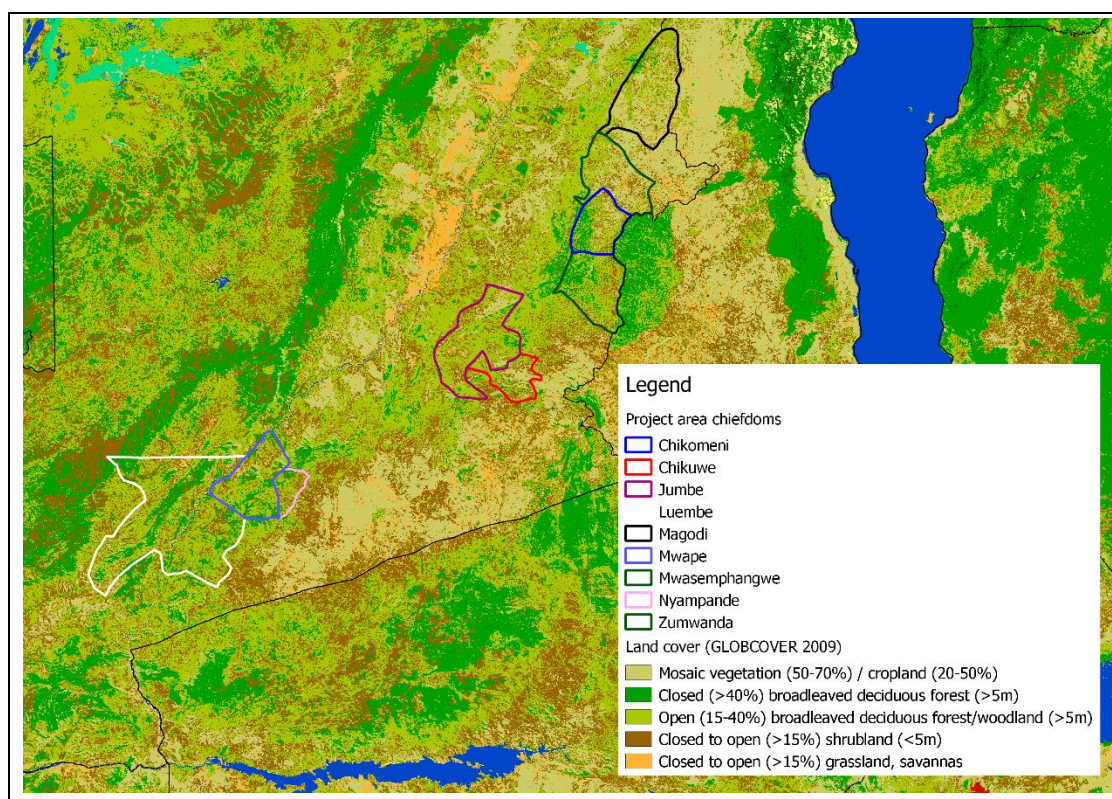


Figure 3: Land classification of the project area based on the GlobCover 2009 land cover map⁸ (ESA 2010 and UC Louvain, 2010)

b) The project does not occur on wetlands

The total project area and the farms not occurring on wetlands follows the definition of wetlands according to the 2003 IPCC GPG LULUCF guidance – where a wetland category includes land that is covered or saturated by water for all or part of the year (e.g. peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. The most feasible and

⁸ The GlobCover Land Cover product is the highest resolution (300 meters) Global Land Cover product ever produced and independently validated, derived from an automatic and regionally-tuned classification of a time series of MERIS FR composites

appropriate strategy to determine this is to map the major IPCC soil classes for the potential project area and determine whether or not it falls into wetland or organic soil class. Based on a study by Batjes (2010)⁹ which derived the IPCC default soil classes from the Harmonized World Soil Database¹⁰, the soils in the entire project area belongs to the IPCC soil classes of Low Activity Clay soils (LAC) and High Activity clay soils (HAC). None of the project areas belong to the category of IPCC classes of organic soils (ORG) or wetlands (WET) (Figure 4). The clay soils constitute one stratum.

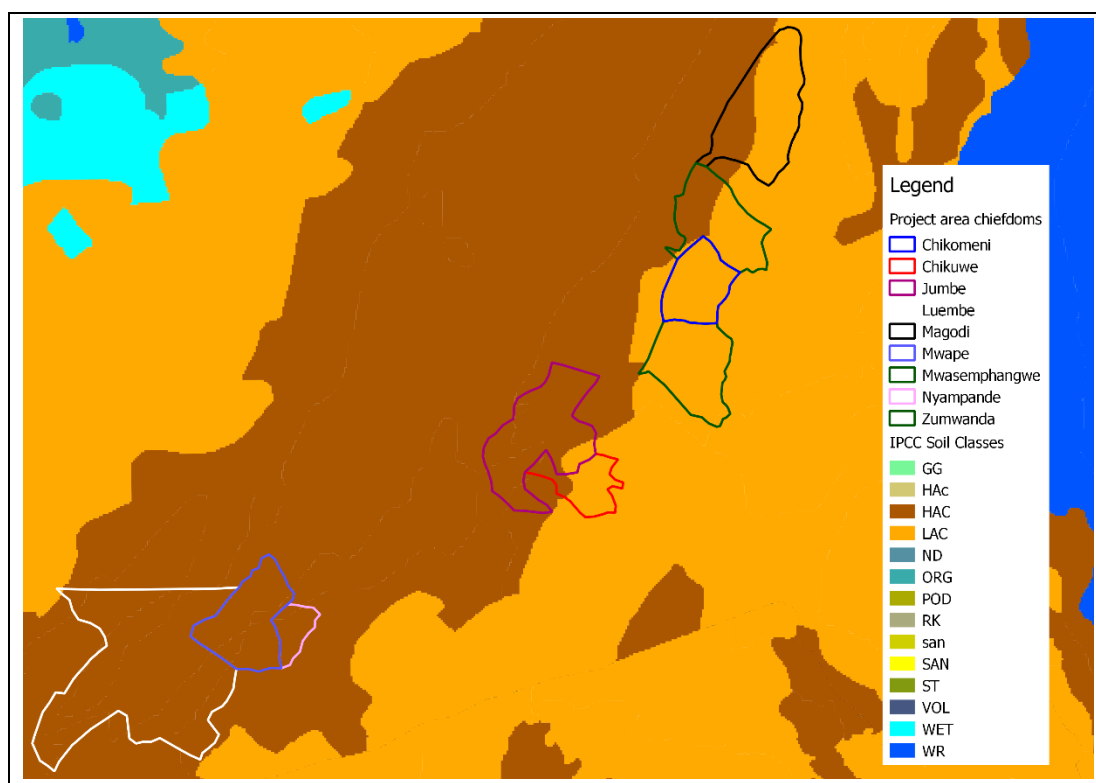


Figure 4: Project area IPCC soil classes based on Batjes (2010)

c) *The land is degraded and will continue to be degraded or continue to degrade*

According to the methodology, the CDM Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities (Version 01) should be used to demonstrate that the project land is degraded and will continue to degrade. The methodology states:

⁹ Batjes NH 2010. IPCC default soil classes derived from the Harmonized World Soil Data Base (Ver. 1.1) Report 2009/02b, Carbon Benefits Project (CBP) and ISRIC – World Soil Information, Wageningen (with dataset)

¹⁰ FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.

Provide documented evidence that the area has been classified as “degraded” under verifiable local, regional, national or international land classification system or peer-review study, participatory rural appraisal, satellite imagery and/or photographic evidence in the last 10 years.

Land degradation occurs throughout the country, but is severe in the Central, Eastern, Southern, Western, and Lusaka Provinces of Zambia, and has resulted in low land productivity, and concomitantly low crop and animal productivity¹¹. It is attributed to poor land use practices such as slash-and-burn agriculture, continuous mono-cropping, cultivation on sloped areas without conservation measures, and overgrazing¹². The practices easily accelerate soil erosion, and drives deforestation as new lands have to be converted to agricultural lands to replace croplands that have become unproductive. Soil erosion has been observed to result in low crop yields and low livestock productivity, causing food insecurity.

Recent studies indicate that the drivers of land degradation, which are essentially poor land management practices is still prevalent across the project areas and the entire province; while the level of application of improved land management practices, which would mitigate against land degradation, remains very low¹³. Hence, lands in the project area are degraded and expected to remain degraded and/or continue degrading.

d) The area of land under cultivation in the region is constant or increasing in absence of the project

Between 2000 and 2009 agricultural land expanded from 398,000 ha to 505,000 ha in the Eastern Province according to surveys from the Central Statistical Office of Zambia.¹⁴ The land use/cover analysis undertaken for the REDD+ component indicates that within the project geographic boundary, agricultural land increased from 168,287 ha in 2002 to 261,378 ha in 2013. Hence, in the absence of the project, land under cultivation in the region is increasing.

e) Forest land, as defined by the national CDM forest definition, in the region is constant or decreasing over time

Forest cover change over that last 11 years (2002 to 2013) has been analyzed for the REDD+ component. The results show an average annual deforestation rate of 2.3%. Other sources corroborate this trend of forest loss: the UN-REDD report on the drivers of deforestation indicates that the Eastern Province where the project is located report a historical annual deforestation rate

¹¹ Umar, 2010. Reversing Agro-Based Land Degradation through Conservation Agriculture: Emerging Experiences from Zambia's Smallholder Farming Sector. Accessed [here](#).

¹²Ministry of Tourism, Environment and Natural Resources, 2002. Zambia national action programme for combating desertification & mitigating serious effects of drought in the context of the United Nations Convention to Combat Desertification, Accessed [here](#).

¹³ Reversing Agro-Based Land Degradation through Conservation Agriculture: Emerging Experiences from Zambia's Smallholder Farming Sector. Accessed [here](#).

Kwesiga *et al.*, 2005. Improved fallows in Eastern Zambia: History, Farmer Practice and Impacts. Accessed [here](#). Umar, 2010.

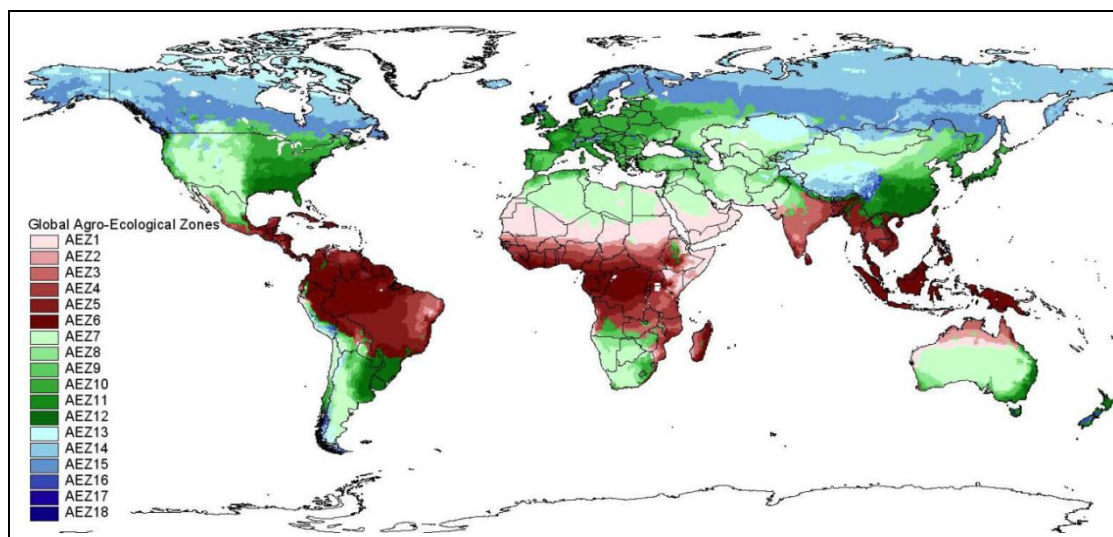
¹⁴ CSO/MACO/FSRP Crop Forecast Surveys. Various years. Lusaka: GRZ in Sitko *et al.* 2011. Technical Compendium: Descriptive Agricultural Statistics and Analysis for Zambia in Support of the USAID Mission's Feed the Future Strategic Review. (see Annex 4)

(1965 to 2005) of 0.85% (Vinya *et al.* 2011¹⁵). The decreasing forest cover is due to forest conversion to small-scale agricultural lands – driven by increasing human population (the Eastern province has population growth rate of about 2.7% per year¹⁶).

f) There must be studies (for example: scientific journals, university theses, local research studies or work carried out by the project proponent) that demonstrate that the use of the Roth-C model is appropriate for: (a) the IPCC climatic regions of 2006 IPCC AFOLU Guidelines, or (b) the agroecological zone (AEZ) in which the project is situated.

The 18 AEZs of the Center for Sustainability and the Global Environment (SAGE) were used for the stratification. The zones are defined by Length of the Growing Period (LGP) as well as climatic zones (Monfreda *et al.*, 2007¹⁷).

Figure 5 shows the 18-AEZ global map by 0.5 degree grid cell. The red shades in the map denote tropical AEZs, with the more intense shades denoting longer growing periods. The green shading denotes temperate AEZs, whereby the darker greens also indicate longer LGPs.



¹⁵ Vinya *et al.*, 2011. Preliminary study on the drivers of deforestation & potential for REDD+ in Zambia. Accessed [here](#).

¹⁶ Central Statistics Office, 2010. Zambia 2010 census of population and housing: Preliminary Population Figures. Accessed [here](#).

¹⁷ Monfreda C., Ramankutty N., Hertel T. (2007). Global Agricultural Land Use Data for Climate Change Analysis. In: Hertel T. (eds.) Economic Analysis of Land Use in Global Climate Change Policy. Routledge. SAGE derived 6 global LGPs by aggregating the IIASA/FAO GAEZ data into 6 categories of approximately 60 days per LGP: (1) LGP1: 0-59 days, (2) LGP2: 60-119 days, (3) LGP3: 120-179 days, (4) LGP4: 180-239 days, (5) LGP5: 240-299 days, and (6) LGP6: more than 300 days. These 6 LGPs roughly divide the world along humidity gradients, in a manner that is generally consistent with previous studies in global agro-ecological zoning (Alexandratos, 1995). They are calculated as the number of days with sufficient temperature and precipitation/soil moisture for growing crops. In addition to the LGP break-down, the world is subdivided into three climatic zones – tropical, temperate, and boreal – using criteria based on absolute minimum temperature and growing degree days, as described in Ramankutty and Foley (1999).

Figure 5: SAGE Global map of the 18 AEZs. Source: Monfreda *et al.*, 2007

A peer-reviewed study has been chosen to demonstrate that the application of the RothC model is appropriate for the SALM project area and that the model is validated for a similar AEZ/climate region. The study by Kaonga and Coleman (2008)¹⁸, located in the tropical montane zone of Zambia evaluated the soil organic turnover in fallow-maize cropping systems and tested the performance of the RothC model using empirical data. The data for this study came from two improved fallow experiments at Msekera site in eastern Zambia.

The map below (Figure 6) shows that the reference site is located very close to the project areas within the same SAGE AEZ.

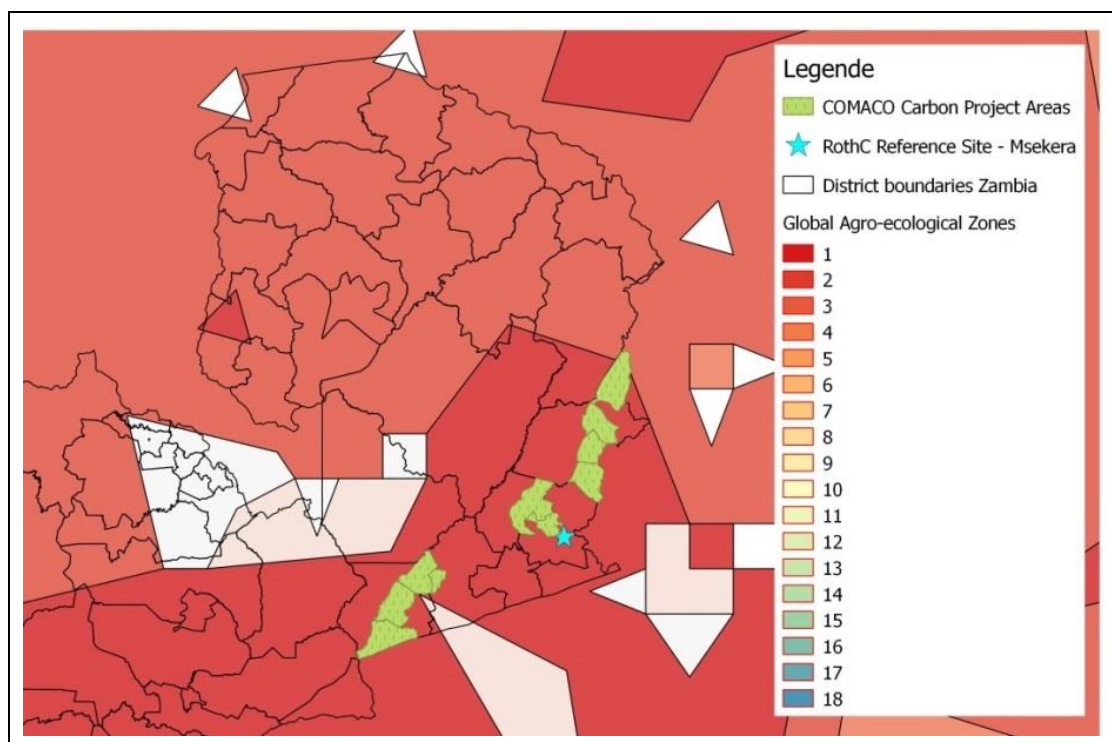


Figure 6: Project areas and the RothC study site shown within the SAGE Global map of the 18 AEZs. Source: Monfreda *et al.*, 2007

Table 6 below shows the comparison of important parameters – demonstrating the similarity of study site with the project location.

Table 6: Comparison of parameters between research site and project location

Parameter	Msekera experimental site	Project area
Country	Zambia	Zambia
Elevation	1,030 m above sea level	Approx. 1,000 m above sea level

¹⁸ 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

Global AEZ	AEZ 3 (Tropical moist semi-arid)	AEZ 3 (Tropical moist semi-arid)
National AEZ	Region I and IIa	Region I and IIa
Mean annual precipitation	1,000 mm	980 mm
Mean annual temperature	23°C	20-25°C
Soil clay content	26%	17-31% (average) ¹⁹

The conclusions from RothC model validation based on this reference study are that fitting the RothC model to experimental data from improved fallows in Msekera resulted in reasonable estimation of annual plant C inputs to the soil in sole maize and tree fallow stands. The fact that RothC-calculated total annual organic C inputs reasonably well, and model predictions of SOC fitted the observed data to within experimental error, indicates that the model is giving reasonable simulations in this environment (Kaonga and Coleman, 2008).

2.2.2 REDD+ component

The methodology has no geographic restrictions and is applicable worldwide. It has five applicability conditions – numbered a) to e) below. Information to show that the project activities meet these conditions is provided under each of the applicability conditions:

a) *Baseline activities may include planned or unplanned logging for timber, fuel-wood collection, charcoal production, agricultural and grazing activities as long as the category is unplanned deforestation according to the most recent VCS AFOLU requirements.*

Within the project area, there is a patchwork of deforestation (see section 3.1). There are numerous villages spread throughout the chiefdoms. All forest areas are potentially accessible. The core activity causing loss of forest in the project area is conversion to small-scale agriculture. Some of the tree biomass is burnt in the process, while some end up into charcoal making and firewood. Charcoal making is a major cause of forest degradation. In some cases it precedes agricultural expansion as areas where charcoaling has been carried out are more open and easily converted to crop fields. Shifting cultivation, where lands converted from forest to agriculture would be left to regrow and become forest again used to exist in the past. The current trend is almost entirely permanent conversion of forestlands to crop fields with very short fallow practised by a minority of the farmers. The predominant small-scale agriculture and charcoal making are categorised as unplanned deforestation activities according to the VCS AFOLU Requirements (version 3.4). The deforestation pattern is typically of a mosaic nature. Further descriptions of the deforestation agents and drivers are presented in section 3.1.

b) *Project activities may include one or a combination of the eligible categories defined in the description of the scope of the methodology (table 1 and figure 2).*

¹⁹ Clay % obtained from the Harmonized World Soil Database
(<http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/>)

The project activity falls in the category avoided deforestation of secondary forest: model G of the methodology as shown in Figure 7. The goal of the project is to avoid further deforestation of the secondary forest.

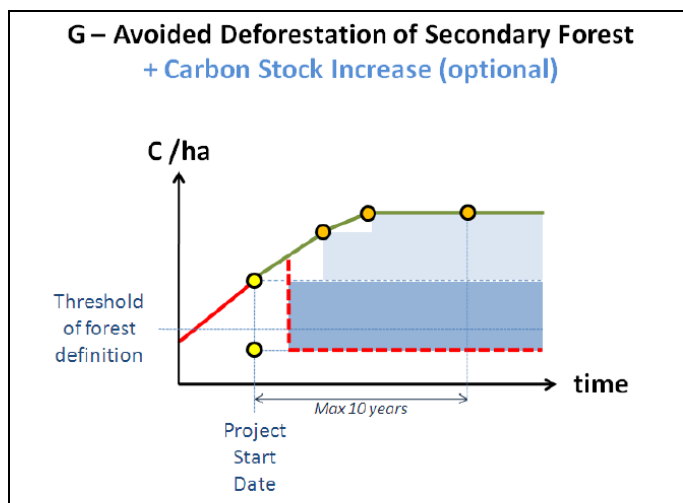


Figure 7: Project activity category

c) The project area can include different types of forest, such as, but not limited to, old-growth forest, degraded forest, secondary forests, planted forests and agro-forestry systems meeting the definition of “forest”.

Based on satellite image analysis, the vegetation in the project area has been classified as forest (Figure 8). The GIS files are available to the validator. Forest is defined in Zambia as “land with tree crown cover of more than 10%, an area of more than 0.5 hectare and the trees must be able to reach a minimum height of 5m at maturity”²⁰. The forests in the project area have evolved over time following cycles of human disturbances and forest regrowth and is, therefore, considered as secondary forest. Over 65% of the forests in Zambia are secondary forests (Mukosha and Siampale, 2009²¹).

²⁰ FAO, 2000. The Forest Resources Assessment Programme: On definitions of forest and forest change. Forest Resources Assessment Working Paper 33. Accessed [here](#).

²¹ Mukosha J., and Siampale, A. 2009. Integrated Land Use Assessment Zambia 2005–2008. Lusaka, Zambia and Rome: Ministry of Tourism, Environment and Natural Resources and Forestry Department, Government of the Republic of Zambia and the Food and Agriculture Organization of the United Nations.

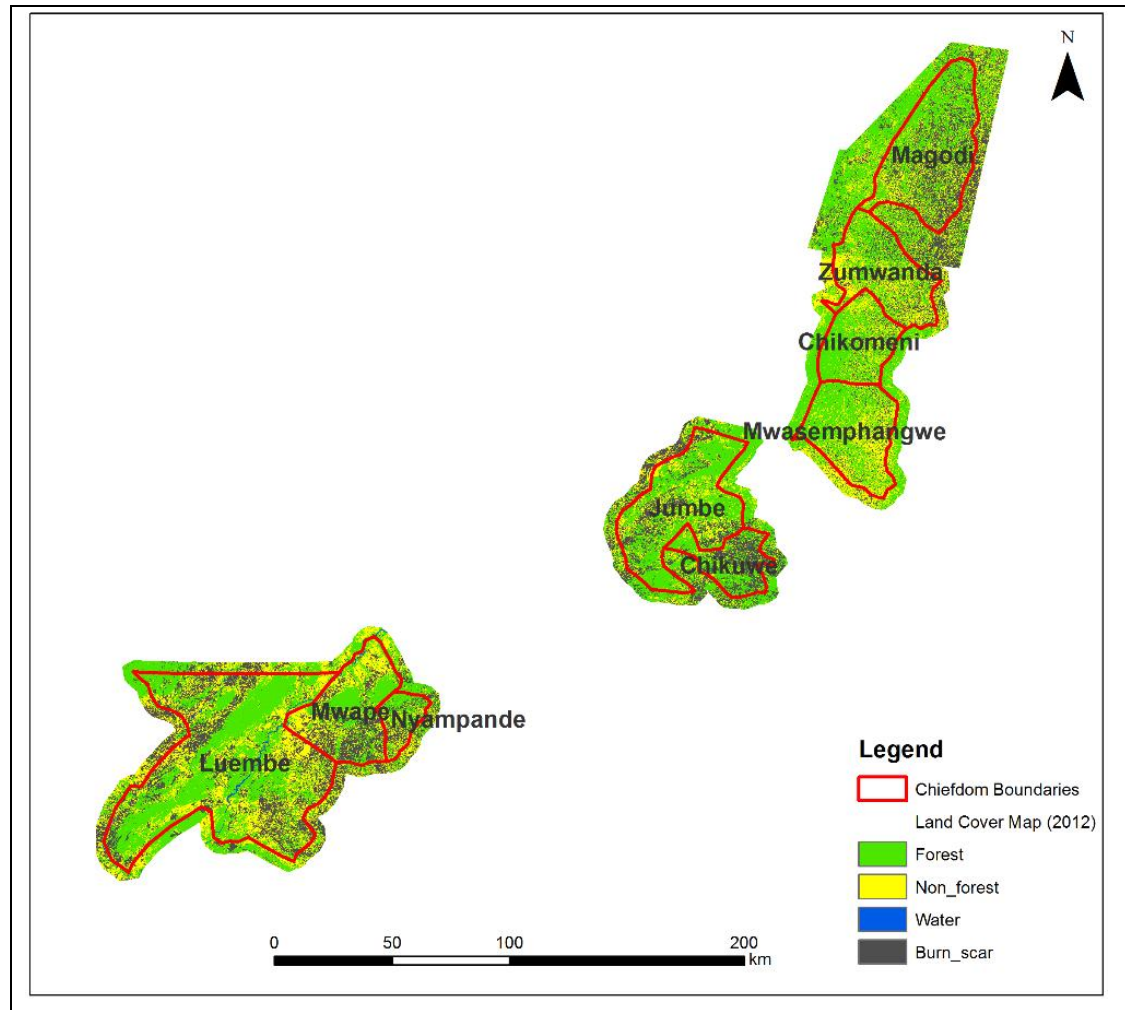


Figure 8: Forests in 2012 - constituting the project area

d) At project commencement, the project area shall include only land qualifying as “forest” for a minimum of 10 years prior to the project start date.

This is evidenced through the land use/cover analysis using satellite imageries of 2002 and 2013. Based on this analysis (detailed in section 3.1), only areas that were forests in 2002 and 2013 constitute the project area (Figure 9). A forest is defined as in c) above. The respective GIS files are available to the validator.

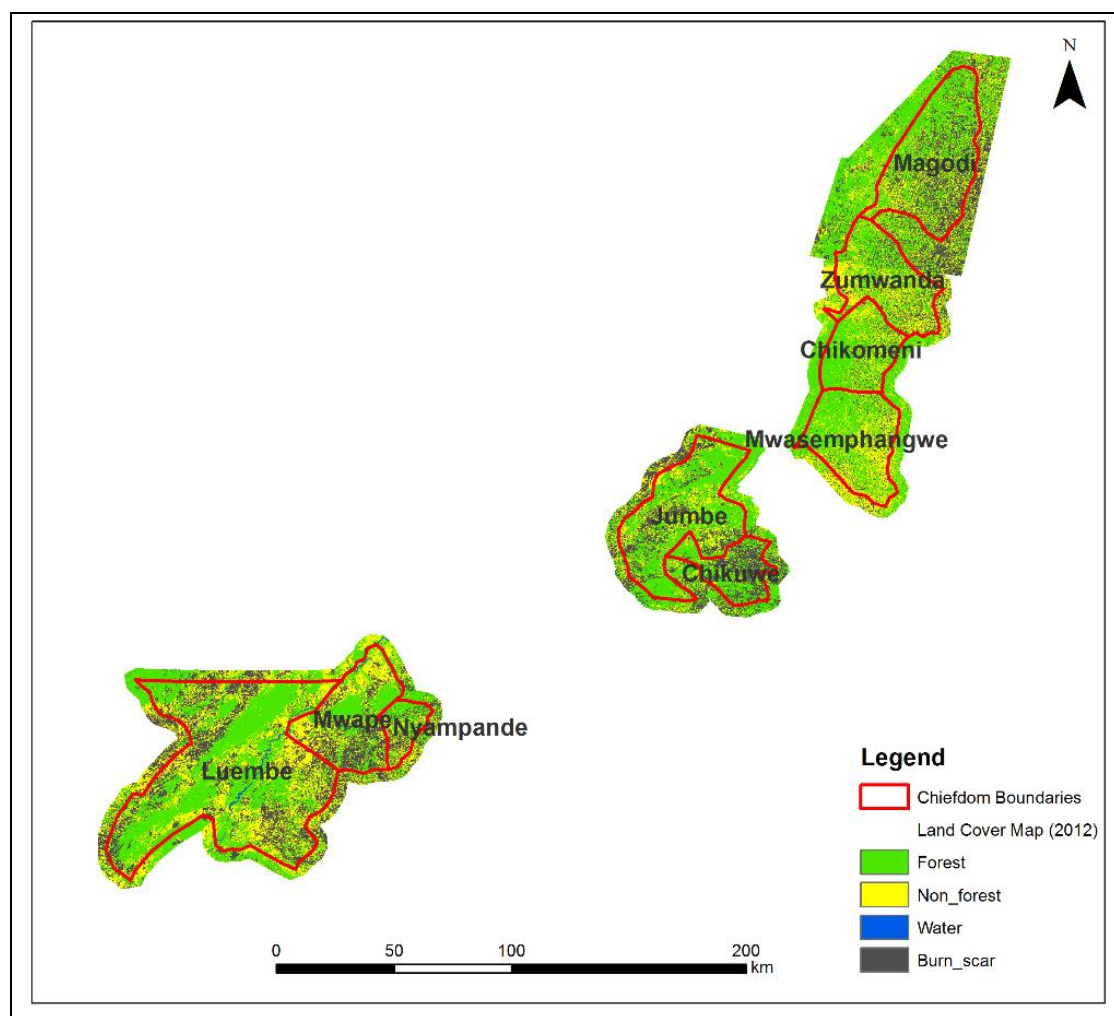


Figure 9: Forest areas in 2002 and 2013

e) The project area can include forested wetlands (such as bottomland forests, floodplain forests, mangrove forests) as long as they do not grow on peat. Peat shall be defined as organic soils with at least 65% organic matter and a minimum thickness of 50 cm. If the project area includes a forested wetlands growing on peat (e.g. peat swamp forests), this methodology is not applicable.

According to Joosten (2009)²², Zambia has an estimated 1.5 million ha of peatlands. However, peat as defined in e) above do not occur in the project area. This is demonstrated using the IPCC soil classes; the project area does not fall into organic soil class (Figure 10). Based on a study by Batjes (2010)²³, which derived the IPCC default soil classes from the Harmonized World Soil

²² Joosten, H. 2009 The Global Peatland CO₂ Picture: Peatland status and emissions in all countries of the world. Accessed [here](#).

²³ Batjes NH 2010. IPCC default soil classes derived from the Harmonized World Soil Data Base (Ver. 1.1) Report 2009/02b, Carbon Benefits Project (CBP) and ISRIC – World Soil Information, Wageningen (with dataset)

Database²⁴, all the soils in the project area belong to the IPCC soil classes: Low Activity Clay soils (LAC) and High Activity Clay soils (HAC). None of the area has the category of IPCC classes of Organic soils (ORG) or Wetlands (WET).

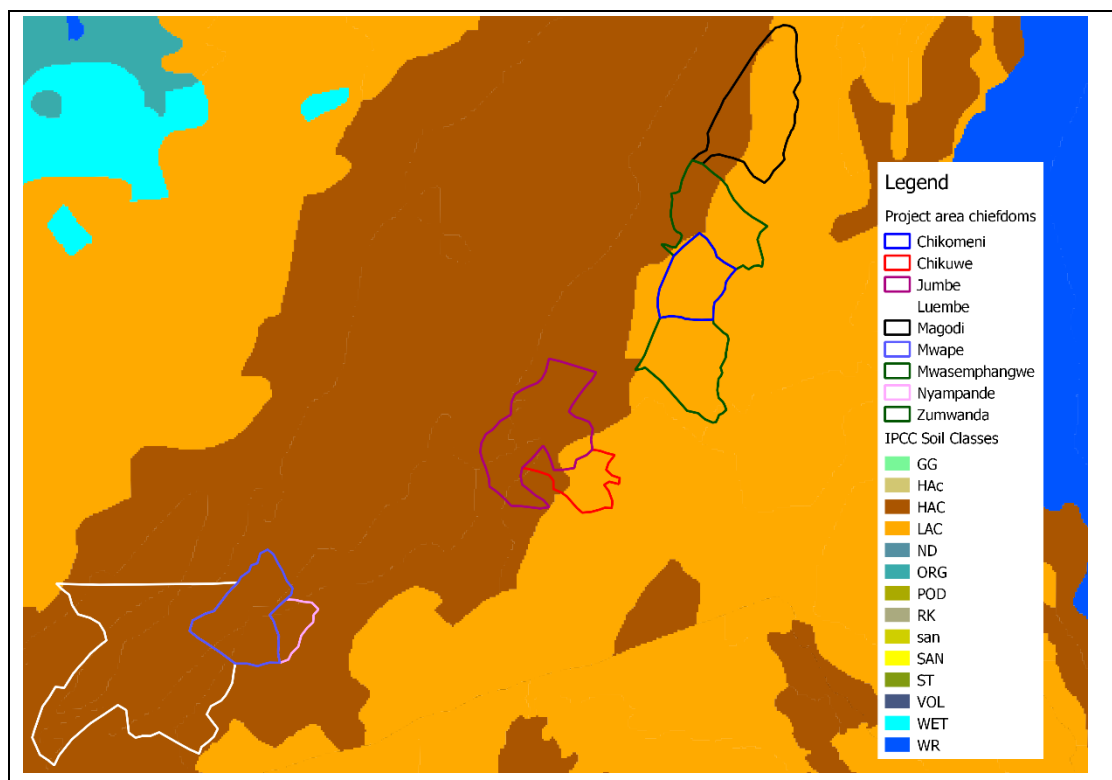


Figure 10: IPCC soil classes in the project area based on Batjes (2010)

As demonstrated in a) to e) above, the methodology is applicable to this AUD project activity.

2.3 Project Boundary

Geographic boundary

The project geographic boundary has been defined as the physical boundaries of the nine chiefdoms. Both the SALM and REDD+ components will be implemented within this geographic area. As a grouped project, this is the boundary where the first project activity instances and all future project activity instances will be developed. The geographic boundary and the reference region (described below) have the same boundary (Figure 11).

²⁴ FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.

2.3.1 SALM component

Project area

The SALM component will be implemented on agricultural lands belonging to farmers registered in groups/ cooperatives. The project-participating farms have been mapped with GPS points, and the information is stored as GIS files. The first project activity instances for the SALM component is shown Table 7. These figures are conservative as these are only the farmers and fields that COAMCO 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. As a grouped project, groups of farms could be added to the project as future project activity instances as long as they fall within the boundaries of the nine chiefdoms and meet the eligibility criteria for inclusion (section 1.13).

Table 7: The first project activity instances of the SALM component

Year	Number of farmers	Area (ha)
2013 to 2015	18,310	7,372
Total	18,310	7,372

The project proponent has gained control over the SALM component project area through the SALM agreements (pledges) signed in the registration process of participating farmer cooperatives. The land tenure system is customary. The farmers willingly agree to implement the SALM project activity of their agricultural lands. This is monitored through regular compliance survey as part of COMACO agreement with the farmers.

Carbon pools and sources of emissions of greenhouse gases

See Table 8 below.

Table 8: Carbon pools and sources of emissions selected for accounting in the SALM component

Source/sink	Gas	Justification
Above-ground tree biomass	CO ₂	This carbon pool is covered by SALM practices. The increase in above ground biomass of woody perennials planted as part of the SALM practices is part of the methodology. However, the project will not implement planting of woody perennials. Hence, this carbon pool is not accounted for.
Below-ground tree biomass	CO ₂	This is not accounted for the same reason given for above-ground tree biomass above.
Soil organic carbon (SOC)	CO ₂	A major carbon pool covered by SALM practices. This is modelled using the Roth C carbon model.
Fertilizer use	N ₂ O	Main gas for this source. Emissions from synthetic fertilizer use are estimated using the CDM Tool: Estimation of direct nitrous oxide emission from nitrogen fertilization

Fossil fuels combustion	CO ₂ , CH ₄ , N ₂ O	Emissions are estimated using the CDM Tool: Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities
Burning of crop residues (biomass)	CH ₄ , N ₂ O	Emissions are estimated using the Tool: Estimation of non-CO ₂ emissions from the burning of crop residues of the SALM methodology.

2.3.2 REDD+ component

The project boundaries of the REDD+ component have been defined and titled according to the methodology to ease referencing to the methodology.

Methodology Step 1: Definition of boundaries

Spatial boundaries

Reference region

The methodology requires that a reference region be defined, in addition to defining a leakage belt and leakage management area. The reference region is the analytical domain from which information on historical deforestation is extracted and projected into the future to spatially locate the area that will be deforested in the baseline case.

The reference region has been defined as the physical boundaries of the nine chiefdoms. It encloses the project area, leakage belt, and leakage management area (Figure 11). Its size is 1,444,088 ha. The methodology suggests for projects above 100,000 ha, the reference region may be about 5-7 times larger than the project area. The reference region is 12 times larger than the project area of the first project activity instances (116,629 ha). When further project activity instances are added, the ratio may not fall below 5.

The reference region has been selected to be the boundaries of the chiefdoms because this represents the closest match in terms of socio-economic and biophysical conditions to the project area – as described in the subsequent sections. There is presently no sub-national baseline available that could be used to define the reference region as stipulated in the methodology. Though a jurisdictional REDD+ program may be developed encompassing the Eastern Province, a baseline has not been established. Hence, a baseline has been defined for the project

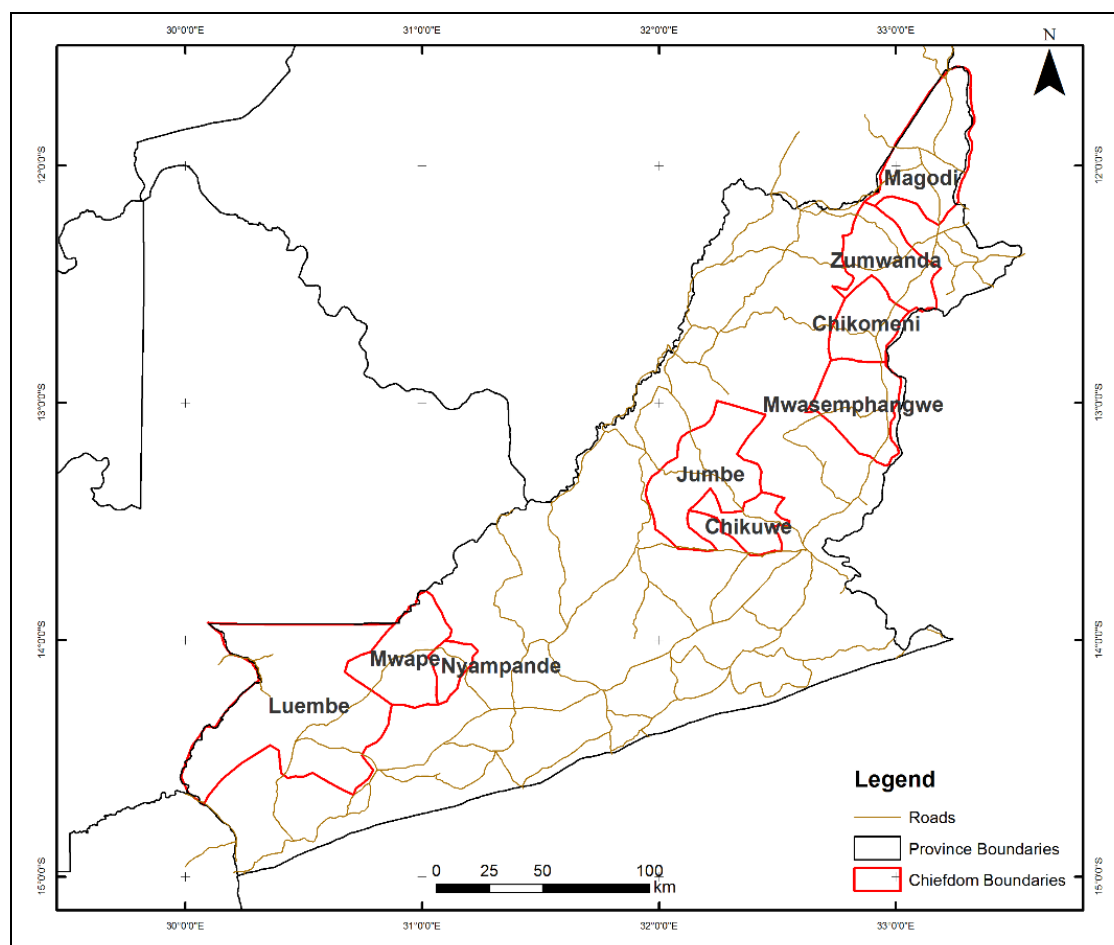


Figure 11: Geographic boundary/Reference region

The deforestation patterns and drivers observed in the reference region provide a credible proxy for what is expected to occur in the project area. The criteria relevant to demonstrate that the conditions determining the likelihood of deforestation within the project area are similar to those found within the reference region are discussed as follows:

Agents and drivers of deforestation

Agent group: The main deforestation driver across the entire reference region is small-scale agriculture. This is also recognised as the main deforestation driver throughout the country²⁵ Charcoal making is recognised as a forest degradation driver. Human populations are spread across the chiefdoms, and all forested areas are potentially accessible (see Figure 12).

²⁵ Vinya, R., Syampungani, S., Kasumu, E.C., Monde, C. & Kasubika, R. (2011). Preliminary Study on the Drivers of Deforestation and Potential for REDD+ in Zambia. Chomba *et al.*, 2012.

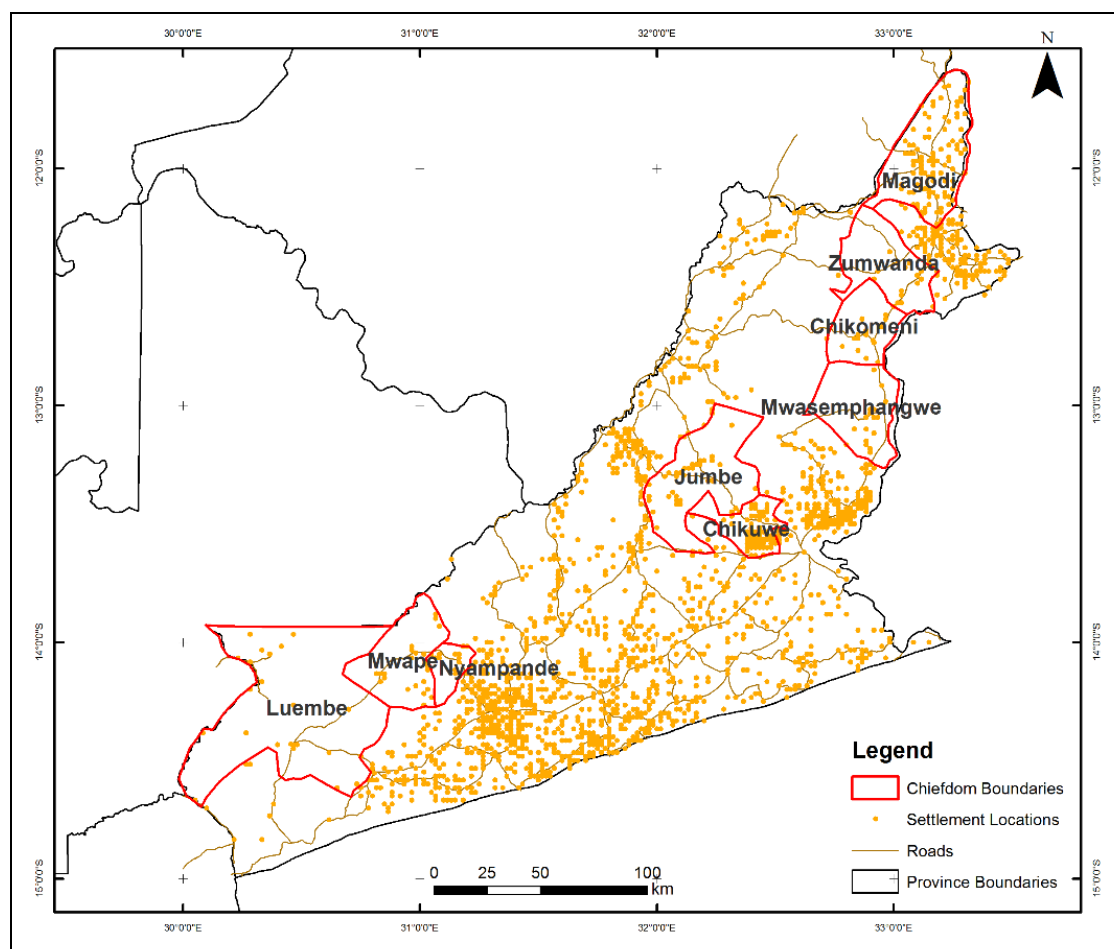


Figure 12: Distribution of human settlement (villages) within the reference region.

Population in the reference region is expected to continue to increase in the foreseeable future. The entire reference region can be classed as rural, where livelihoods are heavily dependent on agriculture, leading to agricultural expansion into forested lands. Hence, agricultural expansion is responsible for the mosaic deforestation pattern observed in the area, reflecting the pattern of human settlements that is spread across the area. As the project area is entirely enclosed within the reference region, the patterns of deforestation, agents, and drivers in the project area mirror those observed in the reference region. Farming practices, culture, and norms and practices of natural resource management are not expected to differ between the project area and the reference region.

Infrastructure drivers: Significant infrastructural developments are generally linked to mining activities and include roads and railways, and the mining infrastructure²⁶. Such large infrastructural developments do not occur in the project area. They are not documented to have occurred in the reference region at a scale that affected forest resources significantly. The road density in the reference region is estimated at about 0.5 km for every 1,000 ha of land²⁷. The

²⁶ Vinya, R., Syampungani, S., Kasumu, E.C., Monde, C. & Kasubika, R. (2011). Preliminary Study on the Drivers of Deforestation and Potential for REDD+ in Zambia.

²⁷ The road layer was obtained from DIVA-GIS. Accessed [here](#).

reference region is not among the mineral-rich regions where large scale infrastructural projects take place. (The mineral resources of Zambia are concentrated in the Copperbelt, North-Western, Central Province, Southern Province, and Lusaka Provinces²⁸). Hence, both in the reference region and the project area infrastructure drivers do not play a noteworthy role in deforestation.

Other spatial drivers expected to influence the project area: There are no other spatial drivers in the reference region that are expected to influence the project area during the baseline period.

Landscape configuration and ecological conditions

According to the methodology, at least three of the following four conditions must be satisfied:

Forest/vegetation classes: The methodology stipulates that “at least 90% of the project area must have forest classes or vegetation types that exist in at least 90% of the rest of the reference region”. The forest class in the reference region and project area are entirely the same (Figure 13). The GIS files are available to the validator.

²⁸ Ministry of Mines and Mineral Deposits, (n.d). Investment Opportunities in the Mining Industry. Accessed [here](#).
Mitchell, C., (n.d). Industrial Mineral Resources of Zambia. Accessed [here](#).

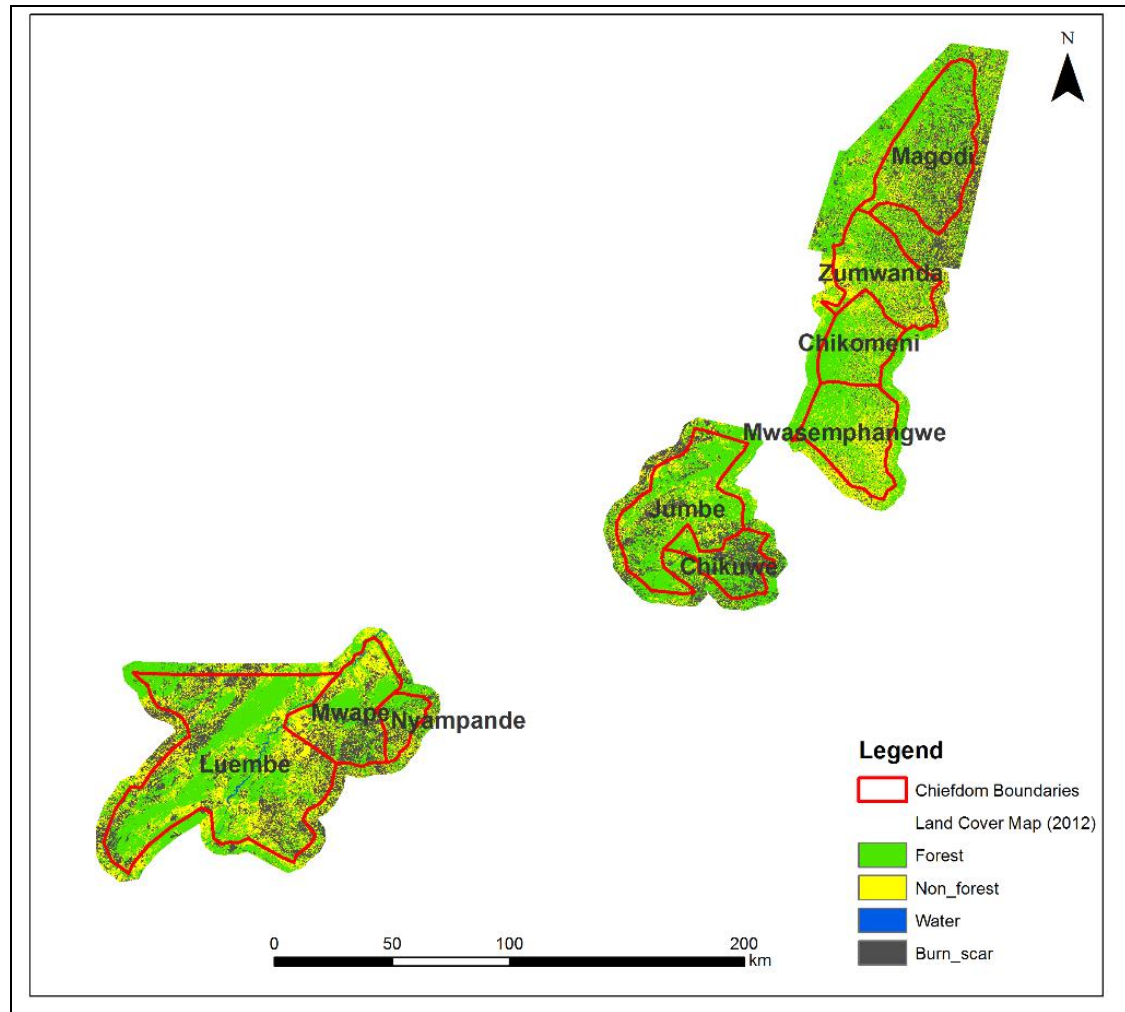


Figure 13: Forest class in the project area and reference region

Elevation: The methodology stipulates that “at least 90% of the project area must be within the elevation range of at least 90% of the rest of the reference region”.

The project area is 100% within the elevation range of the reference region (see Figure 14)²⁹. The GIS files are available to the validator.

²⁹ Elevation data were derived from the ASTER. Accessed [here](#).

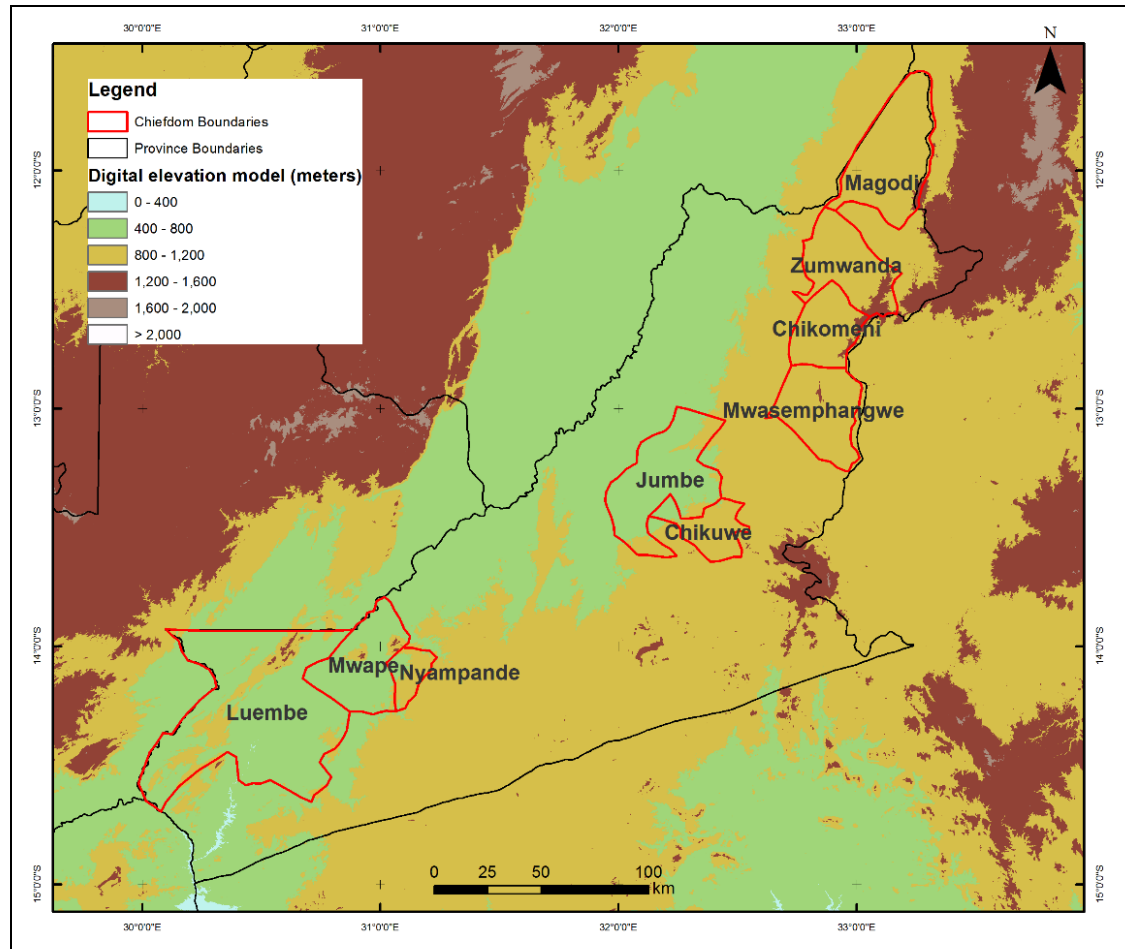


Figure 14: Elevation of reference region and project area

Slope: The methodology stipulates that “the average slope of at least 90% of the project area shall be within $\pm 10\%$ of the average slope of at least 90% of the rest of the reference region”.

The project area is 100% within the slope range of the reference region (see Figure 15)³⁰. The GIS files are available to the validator.

³⁰ Elevation data were derived from the ASTER. Accessed [here](#).

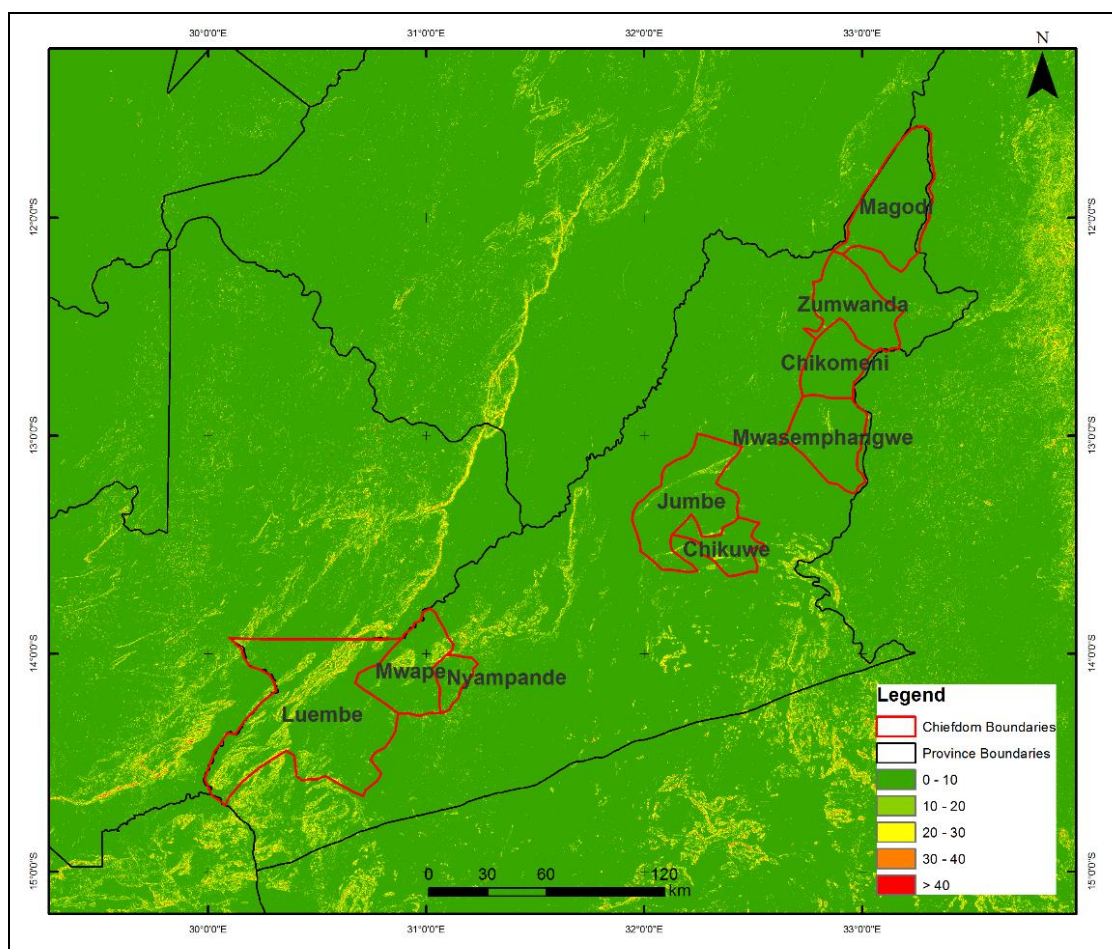


Figure 15: Slope of reference region and project area

Rainfall: The methodology stipulates that “the average annual rainfall in at least 90% of the project area shall be within $\pm 10\%$ of the average annual rainfall of at least 90% of the rest of the reference region”.

This condition is not evaluated as at least three of the above conditions have already been met, as required by the methodology.

Socio-economic and cultural conditions

The following conditions must be met:

Legal status of the land: The legal status of the land in the baseline case within the project area must exist elsewhere in the reference region as per the methodology.

The Land Act, 1995 vests all lands in Zambia in the President, recognising two types of tenure: customary tenure and leaseholds rights to state land³¹. All the land in the project area and

³¹ USAID, 2010. Property rights and resource governance, Zambia. Accessed [here](#).

reference region is entirely under the 9 chiefdoms, hence, are under customary tenure legal status.

Land tenure: Land-tenure system prevalent in the project area in the baseline case is found elsewhere in the reference region.

The land tenure system in both the project area and reference region is exclusively customary tenure.

Land use: Current and projected classes of land-use in the project area are found elsewhere in the reference region

The project area and reference region land use classes are derived from remote sensing analysis (Figure 13). The two spatial boundaries have the same land use classes. They are typically rural area, heavily dependent on agricultural activities – the main driver of land use change. As mentioned above, the main driver of land use change in both the project area and reference region are entirely the same: small-scale conversion to agriculture. Future land use classes are also expected to be similar.

Enforced policies and regulations: The project area shall be governed by the same policies, legislation and regulations that apply elsewhere in the reference region.

As the project area is entirely within the reference region, the same laws that govern the project area certainly do govern to entire reference region. Relevant policies/regulations include the Land Act, 1995 and the new Forests Act, 2015.

REDD Project area

The project area includes all lands within the boundaries of the Community Conservation Areas in all nine chiefdoms that are 'forests' in 2013, and were forest in 2002, which totals 116,629 ha³². Forest is defined in Zambia as "land with tree crown cover of more than 10%, an area of more than 0.5 hectare and the trees must be able to reach a minimum height of 5m at maturity"³³. The project area is shown in Figure 16. As a grouped project, additional areas (parcels of forests) could be added to the project area as long as they fall within the nine chiefdom boundaries and meet the eligibility criteria for inclusion (section 1.13). Hence, the project area could increase in the future.

³² Note that this is the project area for the first activity instances.

³³ FAO, 2000. The Forest Resources Assessment Programme: On definitions of forest and forest change. Forest Resources Assessment Working Paper 33. Accessed [here](#).

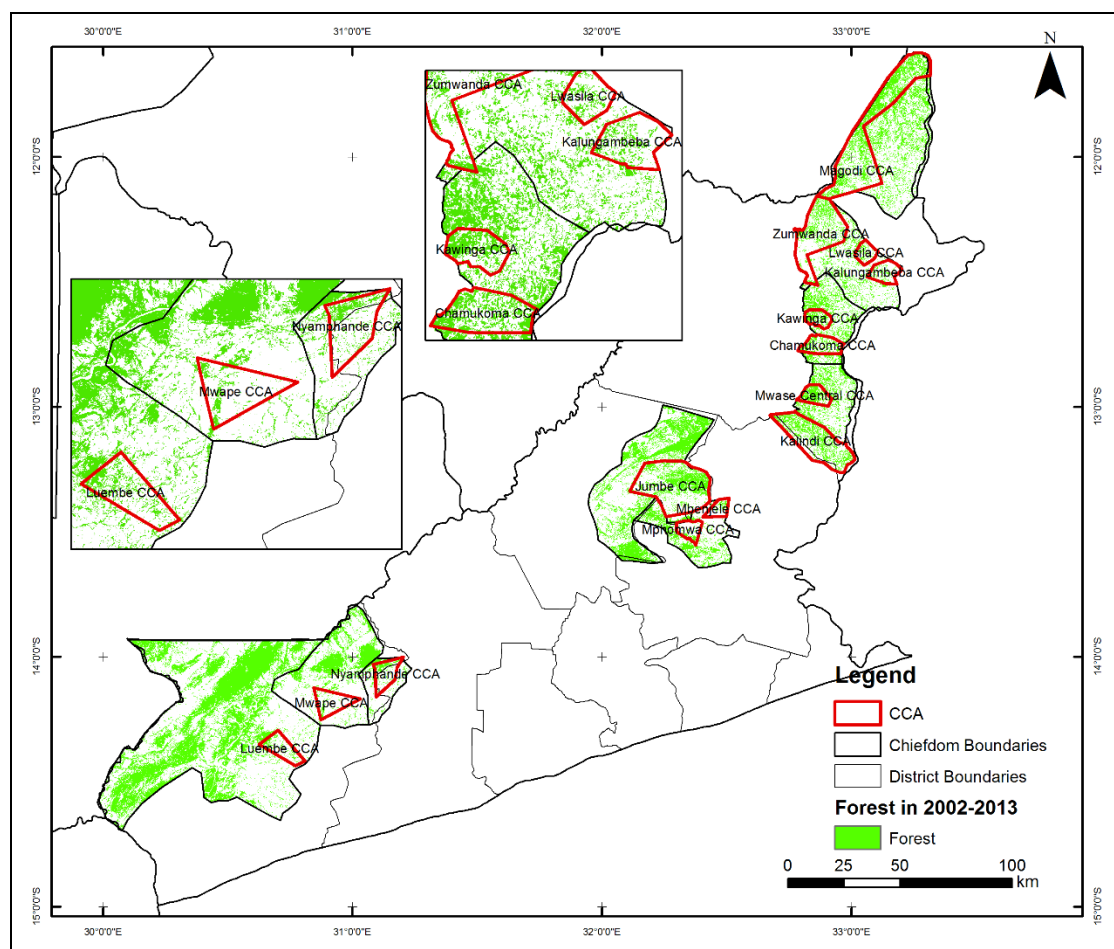


Figure 16: Project area

The area of the first project activity instances for the REDD+ component is shown in Table 9. The potential project area for the REDD+ component is estimated at 288,810 ha considering the reference region of the first project activity instances.

Table 9: First activity instances for the REDD+ component

Name of chiefdom	Name of CCA	Forest area (ha)	Total CCA area (ha)
Chikomeni	Chamukoma	5,175	11,987
	Kabinga	3,500	7,137
Jumbe	Jumbe	22,058	58,784
Masemphangwe	Kalindi	17,673	42,644
	Mwase Central	5,215	8,846
Zumwanda	Kalungambeba	1,962	10,218
	Lwasila	1,594	6,498
	Zumwanda	12,373	43,375
Magodi	Magodi	37,074	76,364

Chikuwe	Mbenjele	1,333	5,738
	Mphomwa	1,332	7,619
Mwape	Mwape	1,496	13,691
Nyamphande	Nyamphande	2,943	11,309
Luembe	Luembe	2,901	12,816
Total		116,629	317,026

The KML files of the physical boundaries that define the project area are available as supporting document.

The project proponent has gained control over the REDD+ component project area through formal agreements been signed with the Royal Highnesses of the nine chiefdoms. The AUD project activity is implemented by the communities and chiefdoms, with support from COMACO and relevant government institutions i.e. the FD, and DNPW.

REDD+ Leakage belt

In order to determine the leakage belt a mobility analysis was carried out as per the methodology. The final result of the analysis shows that the leakage belt is presented by the forests which are inside of a 1 km buffer around the existing non-forest areas within the CCAs.

This result is primarily based on:

- Historical land use analysis
- Expert opinion
- Participatory rural appraisal

Based on the literature review, local stakeholder consultation and expert opinions the main driver of deforestation in the region is small scale agriculture. This was also confirmed by the rural appraisal carried out in the field (supporting document: UNIQUE, CLMP Driver analysis and effectiveness factors, 2015).

The historical land use analysis confirmed and showed that the deforestation in the past has occurred in the vicinity of the non-forest lands. This means that the farmers were using the next accessible areas for cultivation and, therefore, limiting the deforestation in a certain area. The area was furthermore limited by the slope, which showed to be one important factor in the deforestation.

Using a distance analysis in GIS, it showed that more than 90% of the deforestation in the periods 2002-2013 has occurred in a distance which is within 1 km counting from non-forest areas.

Presuming that this trend would continue in the future, the leakage belt has been defined as forests which are in the 1 km buffer around the existing non-forest areas within the CCAs.

Consideration of other VCS AFOLU projects

Currently no other VCS AFOLU projects are within the boundary of the reference region.

REDD+ Leakage management areas

These are non-forest areas located both inside and up to 1 km outside the boundaries of the non-forest areas within the CCAs in which the project proponent will implement activities that will reduce the risk of activity displacement leakage. The SALM component of the project enhances crop land management and intensifies agricultural production to minimize shifting cultivation. The boundary of the SALM farms within the CCAs are defined according to SALM pledges and relate to the proposed AUD project activity. The boundary of leakage management areas are defined using the common projection and GIS software formats used in the project, and shall be re-assessed and validated at each fixed baseline period. The KML files are available as supporting documentation.

The spatial boundary of the REDD+ component of the project is summarised in the Table 10 below:

Table 10: Spatial boundaries of the REDD+ component

Spatial boundaries		Area (ha)	Remarks
Reference region		1,444,088	All areas (forest and non-forest)
Project area		116,629	For the first project activity instances only
Leakage belt	Total area	67,096	Land area within distance of baseline activity displacement
	Forest	9,692	Forest areas within the leakage belt subject to leakage
Leakage management area		57,403	

Forest definition

Forest is defined according to the national definition applied in Zambia: forest is “land with tree crown cover of more than 10%, an area of more than 0.5 hectare and the trees must be able to reach a minimum height of 5m at maturity”³⁴. The project area comprises only forests as shown in Table 9 and Figure 16.

³⁴ FAO, 2000. The Forest Resources Assessment Programme: On definitions of forest and forest change. Forest Resources Assessment Working Paper 33. Accessed [here](#).

REDD+ Temporal boundaries

Start date and end date of the historical reference period

The start date and end date of the historical reference period is 1 May 2002 and 17 July 2013. Analysis of historic baseline deforestation drivers, patterns, etc. are all related to this period. The end date of the reference period and the start of the fixed baseline period below are both 17 July 2013. It is one year after project start date. This is because reliable LANDSAT images (images without errors, clouds, etc.) were unavailable for 2012, hence, 2013 images were used for analysing land use change, deforestation rate, etc., and the generating Forest Cover Benchmark Map.

Starting date of the project crediting period of the AUD project activity

See section 1.6

Starting date and end date of the first fixed baseline period

The project fixed baseline is 10 years starting 22 June 2013 and ending 21 July 2023. The baseline will be renewed every 10 years as per the methodology.

The fixed baseline period is one year later than the project start date. 2012 satellite images of good quality collected from the same satellite platform or comparable ones that could be used to establish forest cover were unavailable for 2012. Hence, 2013 imageries have been used. The 2002 and 2013 satellite imageries used for forest cover analyses were LANDSAT imageries. Using 2013 imageries for a project that started in 2012 is conservative as any reductions of deforestation due to project activities are not accounted for.

Monitoring period

The minimum duration of monitoring period will be one year and the maximum duration will be one fixed baseline period (10 years).

REDD+ carbon pools

See Table 11 below.

Table 11: Carbon pools selected for accounting in the REDD+ component

Carbon pools	Included/Excluded	Justification
Above-ground:	Tree: included	As per methodology, carbon stock change in this pool is always significant

	Non-tree: excluded	According to methodology, must be included in categories with final land cover of perennial crop. The final land cover in this project is not perennial crops, but annual crops.
Below-ground	Included	The change in this carbon pool is expected to be significant
Dead wood	Excluded	Change in this carbon pool is expected to be insignificant ³⁵
Harvested wood products	Excluded	There is no significant logging in baseline or expected in the project scenario. As the project activity category is avoided deforestation without logging, exclusion is conservative.
Litter	Excluded	This carbon pool is insignificant both in the baseline and project scenario ³⁶ .
Soil	Included	As recommended by methodology, when forests are converted to cropland, carbon stock change can be significant.

REDD+ sources of emissions of greenhouse gases

See Table 12 below. As fire is used as part of the process of converting forest to agricultural land (slash-and-burn), non-CO₂ emissions from biomass burning has been included.

Table 12: Source of GHG emissions included and excluded in the project

Carbon pools	Gas	Included/Excluded	Explanation
Biomass burning	CO ₂	Excluded	Accounted for as carbon stock change
	CH ₄	Included	Significant as fire is used in the process of converting forestlands to agriculture.
	N ₂ O	Excluded	Insignificant source as per methodology stipulation
Livestock	CO ₂	Excluded	Not a significant source as per methodology
	CH ₄	Excluded	Not a significant source
	N ₂ O	Excluded	Not a significant source

2.4 Baseline Scenario

³⁵ Based on figures from Kamelarczyk (2009), deadwood biomass constitutes between 1% and 7% only of total biomass in forests in Zambia.

³⁶ Litter biomass constitutes between 4% and 7% only of total biomass in forests in Zambia (Kamelarczyk (2009)).

2.4.1 SALM component

The project baseline is identified by applying the CDM “Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities” Version 01. The main sources of information used include the project baseline surveys, and agricultural statistics by Tembo and Sitko 2013³⁷. The baseline conditions is summarised in Table 13. The baseline scenario and the demonstration of additionality are determined for the entirety of the geographic project area within which project activity instances are developed. The project monitoring system ensures that the baseline scenario and the additionality are representative for all potential farms in the project as well as the initial project activity instances (farms currently adopting SALM).

Table 13: Baseline conditions

Characteristics	Value
Land use	
Landholding (ha/farmer)	0.9-1.8 (average = 1.2)
Dominant cropping system	Cereals production (maize)
Average cereals crop yield – maize (tonne/ha/yr.)	1.31
Farming practices*	
Use compost	0.78%
No burning	3.36%
Residues management	3.21%
Crop rotation	19.86%
Pot-holing (indicator of conservation agriculture)	4.94%
Intercropping	2.12%
Alley-cropping	0.14%
Use of fertilizer	41.78%

* Farming practices as a percentage of agricultural land in the baseline.

The baseline conditions of the project area are characterised by:

- The dominant land use and livelihood activity at the household level is agriculture. Expansion of agricultural land use is continuing due to increasing population, and limited alternative livelihoods options. Agricultural land increased from 398,000 ha to 505,000 ha between 2000

³⁷ Tembo and Sitko 2013. Technical Compendium: Descriptive Agricultural Statistics and Analysis for Zambia.

and 2009 in the Eastern Province according to surveys from the Central Statistical Office of Zambia.³⁸

- 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)³⁹.
- Cereal production, particularly maize is the dominant cropping system, with about 75% of cropland allocation. Other important crops are beans and groundnuts and root crops: cassava and potatoes. Average cereal yield (maize being the main one) is low, at 1.3 tons/ha. Yields could be more than doubled with application of improved agricultural land management practices, such as those implemented in this project.
- There is low level of application of good agricultural practices among the farmers as shown in Table 13. A combination of factors is responsible for this situation – including limited information and access to new technologies, weak agricultural extension system, and low financial capacities of the small-scale farmers.

In recognition of the above scenarios, a number of initiatives e.g. government's Fertilizer Support Program/Farmer Input Support Program (FSP/FISP) program, and USAID's Feed the Future have been initiated in recent years. The main aims of these initiatives are, among others, to improve agricultural productivity of the small landholder farming system. However, the main approach has though been increasing access to inputs such improved seeds and inorganic fertilizers rather than adoption of good agricultural land management practices.

The low input smallholder subsistence agriculture and its attendant features outlined in the preceding section is the most dominant land use system in the project area, and has been so over several decades. It is expected to continue and, therefore, is the baseline scenario.

2.4.2 REDD+ component

The baseline scenario of the REDD+ component has been established following the methodology as described in the following steps.

A jurisdictional REDD+ program may be developed encompassing the Eastern Province, though a baseline for it has not been established. Hence, a baseline has been defined specifically for this project. However, if in the future a jurisdictional baseline is defined, the baseline of this project will be revised using the jurisdictional baseline. The Forestry Department is currently undertaking LULC maps for the whole country, which it recommends should be used for REDD+ projects in the country; hence, a new baseline may be derived from this effort.

³⁸ 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. (see Annex 4)

³⁹ The Simpson Diversity Index measures household-level crop diversification. It takes into account the proportionate of a household's total area that is dedicated to each crop ranging. It can therefore range from between zero and one. As a household becomes more diversified the index moves towards one.

Methodology Step 2: Analysis of historical land-use and land-cover change

Collection of appropriate data sources

Land cover data used were mid-resolution LANDSAT satellite imagery for 2002, 2008 and 2013 of the entire reference region. The analysis of deforestation rates and patterns has been produced using these satellite data, which are described in detail in Table 14, and includes three dates over the 10-year historical reference period: 2002, 2008, and 2013. These are freely available Landsat imagery. Ground-truthing or validation consisted of comparing results from high resolution images from Google Earth (Digital Globe imagery, 1m spatial resolution).

The methodology requires that medium resolution spatial data should be used in the land cover and change detection analysis, covering the past 10-15 years from the project start date. We used Landsat images (30m resolution) for the analysis as this is the most common and freely accessible image. There is, however, a permanent problem using optical imagery in tropical countries: the common presence of clouds that mask out the landscape from the satellite sensor. Images were selected as close to the target years as possible i.e. 2002, 2008 and 2013 for which near cloud free images were available.

Table 14: Data used for historical LU/LC change analysis

Landsat Path / row	Scene acquisition dates		
	2002	2007	2013
p169r68	08.05	28.04	17.07
p169r69	08.05	28.04	17.07
p170r69	12.03	21.05	19.04
	15.05		06.06
p170r70	12.03	21.05	22.04
	15.05		06.06
p171r70	20.04	26.04	28.05

Definition of classes of land-use and land-cover

One forest class and one non-forest (post-deforestation land use) class were identified in the reference region as summarised in Table 15: The methodology proposes that forest lands be classified into strata of homogenous carbon densities. In this project, however, strata are not defined due to lack of good quality (season/cloud free) data to classify forest into strata with homogenous carbon densities. Hence, as per the methodology, the minimum classes of “Forest Land” and “Non-Forest Land” classes are defined; the Non-Forest Land is agriculture in Table 15. After deforestation, the forest is converted to the same land use i.e. small-scale agriculture, with very low carbon stock densities. Average biomass in the forest and non-forested classes are assumed to remain constant both in the baseline and project scenario.

Table 15: List of all land-use and land-cover classes existing at the project start date within the reference region

Class identifier		Trend in carbon stock	Present in	Baseline activity			Description
<i>ID_{cl}</i>	Name			LG	FW	CP	
1	Forest	Constant	PA, RR, LK	No	Yes	Yes	Forests with $\geq 10\%$ tree crown cover
2	Agriculture	Constant	RR, LM	No	No	No	Cropland with $< 10\%$ tree crown cover

PA = Project area; RR = Reference region; LK = Leakage belt; LM = Leakage management area; LG = Logging; FW = Fuelwood; CP = Charcoal production. Note: although FW, and CP are considered as baseline activities, they are degradation drivers, not deforestation drivers.

No areas of land are expected to undergo significant decrease in carbon stocks that would lead to an overestimation of the GHG emission reductions achieved by the project activity since:

- The project uses a conservative definition of forest;
- The trend in carbon stock changes for the forest LULC will be constant or increasing, while that for the non-forest land could decrease but is assumed to remain constant.
- The project does not seek credits for any increases in carbon stocks in the forest land class. Therefore, a single LULC map representing the spatial distribution of the forest at the project start date is generated.

Definition of classes of land-use and land-cover

Two possible LULC classes are defined and their changes/transition over time is shown in Table 16.

Table 16: List of land-use and land-cover change categories

Class identifier		Trend in carbon stock	Present in	Activity in the baseline case			Name	Trend in carbon stock	Present in	Activity in the project case		
<i>ID_{ct}</i>	Name			LG	FW	CP				LG	FW	CP
1	Forest	Constant	PA, RR, LK	No	Yes	Yes	Forest	Constant	PA, RR, LK	No	Yes	No
2	Agriculture	Constant	RR, LM	No	No	No	Agriculture	Constant	RR, LM	No	No	No
1	Forest	Constant	PA, RR, LK	No	Yes	Yes	Agriculture	Decreasing	RR, LK	No	No	No
2	Agriculture	Constant	RR, LM	No	No	No	Agriculture	Decreasing	RR, LK	No	No	No

Analysis of historical land-use and land-cover change

The analysis of the historical land-use as well as the land-cover change was performed using well known Remote Sensing techniques. QGIS and the plugin “Semi-automatic classification plug-in”⁴⁰ were used for most of the GIS works and land use classification, whereas TerrSet Land Change Modeller⁴¹ were used for the deforestation modelling.

Pre-processing

The analysis was based on Landsat 5, 7 and 8 imagery which have a resolution of 30m. In Table 14 the available scenes used are listed.

Since the available imagery had different properties in respect of data of acquisition, cloud cover, image quality etc., certain pre-processing steps were made to ensure good quality of the analysis.

- Atmospheric correction – in order to reduce the effects of the atmospheric light distortion this procedure has been carried out for each image. It enables a comparison between multi-temporal images and improves the results of the classification.
- Cloud masking – due to the limited amount of images available for the project region, it was not possible to completely avoid the use of images with clouds. For a small part of the project area, images were used where clouds are clearly visible. The clouds and their cast shadow were masked out from the images and shows as “unclassified” in the final results

In general the analysis was done for each scene separately and therefore the pre-processing steps were also performed separately for each scene.

Interpretation and classification

The land use classification which was performed is per-pixel classification using the Maximum-Likelihood algorithm.

One major input in the classification is the datasets which are defining the training areas of each land use class. Since no field work was available to acquire these datasets, and no additional information was available, the delineation of the training areas was done using high-resolution satellite imagery accessed through Google Maps and Bing Maps.

The training areas have been delineated for each image separately and have been attributes with land use classes on two levels as shown in the table below:

Land Use – Level 1

⁴⁰ Congedo Luca, Munafò Michele, Macchi Silvia (2013). “Investigating the Relationship between Land Cover and Vulnerability to Climate Change in Dar es Salaam”. Working Paper, Rome: Sapienza University.

⁴¹ <http://www.clarklabs.org/products/land-change-modeler.cfm>

Forest	Forest
Non-forest	Non-forest Burnt scars Water

Afterwards each image was classified using the Semi-automatic classification using ENVI5.1 and the resulting classification was individually saved.

Post-processing

After the classification for each image was performed, the post-processing steps were carried out in order to smooth the results of the per-pixel based classification.

- Majority filter – in order to remove individual pixels and to improve the general result a majority filter with a window of 3x3 pixels has been implemented at the end.
- Mosaicking – all individual images after the majority filtering have been mosaicked into one image, which was cropped to the extent of the project region.

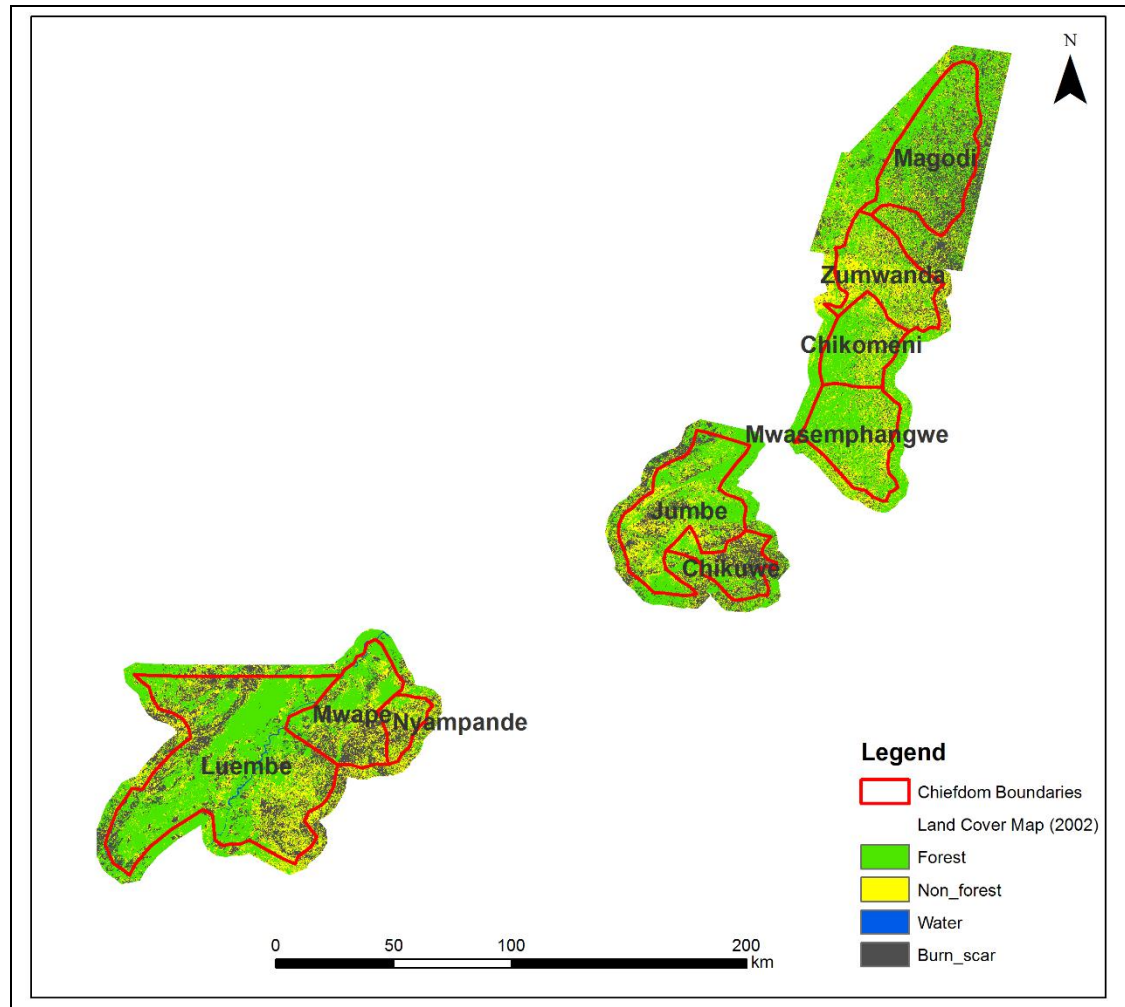
Land cover change data exist for 2002, 2008 and 2013, via analysis of Landsat-5 data for the entire reference area (VM Table 5). The result is a map of cover and change for forest, non-forest, water and cloud over the three time periods, with less than 10 percent cloud cover in any time period. Change rates are calculated in percent per year for areas that were cloud free in both dates in question. A maximum forest cover map for 2013 was produced using all dates of imagery, i.e. filling in cloudy areas in 2013 with classifications from earlier years, if not forest.

The land-cover change analysis is based on traditional methods of remote sensing analysis that have been applied successfully in many tropical forest regions.

For further details on pre-processing, interpretation and classification, and post-processing steps, refer to supporting documentation and supplementary Information – Land cover and land change analysis for COMACO.

At the end of step 2, a series of maps for the reference region and project area were produced from this analysis, as per the methodology requirements. Forest cover benchmark maps for the first and the last date analyses are shown below in **Error! Reference source not found.** Figure 17. Deforestation for the two sub-periods analysed (2002-2008, and 2008-2013) are presented in Figure 18. The Deforestation maps for 2002-2008 and 2008-2013 periods represent the Land-Use and Land-Cover Change map for the respective periods. The GIS files are available to the validator.

A Land-Use and Land-Cover Change Matrix for the most recent period analysed is also shown in Table 17.



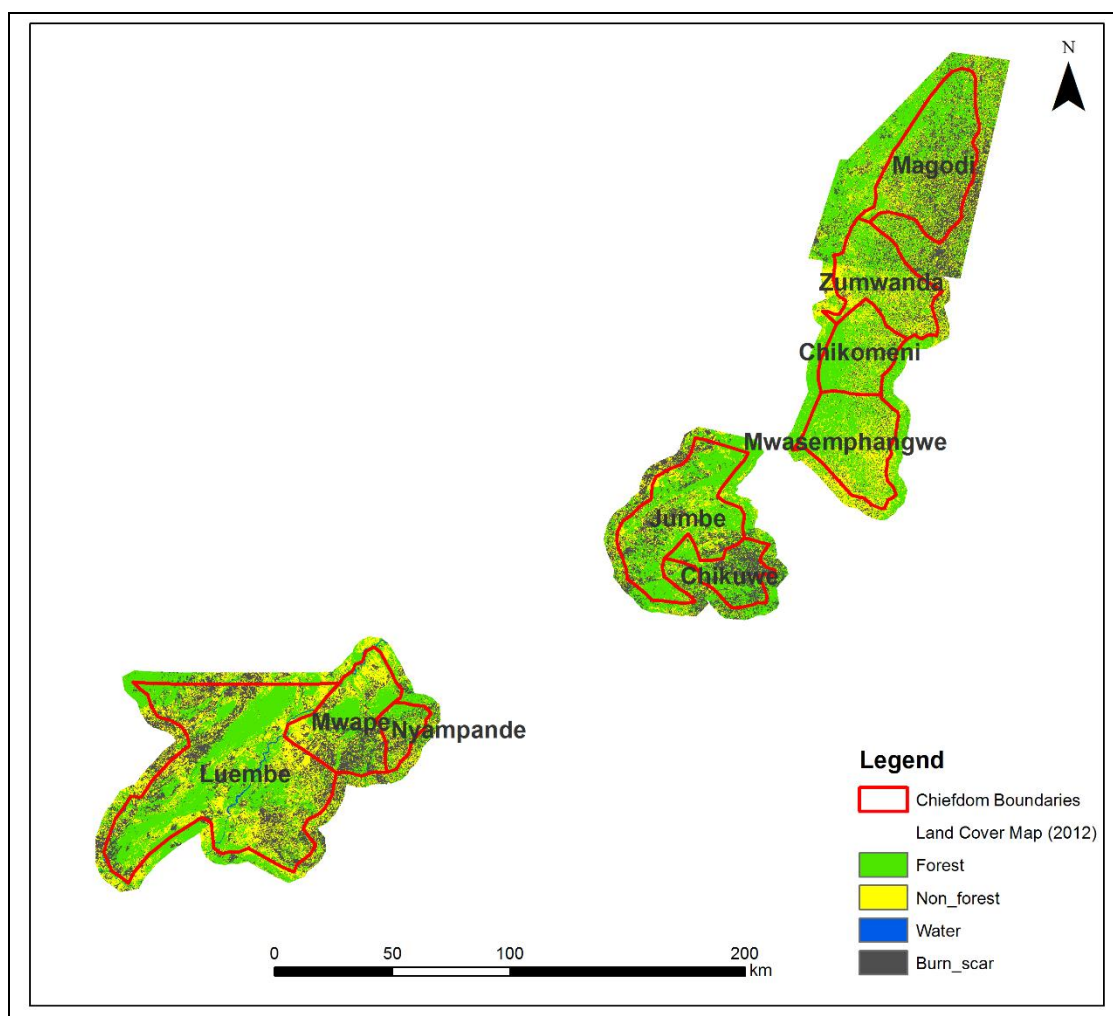
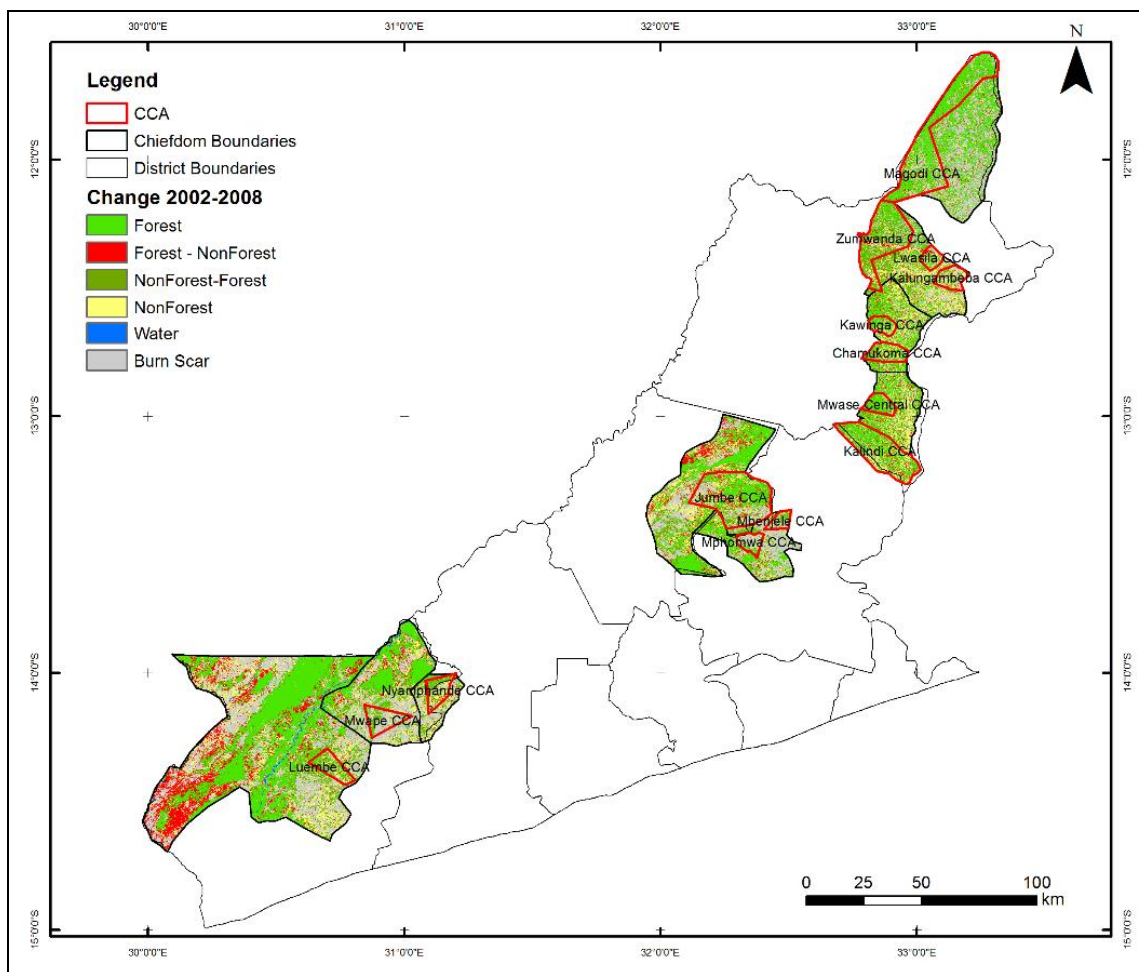


Figure 17: Forest cover benchmark maps for 2003 (top), and for 2013 (bottom)



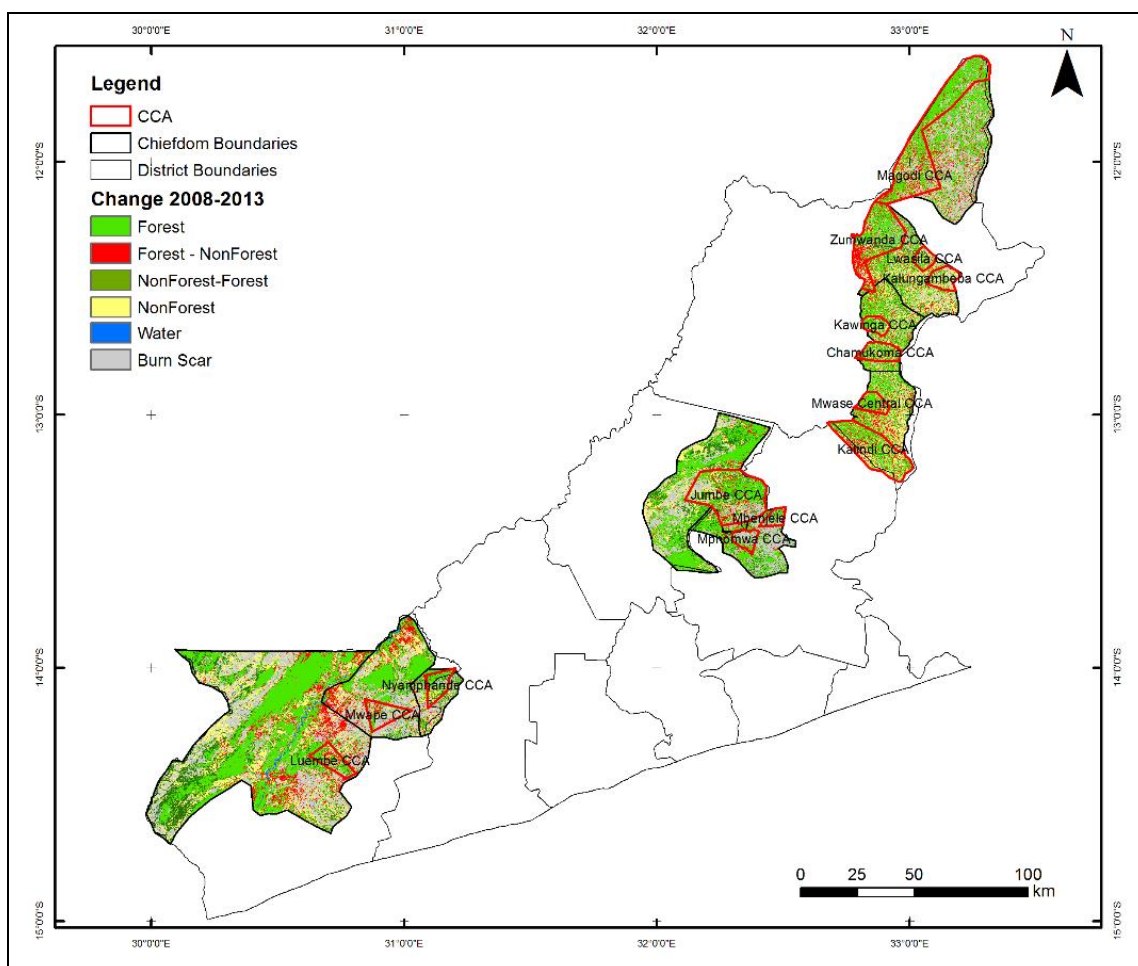


Figure 18: Deforestation map 2002-2008 (top), and Deforestation map 2008-2013 (bottom)

Land use land cover change matrix

Table 17 shows the area in hectares of each forest class converted to non-forest in the reference region during the last period analyzed 2008-2013.

Table 17: Land use land cover change matrix (2008 – 2013)

Land use land cover change matrix		
Initial/Final	Forest land class (ha)	Non-forest land class (ha)
Forest land class* (ha)	546,008	142,653
No-forest land class (ha)	192,179	261,378

Map accuracy assessment

Since no other data sources as reference for land use were available, the accuracy assessment was done using reference areas collected in the same manner as the training areas. In principle

all reference areas were collected at the same time, and afterwards were divided in two datasets: 2/3 of all reference areas were used as training areas and 1/3 of the reference areas were used for the accuracy assessment.

The accuracy assessment is a process where the land use classification is compared with the real ground data, and is a measure of the maps errors. This procedure was done using the QGIS plug-in “Semi-automatic classification plugin” which gives as an output an “Error matrix”.

For the LULC maps, the accuracy achieved is shown in the error matrix below (Table 18).

Table 18: Map Accuracy assessment – Error matrix

Land use/cover	Producer's accuracy (2002)	User' accuracy (2002)	Producer's accuracy (2013)	User' accuracy (2013)
Forest	91,6%	91,2%	90,7%	89,2%
Non-forest	77,3%	82,5%	79,9%	78,9%
Water	77,0%	66,1%	83,3%	85,7%
Burn-scars	89,9%	93,5%	93,7%	93,6%
Overall	87,1%		90,2%	

Methodology Step 3: Analysis of agents, drivers and underlying causes of deforestation and their likely future development

Identification of agents of deforestation

Small-scale subsistence farmers are the one main agent of deforestation. They are by far the dominant agents of deforestation in the region and are expected to be so in the coming decades. Table 19 below lists the agents of deforestation identified in the chiefdoms based on the interviews with farmers and workshops. Note that the contributions of other agents to deforestation is not direct, but rather indirectly, as their activities degrade the forests and are largely a precursor to deforestation.

Table 19: Deforestation agents

Agent	Description	Trend	Contribution to deforestation
Small scale farmers	New families expand cropland as the population increases. They open new fields for small scale farming. Agricultural practices reduce the soil fertility, resulting in shifting cultivation onto fallows or forest areas.	Increasing population in reference region, project area and leakage belts.	90%
Firewood collectors	Rural households degrade nearby forest and fallow to collect firewood.	Increasing population in	5%

		reference region, project area and leakage belts	
Charcoal producers	Charcoal is produced by migrant or landless families. In times of drought, smallholder farmers become charcoal producers.	Increasing population in reference region, project area and leakage belts	3%
Logging operators	Logging for certain high value timber species for export is encountered throughout the valley where those species exist and are not protected by cultural norms (graveyard forests).	Stable and reducing as availability of tree species drop. Timber demands internal and external	2%

Only small scale farmers are significant deforestation agents, the other agents are predominantly degradation agents and have an indirect impact on deforestation. Those agent groups will gain in importance if agricultural expansion decreases. Signs of this can be seen in chiefdoms that have small areas of fertile land available.

Table 20 summarizes the drivers of deforestation in relation to the agents. There is a difference in the quantity of deforestation and its location, those factors have different variables.

Table 20: Deforestation agents

Agent/Driver	Driver variables explaining quantity of deforestation	Driver variables explaining the location predisposing factors
Small scale farmers/ Agricultural expansion	Population density changes Low yield for maize Demand/supply for arable land Price changes for tobacco Price changes for cotton Incentives for cotton (fertilizer)	Proximity to existing settlements, markets, roads Perception of land fertility Management category of the land
Smallholder farmers/ Firewood collectors/ Firewood collection	Population density changes Low efficiency of cooking devices Low efficiency in brick making Low efficiency in brewing	Proximity to existing settlement Proximity to newly established fields
Charcoal producers/ Charcoal production	Population density change Demand for charcoal Ease of charcoal production	Proximity to road
Logging operators/ Timber extraction	Price for timber Ease of logging operations	Density of high value species Proximity to road

Small scale farmers/ Agricultural expansion	Population density changes Low yield for maize Demand/supply for arable land Price changes for tobacco Price changes for cotton Incentives for cotton (fertilizer)	Proximity to existing settlements, markets, roads Perception of land fertility Management category of the land
--	---	--

Identification of deforestation drivers

The project identified the population of rural farmers expanding agricultural fields as the main agent driving deforestation. The driver variables explaining the location of deforestation are:

- Distance from the settlements and roads to the forests,
- Topography i.e. elevation and slope

Both of these determine accessibility to the forests. While the driver variables explaining the quantity of deforestation are:

- Population, and
- Market access.

Populations, forest access and market access would be expected to increase in the future in the baseline case. The bio-physical variables (altitude, climate and the availability of suitable terrain) are not expected to limit deforestation in the foreseeable future as farmers are able to evolve their production systems to all of the environments existing within the Miombo woodlands.

The following section provides an analytical description of the drivers and their impact based on expert knowledge of the region. A quantitative analysis involving modelling is also conducted to better understand how different variables affect the location of deforestation, and is described in subsequent sections.

Identification of underlying causes

The underlying causes of deforestation of the project area include the following:

1. A rapidly growing population; this increases the demand for food and forest products increasing the demand for land.
2. Conflicting customary and state-defined land tenure, combined with poor enforcement, means that clearing forest is a low-cost way of gaining new land, but at the same time there is no strong incentive to invest in improving the agricultural productivity of land of insecure ownership;

3. Reliance on wood as a source of energy, as alternatives are limited, unaffordable and inaccessible
4. Lack of land use planning including making planned use of land-based resources impossible.

Table 21 summarizes these underlying causes, their influences, future developments and project measures aimed at addressing them:

Table 21: Deforestation causes future trends and project measures

Cause	Drivers determined by this cause	Future trend	Project measures
Population pressure	Population density change Demand for agricultural land	Constant (about 2.6% between 1990-2000, and 2000-2010) – conservatively constant	Zoning of CCAs with chiefs and conservation training, project area protection keeping people from settling
Poverty (energy)	Charcoal demand Firewood demand	Constant	Improved income through market for products, training of farming as a business
Lack of land use planning and enforcement	Availability of agricultural land (Agricultural expansion)	Constant	Improved land use planning with chiefs and cooperatives
Land tenure	Agricultural expansion	Constant	Community delineated land uses are patrolled by honorary forest guards

Analysis of chain of events leading to deforestation

The rural people of the region depend on farming (mainly subsistence) and exploitation of forest (non-timber forest products, timber, and charcoal) for their livelihoods, and have few alternative opportunities to earn a living. The increase in families needing agricultural land leads to new settlements. This is driven by either exhausted agricultural land or the need of families to shift from their ancestral home as the land is scarce there.

The opening of new agricultural land from forest land is associated with opportunistic wood extraction while opening new fields. Given the significant time and resources required for forest clearing and land preparation for agriculture, farmers are more likely to convert heavily degraded forests to agriculture. At the same time, the byproducts of land clearance are charcoal and

firewood. Thus, there is a close relationship between drivers and agents associated with wood fuel production and small-scale agriculture.

Tree fallows are not regenerating into a forest and are becoming more nutrient deficient from shorter fallow cycles. This encourages migration into other forest areas where soil fertility is perceived as high. Figure 19 below illustrates this chain of events leading to deforestation in the Luangwa valley through a conceptual model developed based on extensive consultation with local experts and stakeholders.

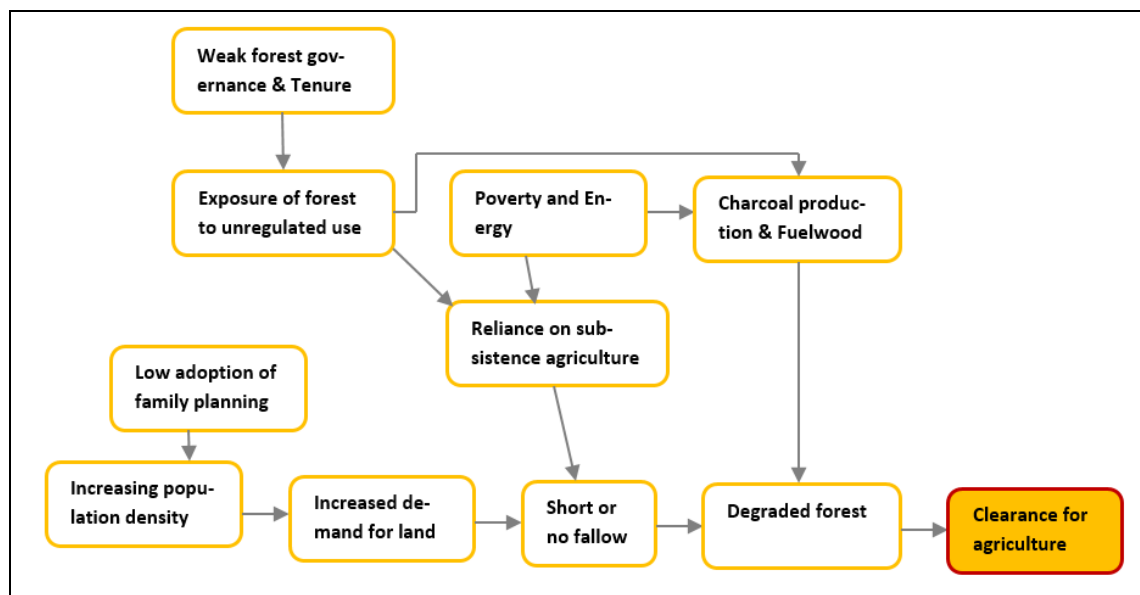


Figure 19: Chain of events leading to deforestation

Conclusions

The underlying causes of deforestation can be summarized as:

- Agricultural expansion of a subsistence nature with largely unsustainable land use practices yet well-rooted form of production;
- A growing rural population dependent on agriculture and forest resources with few alternative economic opportunities;
- A system of land tenure and poor forest governance that make forest clearing and exploitation viable even though it is illegal under the forestry legislation;
- A growing urban population that is increasing market demand for food and forest products.

The sheer scale of fundamentally changing the socio-economic conditions of a large, dispersed and often very isolated rural population and rapid population growth mean that over the next

decades, the underlying causes of deforestation will continue to exist and to interact so as to favour and probably accelerate deforestation in the absence of the proposed project.

The main driver variables explaining the quantity and location of deforestation are:

- Rural population density,
- Access to forest from villages, roads and rivers; and
- Bio-physical variables that determine the suitability of the land for conversion to cropland.

The first two of these drivers are expected to increase in the coming years, as the populations grows and transport infrastructure is improved in accordance with government policy of improving road infrastructure (Government of Zambia, 2006). The present patterns of deforestation for cropland show: firstly, that there is still ample forest land suitable for conversion to cropland on hillsides; and secondly, that bio-physical conditions will not limit where farmers deforest

Based on the evidence provided, we can therefore make a **conclusive** judgement that deforestation will continue in the reference region and the project area without the proposed project activities.

2.5 Additionality

2.5.1 SALM Component

The “Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities”, version 01, is applied to demonstrate additionality of the project.

Procedure:

STEP 0. Preliminary screening based on the starting date of the A/R project activity

The project was developed and is being implemented by COMACO with the World Bank’s BioCarbon Fund supporting the development. The project funders include farmers (labour), COMACO, the USAID and World Bank (BioCarbon Fund).

The first step to develop the project was taken 2010 when the World Bank (BioCarbon Fund) started to screen potential organizations in Zambia to do an agricultural soil carbon project. From 2010, the BioCarbon Fund and COMACO supported project preparation which involved the preparation of the Project Idea Note (PIN) which were reviewed by the BioCarbon Fund. The Zambia National Environmental Management Authority (ZEMA), a Designated National Authority endorsed the project (see Letter of no-objection). This process led the World Bank to draft a Letter of Intent and signing a nine year (2012-2022) Emission Reduction Purchase Agreement (ERPA) on April 2015 with COMACO.

Therefore, the incentive from the planned sale of VCUs (partly as up-front funding) was seriously considered in the decision to proceed with the project activity. The project start date (July 2012) marks the starting point when COMACO started project activities and monitoring in the field.

STEP 1. Identification of alternative land use scenarios to the proposed A/R CDM project activity

Sub-step 1a. Identification of credible alternative land use scenarios to the proposed CDM project activity

The following alternative land use scenarios to the project activity have been identified and evaluated in the subsequent sections:

Scenario 1: The continuation of the land-use and management existing prior to the implementation of the project activity i.e. the lands continuing to be croplands/grasslands used for subsistence agriculture;

Scenario 2: Adoption of sustainable agricultural land management without the incentive from carbon finance (project activity); and

Scenario 3: Abandonment of the land followed by natural regeneration of vegetation or assisted reforestation.

Sub-step 1b. Consistency of credible alternative land use scenarios with enforced mandatory applicable laws and regulations

All alternative land use scenarios are consistent with current laws and regulations (see section 1.11).

STEP 2. Barrier analysis

Sub-step 2a. Identification of barriers that would prevent the implementation of at least one alternative land use scenarios

Table 22 displays the barrier analysis matrix for the three identified alternative land use scenarios. The identified barriers are discussed in Sub-step 2b.

Table 22: Barrier analysis matrix for alternative land use scenarios

Alternative land use scenarios	Investment	Institutional	Technological	Local tradition	Prevailing practice	Local ecological conditions	Social conditions
The continuation of the land-use and management existing prior to the implementation of the project activity							
Adoption of sustainable agricultural land management without the incentive from carbon finance (project activity)	X		X				
Abandonment of the land followed by natural regeneration of vegetation or assisted reforestation					X		X

Sub-step 2b. Elimination of land use scenarios that are prevented by the identified barriers

1. The land-use and management prior to the implementation of the project activity has no barriers to implementation. Low input subsistence agriculture is by far the most dominant activity throughout the region. Considering the generally favorable agro-climatic conditions for crop cultivation in the areas, this land management scenario is regarded as the baseline scenario.
2. Adoption of sustainable agricultural land management (SALM) practices without incentives from the carbon market faces two main barriers: investment and technological barriers; particularly the technological barrier is of fundamental importance as outlined below.

The carbon project requires a written commitment from farmer groups to participate in the project and a robust farm monitoring system engaging the farmer to monitor his/her performance. These innovative systems are unique to a carbon project and will help farmer to reflect the impact of management practices and support targeted extension.

3. Abandonment of the land followed by natural regeneration is not possible anymore because of the high population density in the area (an applicability condition, see section 2.2).

Sub-step 2c. Determination of baseline scenario (if allowed by the barrier analysis)

Continuation of the land-use and management prior to the implementation of the project activity:

The continuation of the current land use system has no barriers since farming is the single most important livelihood for rural people in Zambia. Smallholder peasant agriculture is estimated to account for 92% of total employment in the Eastern Province. (Sitko *et.al.*, 2011).

At the root of this problem are high population and limited access to markets. As a result of continuous cropping with very little investment in soil fertility replenishment, the soils have become severely depleted. The first agricultural priority of farmers is to provide themselves with maize for home consumption, yet yields are low and returns are insufficient to support investment in either organic soil fertility enhancement technologies or inorganic fertilizers.

The relevant studies (Pershing *et al* 2015, Sperling 2013 *et. al.*) in the project region show that the low-input low-output subsistence agriculture on small landholding is the dominant form of land use and livelihood; and although farmers are heavily dependent on the land, proper management of the land is generally lacking. Thus, the lands are generally degraded, and productivity (yield) is low and expected to decline further under current farming system. This is the baseline scenario of this project.

STEP 4. Common practice analysis

COMACO has been providing advisory services for small-scale farming households in the Luangwa Valley for more than 10 years. The organization has projects –apart from wildlife conservation using agroforestry techniques as a way of improving their production in a sustainable way and thereby increasing their incomes for improved living conditions. However, only due to the carbon project a written commitment from farmer groups to adopt SALM practices and a robust farm monitoring system engaging the farmer to monitor his/her performance will be put in place. These innovative systems are unique to a carbon project and will help farmer to reflect the impact of management practices and support targeted extension.

Conclusion: The proposed AFOLU SALM project activity is not the baseline scenario and, hence, it is additional.

2.5.2 REDD+ component

As required by the methodology, the project uses the most recent version (3.0) of the VCS Tool VT0001 “Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities” in order to demonstrate the additionality of the project. The project meets the applicability conditions of this tool since:

- a) The AFOLU project activities do not lead to the violation of any applicable law (see PD section 1.11)
- b) The baseline methodology used for this project (VM0015) provides for a stepwise approach justifying the determination of the most plausible baseline scenario. The steps of the tool have been applied as follows:

Step 1. Identification of alternative land use scenarios to the proposed VCS AFOLU project activity

This step serves to identify alternative land use scenarios to the proposed REDD project activity that could be the baseline scenario, through the following sub-steps:

Sub-step 1a. Identify credible alternative land use scenarios to the proposed VCS AFOLU project activity:

Based on current existing land uses or those that have existed during the time up to ten years prior to the project start date and taking into account relevant national and/or sectoral policies, the following realistic and credible alternative land use scenarios have been identified that could have occurred on the land within the project boundary in the absence of the REDD project activity:

i) Continuation of the pre-project land use:

Continued deforestation and conversion of forest to other land uses due to *agricultural expansion* (including slash-and burn agriculture), in combination with a number of other less intensive practices (namely subsistence harvesting of timber and non-timber forest products, charcoal production).

Details of the pre-project land use are given in section 2.4.2 under Methodology Step 3: Analysis of agents, drivers and underlying causes of deforestation.

ii) The proposed AUD project activity on the land within the project boundary without being registered as a VCS AFOLU project, i.e. in the absence of carbon financing from REDD.

This scenario must be included according to the methodology but it is not credible since any forest protection activities would need long term funding. Additional protection of forests in Zambia for areas such as CCAs is inconceivable based on historical levels of traditional funding sources from international donors and government.

Sub-step 1b. Consistency of credible land use scenarios with enforced mandatory applicable laws and regulations

The following alternative land use scenarios listed in Sub-step 1a are permitted in Zambia and could be practiced in the landscape:

Project activity on the land within the project boundary performed without being registered as the VCS AFOLU project

The following activities are carried out in such a way that they do not meet the relevant regulations and would not be permitted in their current form if the relevant laws and regulations were properly enforced:

The pre-project land-use dominated by agricultural expansion (specifically slash and burn with fallow systems). However, the current, widespread practice of these activities in the region and throughout Zambia shows that the laws and regulations governing them are systematically not enforced and that non-compliance is widespread

In practice, the capacity of the Forest Administration to regulate access is limited and is essentially restricted to the issue of permits at the regional level to commercial loggers and at the local level to agricultural or subsistence users in the case of forests where the administration is present nearby.

In remote areas where forest is plentiful and state authorities absent (such as the zones where shifting-cultivation is heavily practiced) access may be essentially free and open. In more densely populated areas where resources are in shorter supply, there is typically some form of local regulation that affects access linked to customary tenure rights. Where the state or chief is present, it may operate against the local interest, such as awarding permits to commercial loggers or migrants to clear forest for agriculture.

There is a systematic lack of enforcement of forestry laws and regulations throughout the country and official permits reportedly account for less than 5% of the forest products consumed in Zambia (CIFOR, 2013).

Outcome of sub-step 1.b: Since the applicable mandatory legal or regulatory requirements are systematically not enforced and non-compliance is widespread all of the scenarios listed in sub-step 1.a are plausible alternative land uses to the proposed project activity.

Sub-step 1c. Selection of the baseline scenario:

Scenario 1, or continued unplanned deforestation and conversion of forest to other land uses due to agricultural expansion (through slash and burn agriculture), represents the most plausible alternative land use scenario in the absence of the REDD project as it is the most widespread land use throughout the reference region and project area.

The baseline scenario was determined by following the steps outlined in the VCS REDD methodology for Avoided Unplanned Deforestation VM0015, including an in depth analysis of the agents, drivers, and underlying causes of deforestation in the project area. The Barriers Analysis in Step 3 of the Additionality Tool provides further detail on the combination of factors that make the other alternative baseline scenarios unlikely to occur.

Step 2. Investment analysis

The project is not set up as an economic investment activity. In the absence of carbon finance from the sale of GHG credits, the Project Proponent would not be able to financially support the scope of activities required to reduce deforestation in the project area.

Sub-step 2a. Determine appropriate analysis method

The proposed AUD project activity will generate no financial benefits for the Project Proponent other than carbon market-related income. It involves preventing deforestation through the establishment of a community managed conservation area, an activity that will not generate other direct incomes. Therefore a simple cost analysis is applied.

Sub-step 2b. Option I: Simple cost analysis

A simple cost analysis has been undertaken for the project as part of the AFOLU Non-Permanence Risk Assessment; see Financial Viability analysis for the Non-Permanence Risk Assessment. Income for the project activity will be generated solely through the sale of VCUs and the proposed AUD project activity produces no financial benefits other than carbon market-related income.

Step 3: Barrier analysis

As an extension to the simple cost analysis carried out in Step 2, a barrier analysis is performed to further illustrate the additionality of the project.

Sub-step 3a. Identify barriers that would prevent the implementation of the type of proposed project activity

The proposed project activity is founded on the creation and long-term, effective running of various community conservation areas and their associated development and conservation activities with the neighboring communities. The principal barriers that would prevent the implementation of the type of proposed project activity from being carried out if the project activity was not registered as a VCS AFOLU project include:

Investment barriers

Long term funding is not available for this type of project activity:

The scale of this activity to reduce deforestation is unprecedented for non VCS AFOLU projects in Zambia. The history of domestic government investment in nature conservation shows that the funding necessary would not come from government sources. Similarly, no such investments on this scale have been made through donor support. No donors have made commitments to fund long term conservation work with smallholder farmers in Zambia. Some donors have provided funding to a national protected area fund (Lindsey et al 2014, UNEP 2015) but contributed only a small proportion of the costs of existing protected areas and are not expected to contribute long-term.

Institutional barriers

Lack of enforcement of forest or land-use-related legislation:

Generally widespread non-compliance with land-use and forest management regulations mean that the long term protection of natural forest would not be assured by law, nor is the reality of land-use conducive to forest protection over the project lifetime. Long experience has shown that laws governing forest are largely ineffective in Zambia and that Zambia's forests have decreased throughout most of the twentieth century (FAO 2010)⁴². Root causes for continued deforestation on a national level include: the linking of forest clearing to land ownership; reduced public expenditure has diminished the government means to enforce and monitor of existing environmental legislation; regulations that make no accommodation for traditional livelihoods and

⁴² FAO CountryStat: <http://www.countrystat.org/home.aspx?c=FOR>

therefore are not respected by local communities; and national level policies that are neither coordinated nor complementary and a lack of formal land tenure.

Barriers relating to land tenure, ownership, inheritance and property rights:

The current land tenure regime in rural areas poses another institutional barrier to the long-term protection of the CCAs. Within the region of the project area, there has historically been a de facto occupation of chieftdom land by related farmers, coupled with very few individual farmers gaining legal title to their cropland. These factors combine to encourage the continued practice of shifting cultivation and agricultural expansion in the given family area.

Sub-step 3b. Show that the identified barriers would not prevent the implementation of at least one of the alternative land use scenarios (except the proposed project activity)

These barriers would prevent the implementation of scenario 2, the implementation of the project activity within the project boundary without being registered as a VCS AFOLU project.

By contrast these barriers would all maintain the pre-project situation of continued deforestation and conversion of forest to other land uses due to slash-and-burn agriculture expansion.

Step 4. Common practice analysis

In Zambia is not a common practice to implement conservation projects through carbon finance. Except a single REDD project being implemented in the country⁴³, there is no record of any project in the region that has performed similar activities that compare to the scale and timeframe of those proposed by COMACO. The proposed REDD project aims to implement a unique strategy of combating deforestation in the Luangwa Valley through a fully community managed conservation area in which local community groups are the essential actor in the governance structure. Although there are other forested protected areas in the region these have fundamental differences in that they are on national park land, they are mostly run by the government's Zambia Wildlife Authority, and they have fundamentally different funding strategies and future prospects. The established protected areas managed by DNPW are part of the national network of protected areas and managed by the same authority, the government provides for the essential budget of these sites through a combination of grants and loans from donors and government appropriations. The protected areas also have an important tourism objective and generate revenues that help to sustain them and contribute to the funding of other protected areas in the area. (Lindsey et al 2014) By contrast, there is no long term government commitment to fund activities at CCAs and most of the funds for the startup phase have been raised by COMACO from a variety of sources with the objective of ensuring that carbon revenues cover the long term costs.

The CLMP project is one of the first of its kind within Zambia and was conceived in the early 2010's as a pilot project to demonstrate the use of carbon finance for the protection of wildlife

⁴³ BCP Lower Zambezi REDD+ Project:
https://s3.amazonaws.com/CCBA/Projects/Lower_Zambezi_REDD%2B_Project/Validation/BCP_LowerZambezi_REDD+Project_PDD_CCB_21Jun_2013.pdf

corridors between Zambia and Malawi and the development of the surrounding rural communities. Prior to CLMP, no other project had undertaken such a diverse range of forest protection and development activities on the same scale.

In conclusion, the proposed CLMP project is considered additional since it is fundamentally different from the baseline scenario and no other credible similar activities could be done in the project area at the scale of the CLMP project.

2.6 Methodology Deviations

None

3 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

3.1 Baseline Emissions

3.1.1 SALM component

The ex-ante quantification of baseline GHG emission reductions/removals has been based on post-harvest survey conducted by COMACO between 2012 and 2014. Additional sources of data used include:

- Ariga, 2013. Zambia Fertilizer Assessment – which provides estimates of average amount of fertilizers applied by small-holder farmers.
- Jha and Hojjati, 1993. Fertilizer use on smallholder farms in eastern province, Zambia – which provides information on the type of fertilizer most commonly used in Eastern Province, Zambia.

The data collected in the baseline survey have been entered and analysed using the web-based Project Management Information System (Project MIS)⁴⁴, and the results used as inputs for the calculations of GHG emission reductions/removals.

Stratification

Agro-ecological zones are considered suitable for stratification as they define homogenous resource units in terms of bio-physical conditions, including climate, terrain, soil, vegetation, and therefore, influence land productivity and carbon sequestration. However, the project area is considered as one stratum based on the global AEZ 3: tropical moist semi-arid. See section 2.2.1 for details.

⁴⁴ The project MIS can be accessed [here](#).

Project roll out

The project started with registration of 18,310 farmers, who began implementing SALM in the 2012/2013 season, with a total area of 7,373 ha. As aforementioned, these figures of SALM adoption are conservative as these are only the farmers and fields that COAMCO was able to register from among a larger number of farmers/fields that the project has been supporting to adopt SALM practices in the project area. These farmers collectively constitute the first project activity instances. As a grouped project, the plan for expanding the SALM instances is twofold: increase in total number of farmers adopting and increase the number of plots of those farmers already registered under SALM adoption. The project roll-out plan is summarised in Table 23.

Table 23: Project roll out plan for the SALM component

Year	Area joining annually (ha)	Area joining cumulative (ha)
2013	7,372	7,372
2014	0	7,372
2015	0	7,372
2016	5,400	12,772
2017	5,400	18,172
2018	5,400	23,572
2019	5,400	28,972
2020	0	28,972
2020	0	28,972
2022	0	28,972
2023	0	28,972
2024	0	28,972
2025	0	28,972
2026	0	28,972
2027	0	28,972
2028	0	28,972
2029	0	28,972
2030	0	28,972
2031	0	28,972
2032	0	28,972
Total	28,972	28,972

Baseline emissions due to inorganic fertilizer use (BEF_i)

The COMACO surveys recorded whether farmers used inorganic fertilizers or not. Fertilizers were applied on about 42% of the agricultural land. Since the amounts applied were not recorded, two

relevant studies were used, i.e., a Zambia fertilizer study conducted by the International Fertilizer Development Center (Ariga, 2013)⁴⁵ for quantities applied, and a study by Jha and Hojjati, 1993, for the types of fertilizer used⁴⁶. The amount of fertilizers applied 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 (1.2 ha), was reported to be 69 kg. This represents only 48% of the fertilizer need of the households - the remaining being purchased⁴⁷. From these figures, the total application rate was estimated 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 estimated using the reported fertilizer type and application rate. The calculations were done by applying the CDM A/R Tool "Estimation of direct nitrous oxide emission from nitrogen fertilization", version 01, according to following equation:

$$N_2O = M_{SF} * NC_{SF} * (1 - FraC_{GASF}) * EF * MW_{N_2O} * GWP_{N_2O}$$

Where:

N_2O = Direct N_2O emission as a result of nitrogen application within the project boundary, tCO₂-e in a year

M_{SF} = Mass of synthetic fertilizer type applied, tonne in year t

NC_{SF} = Nitrogen content of synthetic fertilizer type applied, g-N (100 g fertilizer)⁻¹; value used = 10/100⁴⁸

$FraC_{GASF}$ = Fraction that volatilises as NH₃ and NOX for synthetic fertilizers, dimensionless; value used = 0.1 (IPCC default value⁴⁹)

EF = Emission Factor for emissions from N inputs, tonne-N₂O-N (t-N input)⁻¹; value used = 0.01 (from the SALM methodology)

MW_{N_2O} = Ratio of molecular weights of N₂O and N (44/28), tonne-N₂O (t-N)⁻¹

GWP_{N_2O} = Global Warming Potential for N₂O, kg-CO₂-e (kg-N₂O)⁻¹; valued used = 310 (IPCC default value)

The estimated baseline GHG emissions are presented in Table 24.

Table 24: Baseline emissions due to inorganic fertilizer use

Year	BEF_t (tCO ₂ -e)
2013	388
2014	388

⁴⁵ Ariga, 2013. Zambia Fertilizer Assessment. Accessed [here](#).

⁴⁶ Jha and Hojjati, 1993. Fertilizer use on smallholder farms in eastern province, Zambia. Accessed [here](#).

⁴⁷ Ariga, 2013. Zambia Fertilizer Assessment. Accessed [here](#).

⁴⁸ Estimated based on guidance from http://www.ctahr.hawaii.edu/mauisoil/c_material.aspx

⁴⁹ IPCC default values accessed [here](#):

2015	388
2016	672
2017	956
2018	1,240
2019	1,524
2020	1,524
2021	1,524
2022	1,524
2023	1,524
2024	1,524
2025	1,524
2026	1,524
2027	1,524
2028	1,524
2029	1,524
2030	1,524
2031	1,524
2032	1,524
Total	25,371

Baseline emissions due to the use of N-fixing species (BEN_t)

The baseline emissions from the use of N-fixing species are not calculated in accordance with the methodology (See Section II.4.2 of SALM methodology). Any existing N-fixing species will be recorded prior to project implementation. Hence, Baseline emissions due to the use of N-fixing species accounted for as zero,

Thus,

$$BEN_t = 0$$

Baseline emissions due to burning of biomass ($BEBB_t$)

Based on analysis of the 2012 COMACO farmers' survey, no burning practice occurred on only 3% of total agricultural land; hence, the burning of biomass (crop residues) was assumed to occur on the remaining 97% of the agricultural land across the farms in the project area. The amount of crop residues available for burning and GHG emissions per ha have been estimated in the

Project MIS applying the formula in the Tool “Estimation of non-CO₂ emissions from the burning of crop residues”, according to the equation of the SALM methodology shown below. The $BEBB_t$ values are presented in Table 25.

$$EBB = MB_C * CF * (2.7 * GWP_{CH_4} + 0.07 * GWP_{N_2O}) * 10^{-3}$$

Where:

EBB = Emissions due to biomass burning in year t , t CO_{2e}

MB_C = Mass of crop residues burnt in year t , tonnes

2.7, 0.07 = Emissions factors for the burning of cropland, g CH₄ / kg and g N₂O / kg, respectively (from Table 2.5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories)

GWP_{CH_4} = Global warming potential of CH₄; value used = 21 (IPCC default value)

GWP_{N_2O} = Global warming potential of N₂O; value used = 310 (IPCC default value)

Table 25: Baseline GHG emissions due to burning of crop residues

Year	$BEBB_t$ (tCO ₂ -e)
2013	369
2014	369
2015	369
2016	639
2017	909
2018	1,179
2019	1,449
2020	1,449
2021	1,449
2022	1,449
2023	1,449
2024	1,449
2025	1,449
2026	1,449
2027	1,449
2028	1,449
2029	1,449
2030	1,449
2031	1,449

2032	1,449
Total	24,112

Baseline removals from existing woody perennials (BRWP_t)

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 implementation plan is not to account for removals from long-term woody perennials both in the baseline and project cases since planting long-term trees is not currently considered among the main project activities. The project promotes alley-cropping with *Gliricida* trees which are considered as a short-term soil fertility tree which is regularly cut, branched or coppiced. Therefore the woody biomass is not taken into account, the only carbon benefit included is the effect of these trees and their management on the soil organic carbon pool.

In addition, the quantities of trees in the baseline were very low, hence, the baseline removals from existing woody perennials has been accounted for as zero. Analysis of the baseline survey indicated that, there 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 (BEFF_t)

The project is in a typical rural area where subsistence farmers use 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 32 tractors per 100 square kilometre⁵⁰. 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,

$$BEFF_t = 0$$

⁵⁰ FAO, 2013 quoted in Stubbs, 2013. Energy usage of agricultural machinery for corn and soybean production in Brazil, India, USA and Zambia. Accessed [here](#).

Baseline removals due to changes in soil organic carbon (BRS_t)

Baseline removals due to changes in soil organic carbon is modelled using the RothC carbon 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, farming practices are considered for estimating SOC only when differences between baseline and project scenarios will result in changes in SOC. This happens when either the model input parameter is changing e.g. due to increasing yields; and/or when the area under the SALM practice is changing e.g. due to increasing adoption. Both cases do not occur in the baseline. Hence, there is no expected increase in SOC in the baseline.

The degradation assessment detailed in Section 2.2 also demonstrates that the project areas are constantly degraded/ degrading. Therefore, SOC in the baseline can be expected to decrease or at most remain in a steady state. Since the applicability conditions restrict the project to lands that are under agricultural pressure and are degrading, it can be conservatively assumed that the baseline removals due to changes in SOC are zero. Therefore, baseline removals due to changes in SOC are conservatively accounted for as zero as per the SALM methodology; thus,

$$BRS_t = 0$$

Total baseline emissions and removals

Total baseline emissions and removals, **BE_t**, have calculated according to the equation below, and are presented in the Table 26:

$$BE_t = BEF_t + BEFF_t + BEBB_t - BRWP_t - BRS_t$$

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, t CO₂e

Table 26: Total baseline emissions and removals

Year	BE _t (tCO ₂ -e)
2013	756
2014	756

2015	756
2016	1,311
2017	1,865
2018	2,419
2019	2,973
2020	2,973
2021	2,973
2022	2,973
2023	2,973
2024	2,973
2025	2,973
2026	2,973
2027	2,973
2028	2,973
2029	2,973
2030	2,973
2031	2,973
2032	2,973
Total	49,483

3.1.2 REDD+ component

The steps/procedures applied in the quantification of baseline emissions/removals are described in the following sections – applying the methodology. Hence, the steps/procedures are titled according to the methodology to ease referencing to the methodology.

Methodology Step 4: Projection of future deforestation

Projection of the quantity of future deforestation

If deforestation drivers, agents or underlying causes have distinct patterns across the reference region, the methodology suggests stratifying the reference region accordingly. 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, no stratification is 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 PD. The entire reference region is, therefore, considered as one unit (Table 27).

Table 27: Reference region

ID	Name	Description	Area (ha)
n.a.	Reference region	Area enclosed within the physical boundaries of nine chiefdoms	1,444,302

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 2002 and 2008, and 4.5% between 2008 and 2013. From the analyses of agents and drivers of deforestation, deforestation is related to population increase. Average deforestation over the 11 year period is about 2.3%. Data from population census 2010 indicates that the Eastern Province population growth rate is constant, compared to other Provinces with a clear increasing/decreasing trend. It stood at 2.7% between 1990-2000, and 2000-2010⁵¹. Therefore, the increasing deforestation rate cannot be clearly explained by the population dynamics; thus, 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 2002 and 2013 LANDSAT satellite image analyses. Annual areas of baseline deforestation in the reference region has been calculated according to the formula below. The figures are presented in Table 28.

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

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

⁵¹ Central Statistics Office, 2000; and Central Statistics Office, 2010. Accessed [here](#) and [here](#).

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 derive values of the annual areas of baseline deforestation in the project area. The detailed steps of this analysis are presented in the subsequent sections. The same approach has been applied to the leakage belt. The results are summarised for the first 10 years in Table 28, Table 29, and Table 30 for the reference region, project area, and the leakage belt respectively.

Table 28: 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)
2013	12,001	12,001	12,001
2014	11,719	11,719	23,719
2015	11,469	11,469	35,189
2016	11,183	11,183	46,372
2017	10,884	10,884	57,256
2018	10,581	10,581	67,836
2019	10,275	10,275	78,111
2020	9,968	9,968	88,079
2021	9,663	9,663	97,742
2022	9,362	9,362	107,105

Table 29: Annual areas of baseline deforestation in the project area

Project year t	Stratum i in the reference region $ABSLPA_{i,t}$ (ha)	Total	
		Annual $ABSLPA_t$ (ha)	Cumulative $ABSLPA$ (ha)
2013	2,600	2,600	2,600
2014	3,447	3,447	6,047
2015	3,923	3,923	9,970

2016	4,280	4,280	14,251
2017	4,628	4,628	18,879
2018	4,847	4,847	23,727
2019	4,883	4,883	28,610
2020	4,907	4,907	33,517
2021	5,022	5,022	38,539
2022	5,176	5,176	43,715

Table 30: Annual areas of baseline deforestation in the leakage belt

Project year	Stratum i in the reference region $ABSLLK_{i,t}$ (ha)	Total	
		Annual $ABSLLK_t$ (ha)	Cumulative $ABSLLK$ (ha)
2013	546	546	546
2014	460	460	1,006
2015	462	462	1,468
2016	472	472	1,940
2017	479	479	2,419
2018	487	487	2,906
2019	475	475	3,381
2020	472	472	3,853
2021	456	456	4,309
2022	410	410	4,720

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 are presented in **Error! Reference source not found.** below.

Table 31: List of variables, maps and factor maps

ID	File Name	Source	Variable represented		Meaning of the categories or pixel value	
			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
2	_____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 than 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 map which comes as an outcome of the procedure presents the deforestation risk in percentage. This map indicating increasing risk from 0, meaning no risk and upto 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 directly when running the LCM. The prediction is based on all areas defined from the land use/cover analysis as forest in 2013. The LCM assigns deforestation sequentially to the pixels of greatest deforestation risk. The deforested areas after 5 years and 10 years are shown in Figure 20 and Figure 21 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 validator.

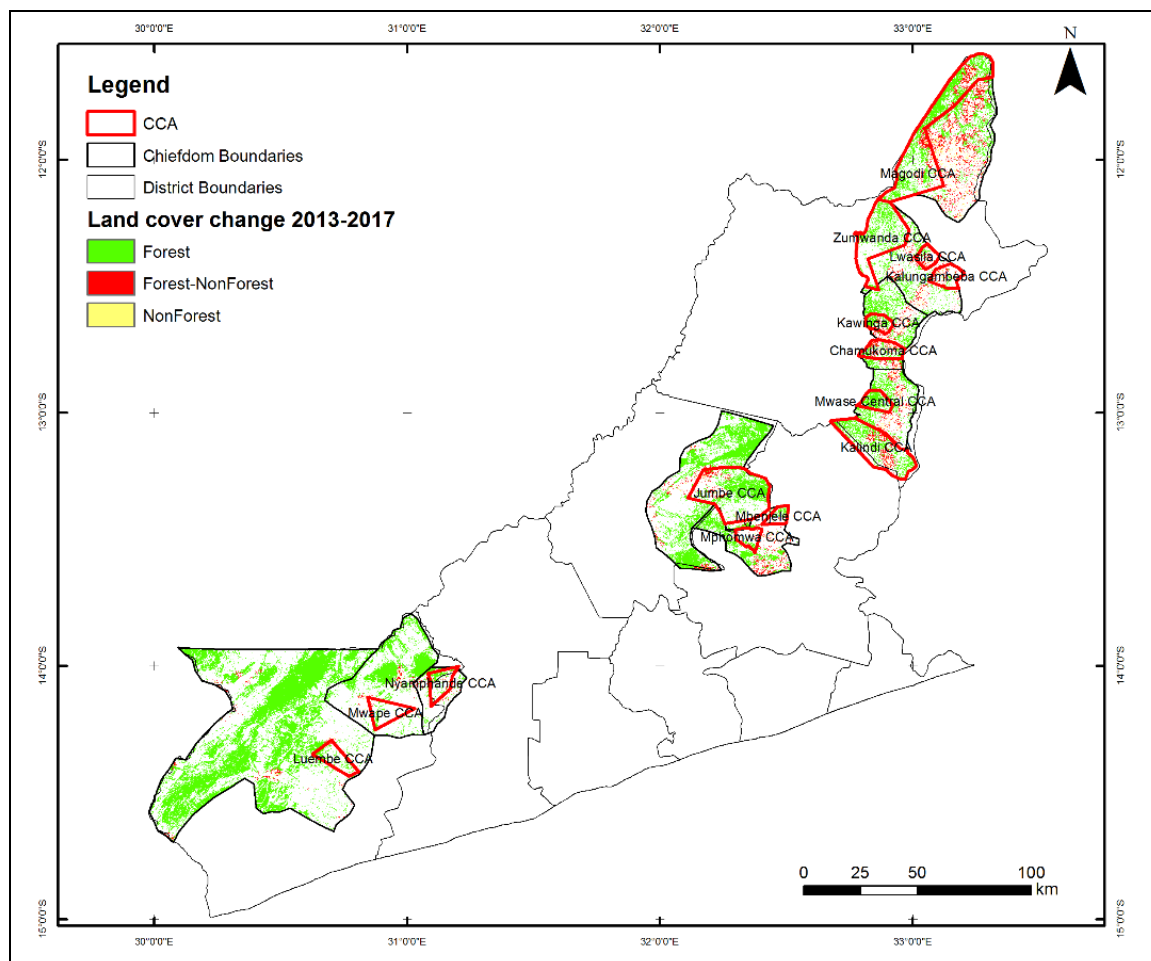


Figure 20: Deforestation areas in 2017 - 5 years into project

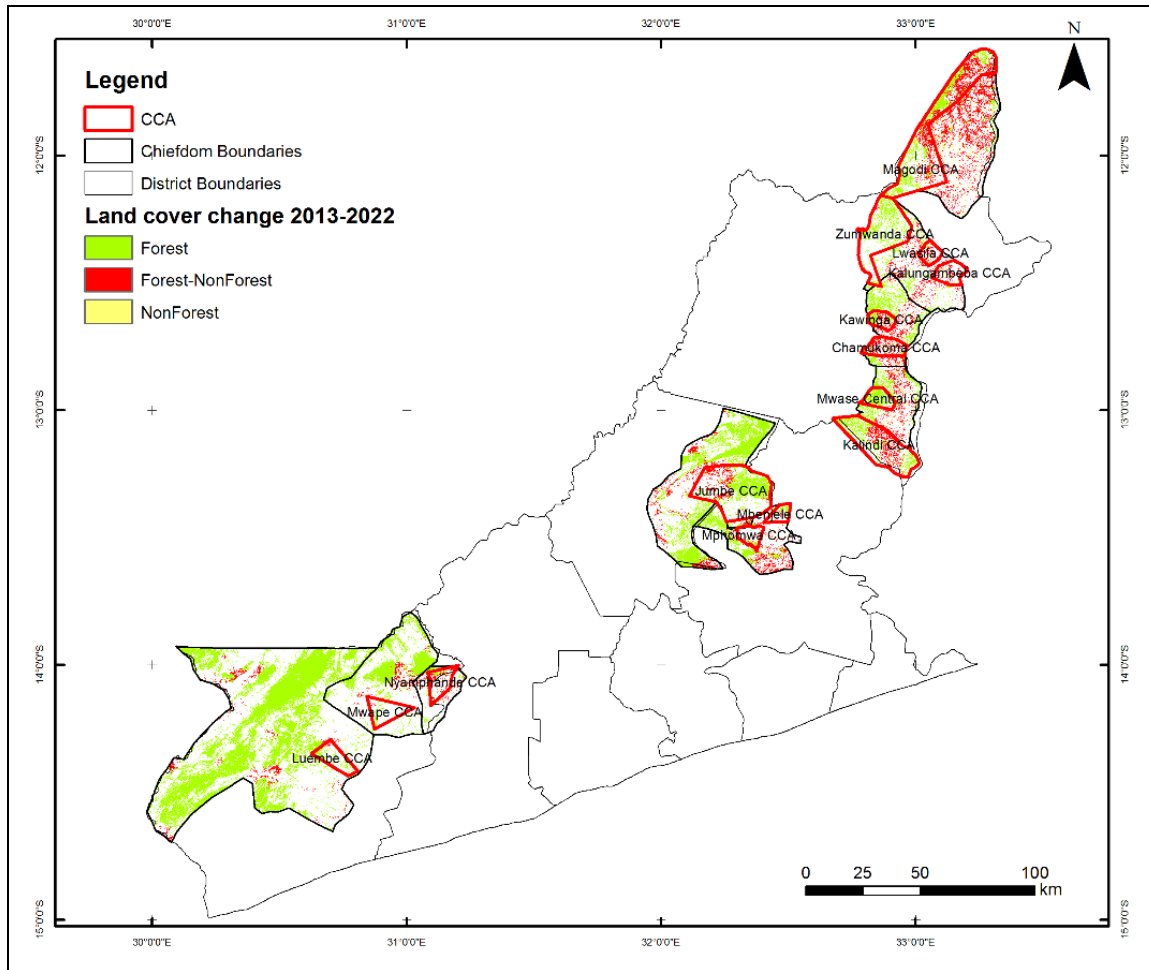


Figure 21: Deforestation areas in 2022 – 10 years into project

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 per forest class in the project area and the leakage belt the map of forests in the project area and leakage belt produced through LULC analysis of 2013 was overlaid on the annual deforestation maps, and the forest areas predicted to be deforested were extracted. The resultant figures are presented in Table 32 and Table 33 for the project area, and leakage belt respectively. During the fixed baseline period, the carbon stocks and boundaries of forest classes within the project area and leakage belt are assumed to remain constant.

Table 32: Annual areas deforested per forest class *icl* within the project area in the baseline case (baseline activity data per forest class)

Area deforested per forest class <i>icl</i> within the project area		Total baseline deforestation in the project area	
<i>IDicl</i> > Name> Project year	1 Forest ha	<i>ABSLPA_t</i> annual ha	<i>ABSLPA</i> cumulative ha
2013	2,600	2,600	2,600
2014	3,447	3,447	6,047
2015	3,923	3,923	9,970
2016	4,280	4,280	14,251
2017	4,628	4,628	18,879
2018	4,847	4,847	23,727
2019	4,883	4,883	28,610
2020	4,907	4,907	33,517
2021	5,022	5,022	38,539
2022	5,176	5,176	43,715

Table 33: Annual areas deforested per forest class *icl* within the leakage belt in the baseline case (baseline activity data per forest class)

Area deforested per forest class <i>icl</i> within the leakage belt		Total baseline deforestation in the leakage belt	
<i>IDicl</i> > Name> Project year	1 Forest ha	<i>ABSLK_t</i> annual ha	<i>ABSLK</i> cumulative ha
2013	546	546	546
2014	460	460	1,006
2015	462	462	1,468
2016	472	472	1,940
2017	479	479	2,419
2018	487	487	2,906
2019	475	475	3,381
2020	472	472	3,853
2021	456	456	4,309

2022	410	410	4,720
------	-----	-----	-------

Calculation of baseline activity data per post-deforestation forest class

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 small-scale 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 Table 34, Table 35 and Table 36 below for the reference region, project area, and leakage belt respectively.

Table 34: Annual areas of post-deforestation class *fcI* within the reference region in the baseline case

Annual areas of post-deforestation class <i>fcI</i> within the reference region		Total baseline deforestation in the reference region	
<i>IDz</i> >	2		
Name>	Non-forest	<i>ABSLRR_t</i>	<i>ABSLRR</i>
Project year	ha	annual ha	cumulative ha
2013	12,001	12,001	12,001
2014	11,719	23,719	23,719
2015	11,469	35,189	35,189
2016	11,183	46,372	46,372
2017	10,884	57,256	57,256
2018	10,581	67,836	67,836
2019	10,275	78,111	78,111
2020	9,968	88,079	88,079
2021	9,663	97,742	97,742
2022	9,362	107,105	107,105

Table 35: Annual areas of post-deforestation class *fcI* within the project area in the baseline case

Annual areas of post-deforestation class <i>fcI</i> within the project area		Total baseline deforestation in the project area	
<i>IDz</i> >	2		
Name>	Non-forest	<i>ABSLPA_t</i>	<i>ABSLPA</i>
Project year	ha	annual ha	cumulative ha

2013	2,600	2,600	2,600
2014	3,447	3,447	6,047
2015	3,923	3,923	9,970
2016	4,280	4,280	14,251
2017	4,628	4,628	18,879
2018	4,847	4,847	23,727
2019	4,883	4,883	28,610
2020	4,907	4,907	33,517
2021	5,022	5,022	38,539
2022	5,176	5,176	43,715

Table 36: Annual areas of post-deforestation classes *fcI* within the leakage belt in the baseline case

Annual areas of post-deforestation classes <i>fcI</i> within the leakage belt		Total baseline deforestation in the leakage belt	
<i>IDz ></i>	2		
Name>	Non-forest	<i>ABSLLK_t</i>	<i>ABSLLK</i>
Project year	ha	annual ha	cumulative ha
2013	546	546	546
2014	460	460	1,006
2015	462	462	1,468
2016	472	472	1,940
2017	479	479	2,419
2018	487	487	2,906
2019	475	475	3,381
2020	472	472	3,853
2021	456	456	4,309
2022	410	410	4,720

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 analysed in the study conducted by Kamelarczyk (2009)⁵², and average carbon stock values were taken from this study.

The methodology allows the use of existing inventories or 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 land use classes defined in this PD correspond to the classes shown below in the inventory.

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

As per the uncertainty requirement of the methodology, 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 area⁵³. This approach has been 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 used for SOC for the forest classes, and the value augmented by 30% for SOC for the non-forest class (agricultural land). The mean carbon stocks, adjusted as described above, are presented in Table 37 and Table 38.

⁵² Kamelarczyk, K. B. F., 2009. Carbon Stock Assessment and Modelling in Zambia. A UN-REDD programme study. Accessed [here](#).

⁵³ The $\pm 90\%$ confidence interval were as the mean $\pm$ per ha values reported in the aforementioned study.

Table 37: Carbon stocks per hectare of initial forest class *icl* existing in the project area

<i>ID_{icl}</i>	Initial forest class <i>icl</i>							
	Name:				Forest			
	<i>ID_{icl}</i>				1			
	Average carbon stock per ha ± 90% CI							
	<i>Cab_{icl}</i>		<i>Cbb_{icl}</i>		<i>CsoC_{icl}</i>		<i>Ctot_{icl}</i>	
Cstock	± 90% CI	Cstock	± 90% CI	Cstock	± 90% CI	Cstock	± 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 38: Carbon stocks per hectare of initial forest class *icl* existing in the leakage belt

<i>ID_{icl}</i>	Initial forest class <i>icl</i>							
	Name:				Forest			
	<i>ID_{icl}</i>				1			
	Average carbon stock per ha ± 90% CI							
	<i>Cab_{icl}</i>		<i>Cbb_{icl}</i>		<i>CsoC_{icl}</i>		<i>Ctot_{icl}</i>	
	Cstock	± 90% CI	Cstock	± 90% CI	Cstock	± 90% CI	Cstock	± 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 forest are converted, the post-deforestation land use class is annual croplands. In the typical shifting cultivation 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 years⁵⁴. Therefore, the average carbon stocks of post-deforestation classes

⁵⁴ Kwesiga *et al.*, 2005. Improved fallows in Eastern Zambia: History, Farmer Practice and Impacts. Accessed [here](#).

has been taken as the average carbon stock of annual crops derived from the ILUA I inventory data for all carbon pools except soils, which is not covered by the which ILUA data (see Excel file **Error! Not a valid bookmark self-reference.**). For soil carbon, average 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 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, and the values are presented in Table 39.

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

Where:

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

SOC_{REF} = the reference carbon stock, tons C ha⁻¹ (value used: 31; Source: IPCC, 2003⁵⁵, Table 3.3.3)

F_{LU} = stock change factor for land use or land-use change type; dimensionless (value used: 0.58; Source: IPCC, 2006⁵⁶, 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 methodology.

Table 39: Long-term (20-years) average carbon stocks per hectare of post-deforestation LU/LC class present in the reference region

ID_{fcl}	Post deforestation class fcl			
	Name:		Annual crop	
	ID_{fcl}	2		
	Average carbon stock per ha $\pm$ 90% CI			
	Cab_{fcl}	Cbb_{fcl}	$Csoc_{fcl}$	$Ctot_{fcl}$

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

⁵⁵ IPCC 2003 LUCF Sector Good Practice Guidance. Accessed [here](#).

⁵⁶ IPCC 2006 Guidelines for National Greenhouse Gas Inventories. Accessed [here](#)

	Cstock	± 90% CI	Cstock	± 90% CI	Cstock	± 90% CI	Cstock	± 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 40 for the initial forest class, and Table 41 for final forest class. Litter, deadwood and wood product pools are not accounted for in this project.

Table 40: Carbon stock changes factors for initial forest class *icl*

Year after deforestation		$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$	$\Delta Csoc_{icl,t}$
1	t^*	-80.9	-2.3	0.1
2	t^*+1	0.0	-2.3	0.1
3	t^*+2	0.0	-2.3	0.1
4	t^*+3	0.0	-2.3	0.1
5	t^*+4	0.0	-2.3	0.1
6	t^*+5	0.0	-2.3	0.1
7	t^*+6	0.0	-2.3	0.1
8	t^*+7	0.0	-2.3	0.1
9	t^*+8	0.0	-2.3	0.1
10	t^*+9	0.0	-2.3	0.1
11	t^*+10	0.0	0.0	0.1

12	t^{*+11}	0.0	0.0	0.1
13	t^{*+12}	0.0	0.0	0.1
14	t^{*+13}	0.0	0.0	0.1
15	t^{*+14}	0.0	0.0	0.1
16	t^{*+15}	0.0	0.0	0.1
17	t^{*+16}	0.0	0.0	0.1
18	t^{*+17}	0.0	0.0	0.1
19	t^{*+18}	0.0	0.0	0.1
20	t^{*+19}	0.0	0.0	0.1

Method 1 of the methodology has been used for $\Delta Cab_{icl,t}$ and $\Delta Cbb_{icl,t}$, and Method 2 for $\Delta Csoc_{icl,t}$.

Table 41: Carbon stock change factors for final class (Method 1)

Year after deforestation		$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$	$\Delta Csoc_{icl,t}$
1	t^{*}	3.0	1.2	0.0
2	t^{*+1}	3.0	1.2	0.0
3	t^{*+2}	3.0	1.2	0.0
4	t^{*+3}	3.0	1.2	0.0
5	t^{*+4}	3.0	1.2	0.0
6	t^{*+5}	3.0	1.2	0.0
7	t^{*+6}	3.0	1.2	0.0
8	t^{*+7}	3.0	1.2	0.0
9	t^{*+8}	3.0	1.2	0.0
10	t^{*+9}	3.0	1.2	0.0
11	t^{*+10}	0.0	0.0	0.0
12	t^{*+11}	0.0	0.0	0.0
13	t^{*+12}	0.0	0.0	0.0
14	t^{*+13}	0.0	0.0	0.0
15	t^{*+14}	0.0	0.0	0.0
16	t^{*+15}	0.0	0.0	0.0
17	t^{*+16}	0.0	0.0	0.0
18	t^{*+17}	0.0	0.0	0.0
19	t^{*+18}	0.0	0.0	0.0

20	t*+19	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 validator.

Calculation of baseline carbon stock changes

The following equation 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

...

$ABSLPA_{icl,t-19}$ = 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 and leakage belt are presented in Table 42 and Table 43 respectively.

Table 42: Total baseline carbon stock change in the project area

Project year	Total net carbon stock change in the project area	
	$\Delta C_{BSLPA\ icl,t}$ Annual tCO ₂ -e	$\Delta C_{BSLPA\ icl}$ Cumulative tCO ₂ -e
2013	-226,746	-226,746
2014	-317,076	-543,822
2015	-380,370	-924,192
2016	-436,336	-1,360,528

2017	-493,753	-1,854,281
2018	-542,115	-2,396,396
2019	-575,889	-2,972,285
2020	-608,815	-3,581,100
2021	-649,918	-4,231,019
2022	-695,112	-4,926,131

Table 43: Total baseline carbon stock change in the leakage belt

Project year	Total net carbon stock change in the leakage belt	
	$\Delta C_{BSLLK\ incl,t}$ Annual tCO ₂ -e	$\Delta C_{BSLLK\ incl}$ Cumulative tCO ₂ -e
2013	-56,171	-56,171
2014	-50,018	-106,189
2015	-52,450	-158,640
2016	-55,633	-214,273
2017	-58,620	-272,893
2018	-61,788	-334,681
2019	-62,922	-397,603
2020	-64,888	-462,491
2021	-65,560	-528,051
2022	-62,989	-591,040

Baseline non-CO₂ emissions from forest fires

Baseline emissions from fires are 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 as fuelwood or converted to charcoal. 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 biomass⁵⁷. Hence, we took this as the fraction of biomass that is burnt. Other biomass carbon pools are excluded as they constitute very small

⁵⁷ Minishi *et al.*, 2010. The role of the Miombo Woodlands of the Southern Highlands of Tanzania as carbon sinks. Accessed [here](#).

fractions of the total biomass (section 2.3). For the average percentage of the deforested area in which fire is used, we applied 100% as conversion is always associated with burning.

The parameters used for the calculations are shown in Table 44, and the estimated Non-CO₂ emissions from forest fires are presented in Table 45.

Baseline non-CO₂ emissions from forest fires have been calculated according to following equations:

$$EBB_{tot,icl,t} = EBB_{N_2O,icl,t} + EBB_{CH_4,icl,t}$$

Where:

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

$EBB_{N_2O,icl,t}$ = N₂O emission from biomass burning in forest class icl at year t ; tCO₂e ha⁻¹

$EBB_{CH_4,icl,t}$ = CH₄ emission from biomass burning in forest class icl at year t ; tCO₂e ha⁻¹

$$EBB_{N_2O,icl,t} = EBB_{CO_2,icl,t} * 12/44 * NCR * ER_{N_2O} * 44/28 * GWP_{N_2O}$$

$$EBB_{CH_4,icl,t} = EBB_{CO_2,icl,t} * 12/44 * ER_{CH_4} * 16/12 * GWP_{CH_4}$$

Where:

$EBB_{CO_2,icl,t}$ = Per hectare CO₂ emission from biomass burning in slash and burn in forest class icl at year t ; tCO₂-e ha⁻¹

$EBB_{N_2O,icl,t}$ = Per hectare N₂O emission from biomass burning in slash and burn in forest class icl at year t ; tCO₂-e ha⁻¹

$EBB_{CH_4,icl,t}$ = Per hectare CO₂ emission from biomass burning in slash and burn in forest class icl at year t ; tCO₂-e ha⁻¹

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

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

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

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

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

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

$$EBB_{CO_2,icl,t} = F_{burnt,icl} * \sum_{p=1}^P (C_{p,icl,t} * P_{burnt,p,icl} * CE_{p,icl})$$

Where:

$EBBCO2_{icl,t}$ = Per hectare CO₂ emission from biomass burning in the forest class icl at year t ; tCO₂e ha⁻¹

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

$Cp_{icl,t}$ = Average carbon stock per hectare in the carbon pool p burnt in the forest class icl at year t ; tCO₂-e 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, ... icl (pre-deforestation) forest classes

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

Table 44: Parameters used to calculate non-CO₂ emissions from forest fires

Initial forest class		Parameters								
$IDicl$	Name	% $Fburnt_{icl}$	tCO ₂ -e ha ⁻¹ Cab	% $Pburnt_{ab,icl}$	% $CE_{ab,icl}$	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	64.2	4.4	4.4

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

Table 45: Baseline non-CO₂ emissions from forest fires in the project area

Project year	Baseline non-CO ₂ emissions from forest fires in the project area		Total baseline non-CO ₂ emissions from forest fires in the project area	
	$ID_{icl} = 1$			
	$ABS_{LPA}_{icl,t}$	$EBBSL_{tot_{icl}}$	Annual $EBBSLPA_t$	Cumulative $EBBSLPA$
	ha	tCO ₂ -e ha ⁻¹	tCO ₂ -e	tCO ₂ -e
2013	2,600	4.4	11,515	11,515
2014	3,447	4.4	15,268	26,783
2015	3,923	4.4	17,375	44,158
2016	4,280	4.4	18,958	63,116
2017	4,628	4.4	20,499	83,615
2018	4,628	4.4	21,469	105,084
2019	4,883	4.4	21,628	126,712
2020	4,907	4.4	21,732	148,443
2021	5,022	4.4	22,243	170,686
2022	5,176	4.4	22,926	193,612

3.2 Project Emissions

3.2.1 SALM component

The steps/procedures applied in the quantification of project emissions/removals are described in the following sections – based on the methodology. The roll out plan of the project is shown in Table 23.

Project emissions due to fertilizer use (PEF_t)

The project is promoting the adoption of SALM practices, which would to improve soil fertility and, therefore, reduce the need for fertilizer application. Hence, inorganic fertilizer application rates are expected to decline. However, for conservativeness, it is assumed that the amount of fertilizers applied in the project will be no greater than the amount applied in the baseline. During the project implementation, due to increase in farm incomes, it is probable that some farmers may increase the use inorganic fertilizers. Therefore, the amount of fertilizers used will be monitored in the project, and if it increases, emissions will be calculated using the latest CDM A/R Tool “Estimation of direct nitrous oxide emission from nitrogen fertilization”, and included as project

emissions, if significant. Therefore, for ex-ante estimation of project emissions due to fertilizer use, it is assumed that project fertilizer emissions are as great as the baseline fertilizer emissions (Section 3.1.1).

Project emissions due to the use of N-fixing species (PEN_t)

The project occurs on degraded/degrading lands as described in section 2.2. Thus, the lands are deemed to be generally nitrogen-deficient. In the project, nitrogen-fixing species, *Gliricidia sepium*, is planted in alternate rows with crops – a practice known as alley cropping. Their biomass is harvested and incorporated into the soil to improve soil fertility and soil organic matter. During the project, the area under *Gliricidia* will be estimated from adoption of alley cropping practices.

Using monitoring data, the area under *Gliricidia* has been estimated for 2013 to 2015, and projected as shown in Table 46. For ex-ante estimation, it is assumed that this rate of adoption will gradually increase, reaching a maximum of about half the area being under *Gliricidia* (54%).

The biomass yield of *Gliricidia* is taken from a study, which quantified it for the same practice and species in Eastern Province. The study estimated average annual biomass yield of 5 kg dry mass per tree⁵⁸. The estimation of biomass yield is presented in the project MIS.

PEN_t was estimated based on the above-stated adoption assumption, and the values shown are in Table 46.

Table 46: Projected adoption of alley cropping in the project

Project year	Percent of agricultural and adopting alley cropping	Trees/ha	Biomass yield (kg dry mass/ha/year)
2012	7%	18	90
2013	15%	25	125
2014	23%	32	160
2015	31%	39	195
2016	38%	46	230
2017	46%	53	265
2018	54%	60	300
2019	54%	67	335
2020	54%	74	370
2021	54%	81	405
2022	54%	88	440

⁵⁸ 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 (see page 3).

2023	54%	95	475
2024	54%	102	510
2025	54%	109	545
2026	54%	116	580
2027	54%	123	615
2028	54%	130	650
2029	54%	137	685
2030	54%	144	720
2031	54%	151	755
2032	54%	158	790

The following equations of the methodology were used for the calculations of PEN_t , and the values are presented in Table 47.

$$N_2O_{direct-N,t} = F_{CR,t} \cdot EF_1 \cdot MW_{N_2O} \cdot GWP_{N_2O} \cdot 10^{-3}$$

$$F_{CR,t} = \sum_{i=1}^I Crop_{i,t} \cdot (Area_{i,t} - Areaburnt_{i,t} \cdot C_f) \cdot Frac_{Renew} \cdot [R_{AG,i,t} \cdot N_{AG,i,t} \cdot (1 - Frac_{Removed}) + R_{BG,i,t} \cdot N_{BG,i,t}]$$

Where:

$N_2O_{direct-N,t}$ = Direct N_2O emission as a result of nitrogen application within the project boundary, tCO_2 -e in year t

$F_{CR,t}$ = Amount of N in crop residues (above and below ground), including N-fixing crops returned to soils annually, $kg\ N\ yr^{-1}$ in year t

EF_1 = Emission Factor for emissions from N inputs, $tonne-N_2O-N\ (tonne-N\ input)^{-1}$; value used is 1% as per methodology.

MW_{N_2O} = Ratio of molecular weights of N_2O and N ($44/28$), $tonne-N_2O\ (t-N)^{-1}$

GWP_{N_2O} = Global Warming Potential for N_2O , $kg-CO_2-e\ (kg-N_2O)^{-1}$ (IPCC default = 310, valid for the first commitment period).

$Crop_{i,t}$ = Harvested annual dry matter yield for crop i in year t , $kg\ d.m.\ ha^{-1}$. For N-fixing trees use the above ground biomass; value used is 5 $kg\ d.m./tree$

$Area_{i,t}$ = total annual area harvested of N-fixing crop i or trees i in year t , $ha\ yr^{-1}$; assumed to be area under alley cropping practice as shown in the above table.

$Areaburnt_{i,t}$ = annual area of N-fixing crop i or trees burnt in year t , $ha\ yr^{-1}$. It is assumed the trees are not burnt to avoid mortality, hence, $Areaburnt_{i,t}$ is zero.

C_f = combustion factor (dimensionless); value used is 0.8 (IPCC Guidelines, Table 2.6)

$Frac_{Renew}$ = fraction of total area under crop that is renewed annually; value used is 1 as per methodology.

$R_{AG\ i,t}$ = ratio of above-ground residues dry matter ($AG_{DM,i,t}$) to harvested yield for crop i in year t ($Crop_{i,t}$), kg d.m. (kg d.m.)⁻¹; value used is 0.02 for deciduous trees as per methodology – since Gliricidia is deciduous.

$N_{AG\ i,t}$ = content of above-ground residues for crop i , kg N (kg d.m.)⁻¹; value used is 0.027 as per methodology

$R_{BG\ i,t}$ = ratio of below-ground residues dry matter ($AG_{DM,i,t}$) to harvested yield for crop i , kg d.m. (kg d.m.)⁻¹; value used is 0.01 as per methodology

$N_{AG\ i,t}$ = content of below-ground residues for crop i , kg N (kg d.m.)⁻¹; value used is 0.022 as per methodology

$Frac_{Removed}$ = Fraction of above-ground residues of crop i removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)⁻¹. Assumed zero as per methodology.

Table 47: Project emissions due to the use of N-fixing species

Year	PEN _t (tCO ₂ -e)
2013	3
2014	3
2015	4
2016	9
2017	14
2018	21
2019	29
2020	32
2021	35
2022	38
2023	41
2024	44
2025	47
2026	50
2027	53
2028	56
2029	59
2030	62

2031	65
2032	68
Total	731

Project emissions from biomass burning (PEBB_t)

The project is promoting residue management including mulching and composting – contrary to the common baseline practice of burning crop residues. Hence, it is expected to counter biomass burning, and emissions due to this practice are expected to reduce drastically in the project.

According to baseline and monitoring surveys, the percentage of agricultural lands with no-burning practice was 3% in the baseline (in 2012); this increased during the project to 11% and 48% of agricultural lands in 2013 and 2015 respectively. Hence, it is expected that project emissions due to the burning of biomass will decline rapidly due to the rapid adoption of no-burning practices by farmers. Future adoption rate has been projected as the average of the previous adoption rate of no-burning practice, and the values used to model project emissions from biomass burning are shown in Table 48.

Table 48: Projected adoption of no burning practice in the project

Project year	Percent of agricultural land adopting no burning practice
2012	3.4%*
2013	11.2%*
2014	38.1%*
2015	48.2%*
2016	58.2%
2017	68.2%
2018	78.3%
2019	88.3%
2020	98.3%
2021	98.3%
2022	98.3%
2023	98.3%
2024	98.3%
2025	98.3%
2026	98.3%
2027	98.3%
2028	98.3%

2029	98.3%
2030	98.3%
2031	98.3%
2032	98.3%

*2012, 2013, 2014, and 2015 are actual figures from annual monitoring surveys.

Project emissions from biomass burning have been estimated as the percentage reduction in the estimated baseline emissions from biomass burning, which are detailed in section 3.1; the estimated values are presented in Table 49.

Table 49: Project emissions from biomass burning

Year	PEBB _t (tCO ₂ -e)
2013	327
2014	228
2015	191
2016	267
2017	289
2018	256
2019	170
2020	24
2021	24
2022	24
2023	24
2024	24
2025	24
2026	24
2027	24
2028	24
2029	24
2030	24
2031	24
2032	24
Total	2,047

Ex-post, emissions from biomass burning will be monitored and actual emissions calculated using monitoring data for the respective years.

Project removals from existing woody perennials (PRWP_t)

Removals from woody perennials is 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 includes removals from woody perennials in the future, only trees planted in the project ("project trees") will be monitored. Therefore, ex-ante project removals from existing woody perennials is accounted for as zero.

Thus,

$$\text{PRWP}_t = 0$$

Project emissions due to use of fossil fuels for agricultural management (PEFF_t)

The small-scale subsistence farmers in the project area have very low financial capacities; hence, the use of gas- or diesel-powered machinery is not expected to increase in the project to cause significant emissions. In the pilot baseline survey, none of the farmers in the project area reported using gas- or diesel-powered machinery for agricultural management. Nonetheless, the use of machinery will be monitored in the project, and if it increases significantly, emissions will be calculated using the Tool 'Estimation of emissions from the use of fossil fuels in agricultural management' (Section VI.2 of the SALM methodology). Ex-ante emissions are accounted for as zero.

Thus,

$$\text{PEFF}_t = 0$$

Project removals due to changes in soil organic carbon (PRS_t)

Among the SALM practices listed in section 1.8, the following are considered for project removals due to changes in soil organic carbon:

- Compost manuring – inputs of carbon from manure, applied and incorporated into the soil.
- Residue management – inputs of carbon from crop residues, and biomass from *Gliricidia sepium*, applied as mulch and incorporated into the soil.

The estimates of SOC were derived using the Rothamsted Soil Carbon Model, which is hereafter referred to as RothC model. Input parameters used in the model are obtained from farmer post-harvest surveys, and additional sources as indicated:

Input parameter	Source
Plant residues inputs into the soil	COMACO post-harvest surveys
Manure input into the soil	COMACO post-harvest surveys
Monthly rainfall	5-year averaged data from local weather stations in Chipata, Lundazi, Mfuwe and Petauke
Mean monthly air temperature	5-year averaged data from local weather stations in Chipata, Lundazi, Mfuwe and Petauke
Monthly open pan evaporation	The modified Hargreaves method ⁵⁹ is used to estimate PET from average radiation and the 5-year averaged temperature and precipitation data
Solar radiation	Mean global annual solar radiation 1,360 W/m ² adapted to the specific latitude of each Chiefdom
Clay content of the soil (%)	Project are average clay content taken from the Harmonized World Soil Database (Ver 1.2) ⁶⁰

Details of the Roth C model, its parameterisation, and modelling procedures can be found from the Rothamsted Research webpage link [here](#).

Monitoring data on plant residues and manure inputs into the soil for 2013 and 2014 were available at the time of writing this document, and have been included in the modelling. Estimates of plant residues and manure inputs for future years are assumed to be a continuation of the 2014 inputs.

The Roth C carbon model predicts a change in soil organic carbon when the model input parameter is changing, for example, due to increasing yields, 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. Hence, assumptions had to be made regarding the future project scenario.

⁵⁹ Droogers & Allen, 2002. Estimating reference evapotranspiration under inaccurate data conditions. Irrigation and Drainage Systems 16: 33–45, 2002.

⁶⁰ FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.

Accessed online: <http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/index.html?sb=1>

Assumptions

To predict project removals due to changes in soil organic carbon, the model was parameterised with the following conservative assumptions:

- Over the long-term, the area over which the above practices are adopted and implemented will increase from the baseline to at least 40% in the project i.e. the SALM practices will be adopted on an average of at least 40% of agricultural lands in the project.
- The amount of crop residues and compost manure inputs (t C/ha) obtained from the 2014 crop season monitoring survey is assumed for the entire project duration.

The amount of composted manure available for each farm was estimated based on the number and types of livestock recorded in the baseline survey, and volatile solid production values according to Tables 10A-4 to 10A-9 of Volume 4 of the 2006 IPCC Guidelines. During project implementation, the number and type of animals will be monitored in order to account for any changes in input parameters. Similarly, 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, and a study by Kaonga (2012) for *Gliricidia* biomass input into the soil. As per the methodology, the area-weighted average values for residue and compost manure yields have been used. The project has designed a web-based MIS system where all the survey and monitoring data are entered, processed and analysed to derive the required values for the soil modelling.

During the project implementation, crop yields will be monitored in order to account for any changes in residues inputs, and any change in model input parameters will be implemented in the modelling accordingly. The input values applied in the carbon modelling for each practice, and the resultant per ha project removals due to changes in soil organic carbon can be found in the RothC model, provided as separate file (*COMACO_RothC model_project_scenario*). The modelled per ha project removals due to changes in soil organic carbon were multiplied by the cumulative project rollout, and the estimated PRS_t are presented in Table 50 below.

Table 50: Project removals due to changes in soil organic carbon (PRS_t)

Year	PRS_t (tCO ₂ -e)
2013	7,672
2014	7,672
2015	7,672
2016	13,292
2017	18,912
2018	24,532
2019	30,152
2020	30,152
2021	30,152

2022	30,152
2023	30,152
2024	30,152
2025	30,152
2026	30,152
2027	30,152
2028	30,152
2029	30,152
2030	30,152
2031	30,152
2032	30,152
Total	501,881

Total ex-ante project net GHG emissions and removals by sinks

Total ante project net GHG emissions and removals by sinks were calculated using the equation below, and the values are presented in Table 51.

$$PE_t = PEF_t + PEFF_t + PEN_t + PEBB_t - PRWP_t - PRS_t$$

Where:

PE_t = Estimate of actual net project GHG emissions and removals by sinks in year t , tCO₂-e

PEF_t = Estimate of project emissions due to nitrogen fertilizer use in year t , tCO₂-e

$PEFF_t$ = Estimate of project emissions due to burning of fossil fuels for agricultural management in year t , tCO₂-e

PEN_t = Estimate of project emissions due to the increase use of N-fixing species in year t , tCO₂-e

$PEBB_t$ = Estimate of project emissions due to biomass burning in year t , tCO₂-e

$PRWP_t$ = Estimate of project removals due to changes in biomass of woody perennials in year t , tCO₂-e

PRS_t = Estimate of project removals due to changes in soil organic carbon in year t , tCO₂-e

Table 51: Total ex-ante project net GHG emissions and removals by sinks

Year	PE _t (tCO ₂ -e)
2013	-6,954
2014	-7,053
2015	-7,089
2016	-12,345
2017	-17,653
2018	-23,015
2019	-28,429
2020	-28,572
2021	-28,569
2022	-28,566
2023	-28,563
2024	-28,560
2025	-28,557
2026	-28,553
2027	-28,550
2028	-28,547
2029	-28,544
2030	-28,541
2031	-28,538
2032	-28,535
Total	-473,732

3.2.2 REDD+ component

In the following sections, the steps/procedures applied in the quantification of project emissions/removals are described – following the methodology. The steps/procedures have been titled according to the methodology for ease of referencing to the methodology.

Methodology Step 7: Ex ante estimation of actual carbon stock changes and non-CO₂ emissions in the project area

Ex ante estimation of actual carbon stock changes

Ex ante estimation of actual carbon stock changes due to planned activities

The UAD project component does not involve planned deforestation or any activities that cause carbon stock reductions such as infrastructure building, and timber harvesting. It also does seek to be credited for carbon stock increases. Some fuelwood harvesting in form of collecting deadwood will occur in the project area during the project, but at a level that is regulated and below the baseline. The entire project area is to be managed using the CCP approach, where communities commit to both avoiding activities that directly cause deforestation and forest degradation, e.g., cultivation and charcoal burning, and implementing sustainable land management practices to improve agricultural productivity (e.g. minimum tillage, rotation with legume, legume cover crop, residue management, crop diversification, composting, creation of firebreaks, agroforestry and wood lots), hence, reducing the need to convert forests into new agricultural lands. These activities are complemented with non-consumptive forest uses such as bee-keeping, and harvesting of non-wood forest products such as mushrooms within well-defined areas. These project activities potentially generate increases in carbon stock, but this is conservatively not accounted for in this project.

Ex ante estimation of carbon stock changes due to unavoidable unplanned deforestation within the project area

The unplanned activity responsible for deforestation in the baseline is small-scale agriculture. The implementation of project activities is expected to halt expansion of small-scale agriculture for the most part. However, some deforestation may still unavoidably occur in the project case. Hence, an overall Effective Index (EI) of reducing deforestation of 69% has been conservatively estimated for the activities implemented in the project. The overall 69% effectiveness of avoiding deforestation/forest degradation is expected to be achieved by the sixth year of the project (2018) due to concerted efforts of the project participants including farmers, the institutions the chiefdoms, and the COMACO incentivised agricultural business model (Table 52). Refer to the report: Drivers and Effectiveness Factor Analysis CLMP in supporting documentation.

Table 52: Effectiveness Index

Project year	Effectiveness Index %
2013	12%
2014	23%
2015	35%
2016	46%
2017	58%
2018	69%
2019	69%
2020	69%
2021	69%
2022	69%

Ex ante estimated net actual carbon stock changes in the project area

Carbon stock changes due to unavoidable unplanned deforestation has been estimated by multiplying the baseline projections of deforestation with the factor, $1 - EI$ as per the equation below, to produce an estimate of emissions from unplanned deforestation in the project case.

$$\Delta CUDdPA_t = \Delta CBSL_t * (1 - EI)$$

Where:

$\Delta CUDdPA_t$ is the total ex ante actual carbon stock change due to un-avoided unplanned deforestation at year t in the project area; tCO₂-e

$\Delta CBSL_t$ is total baseline carbon stock change at year t in the project area; tCO₂-e

EI is ex ante estimated Effectiveness Index; %

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

The results are presented in Table 53.

Table 53: Ex ante estimated net carbon stock change in the project area under the project scenario

Project year	Total carbon stock decrease due to planned activities		Total carbon stock increase due to planned activities		Total carbon stock decrease due to un-avoided unplanned deforestation		Total carbon stock change in the project case	
	Annual $\Delta CPAdPA_t$ tCO ₂ -e	Cumulative $\Delta CPAdPA$ tCO ₂ -e	Annual $\Delta CPAiPA_t$ tCO ₂ -e	Cumulative $\Delta CPAiPA$ tCO ₂ -e	Annual $\Delta CUDdPA_t$ tCO ₂ -e	Cumulative $\Delta CUDdPA$ tCO ₂ -e	Annual $\Delta CPSPA_t$ tCO ₂ -e	Cumulative $\Delta CPSPA$ tCO ₂ -e
2013	0	0	0	0	-200,670	-200,670	-200,670	-200,670
2014	0	0	0	0	-244,148	-444,819	-244,148	-444,819
2015	0	0	0	0	-249,142	-693,961	-249,142	-693,961
2016	0	0	0	0	-235,621	-929,582	-235,621	-929,582
2017	0	0	0	0	-209,845	-1,139,427	-209,845	-1,139,427
2018	0	0	0	0	-168,056	-1,307,483	-168,056	-1,307,483
2019	0	0	0	0	-178,526	-1,486,009	-178,526	-1,486,009
2020	0	0	0	0	-188,733	-1,674,741	-188,733	-1,674,741

2021	0	0	0	0	-201,475	-1,876,216	-201,475	-1,876,216
2022	0	0	0	0	-215,485	-2,091,701	-215,485	-2,091,701

Ex ante estimation of actual non-CO₂ emissions from forest fires

Non-CO₂ emissions from biomass burning has been included in the baseline, and therefore, as per the methodology is also included in the project scenario. The emissions have been estimated by multiplying the baseline non-CO₂ emissions from biomass burning by the factor: $1 - EI$ according to the equation below, and the results are presented in Table 54.

$$EBBPSPA_t = EBBBSPA_t * (1 - EI)$$

Where:

$EBBPSPA_t$ is total ex ante actual non-CO₂ emissions from forest fire due to un-avoided unplanned deforestation at year t in the project area; tCO_{2-e}

$BBPSPA_t$ is total non-CO₂ emissions from forest fire at year t in the project area; tCO_{2-e}

EI is ex ante estimated Effectiveness Index; %

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

Table 54: Total ex ante estimated actual emissions of non-CO₂ gases due to forest fires in the project area

Project year	Total ex ante estimated actual non-CO ₂ emissions from forest fires in the project area	
	$EBBPSPA_t$	$EBBPSPA$
	Annual tCO _{2-e}	Cumulative tCO _{2-e}
2013	10,191	10,191
2014	11,756	21,947
2015	11,381	33,328
2016	10,237	43,565
2017	8,712	52,277
2018	6,655	58,933
2019	6,705	65,637
2020	6,737	72,374

2021	6,895	79,269
2022	7,107	86,376

Total ex ante estimations for the project area

The total ex ante estimated actual net carbon stock changes and emissions of non-CO₂ gases in the project area are presented in Table 55.

Table 55: Total ex ante estimated actual net carbon stock changes and emissions of non-CO₂ gases in the project area

Project year	Total ex ante carbon stock decrease due to planned activities		Total ex ante carbon stock increase due to planned activities		Total ex ante carbon stock decrease due to un-avoided unplanned deforestation		Total ex ante net carbon stock change		Total ex ante estimated actual non-CO ₂ emissions from forest fires in the project area	
	Annual $\Delta CPA_{dPA,t}$ tCO ₂ -e	Cumulative ΔCPA_{dPA} tCO ₂ -e	Annual $\Delta CPA_{iPA,t}$ tCO ₂ -e	Cumulative ΔCPA_{iPA} tCO ₂ -e	Annual $\Delta CUD_{dPA,t}$ tCO ₂ -e	Cumulative ΔCUD_{dPA} tCO ₂ -e	Annual $\Delta CPSPA_t$ tCO ₂ -e	Cumulative $\Delta CPSPA$ tCO ₂ -e	Annual $EBBPSPA_t$ tCO ₂ -e	Cumulative $EBBPSPA$ tCO ₂ -e
2013	0	0	0	0	-200,670	-200,670	-200,670	-200,670	10,191	10,191
2014	0	0	0	0	-244,148	-444,819	-244,148	-444,819	11,756	21,947
2015	0	0	0	0	-249,142	-693,961	-249,142	-693,961	11,381	33,328
2016	0	0	0	0	-235,621	-929,582	-235,621	-929,582	10,237	43,565
2017	0	0	0	0	-209,845	-1,139,427	-209,845	-1,139,427	8,712	52,277
2018	0	0	0	0	-168,056	-1,307,483	-168,056	-1,307,483	6,655	58,933
2019	0	0	0	0	-178,526	-1,486,009	-178,526	-1,486,009	6,705	65,637
2020	0	0	0	0	-188,733	-1,674,741	-188,733	-1,674,741	6,737	72,374
2021	0	0	0	0	-201,475	-1,876,216	-201,475	-1,876,216	6,895	79,269
2022	0	0	0	0	-215,485	-2,091,701	-215,485	-2,091,701	7,107	86,376

3.3 Leakage

3.3.1 SALM component

As per the methodology, the one potential source of leakage is an increase in the use of fuel wood and/or fossil fuels from non-renewable sources for cooking and heating purposes due to the decrease in the use of manure and/or residues as an energy source. Leakage due to the increase in the use of fuelwood from non-renewable sources for cooking and heating purposes may be a significant source of leakage if manure or other agricultural residuals used for cooking and heating are transferred to the fields as part of the project. In the project area, the dominant cooking method is cooking on open fires or three-stone fires, where woodfuel is exclusively used. Hence, activity-shift due to manure and residue use is ignored. Nonetheless, through its whole farm approach, COMACO is enhancing fuelwood supply as the stems of *Gliricidia* grown on the crop fields will also enhance woodfuel supply. All these leakage management measures are expected to reduce leakage potential to a negligible level. Therefore, ex-ante estimate of leakage is zero. However, the project will monitor leakage in respective monitoring periods.

Thus,

$$LHE_t = 0.$$

3.3.2 REDD+ component

Methodology Step 8: Ex ante estimation of leakage

Two sources of leakage are considered in the methodology, and their ex ante estimations are outlined in the subsequent sections:

- Decrease in carbon stocks and increase in GHG emissions associated with leakage prevention measures;
- Decrease in carbon stocks and increase in GHG emissions associated with activity displacement leakage.

Ex ante estimation of the decrease in carbon stocks and increase in GHG emissions due to leakage prevention measures

The main leakage prevention activities are related to adoption of sustainable agricultural land management practices, which include alley cropping with *Gliricidia sepium* shrub, reduced tillage, the use of field residues for mulching, increased use of compost manure, green-manuring, physical structures and biological measures for soil and water conservation, row-planting, cover crops, and the use of improved crop varieties. These activities are implemented in the leakage management area (see section 2.3). The leakage management areas comprise agricultural lands, which in the baseline typically have very low carbon stock levels.

The above practices restore soil fertility, improve crop yields, increase carbon storage in the soil, and reduce/remove GHG emissions. Hence, leakage prevention measures would not increase emissions or decrease carbon stocks. Another leakage prevention measure is an incentive

system where local communities get financial rewards for their forest conservation actions in terms of premium prices for their agricultural produce sold through COMACO. In addition, there are development and technical support to provide alternative livelihood options including NTFPs businesses for the community members that have traditionally depended on slash and burn agriculture to adopt sustainable agricultural land management SALM.

Emissions from livestock grazing – i.e. methane (CH₄) and nitrous oxide (N₂O) – in the leakage management are not accounted for as the project does not support or expect to increase livestock population in the leakage management area. It is acknowledged that limited open-grazing of livestock takes place in the project area, but this is considered negligible. Based on data from the Ministry of Agriculture and Livestock report 2013, average number of cattle per household in the whole Eastern Province is about 2⁶¹.

Total ex ante estimated carbon stock changes and increases in GHG emissions due to leakage prevention measures

The total ex ante estimated carbon stock changes and increases in GHG emissions due to leakage prevention measures are accounted for as zero as there are no significant sources expected.

Ex ante estimation of the decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage

The project aims to involve all potential deforestation agents as a matter of priority in undertaking leakage prevention activities with a goal of avoiding significant displacement of deforestation to outside areas. Some small-scale agricultural activities may nonetheless inevitably be displaced. The level of displacement, also referred to as Displacement Leakage Factor (DLF) in the methodology has been estimated based on the proportion of the baseline agents expected to participate in leakage prevention activities and project activities. The project would engage with all communities whose agricultural activities would potentially be displaced from the CCA into the leakage belt in leakage prevention measures. However, not every agent may effectively avoid displacing their baseline activities; hence, we still conservatively assume that 20% of baseline deforestation could still be displaced to areas outside the project boundary. Therefore, a 20% Displacement Leakage Factor (DLF) is applied for the first 10 years (fixed baseline period). This value is applied to both displaced deforestation and forest fires. The associated carbon stock changes and GHG emissions have been estimated by multiplying the DLF with the baseline carbon stock changes due to deforestation, and baseline forest fire GHG emissions. The results are presented in Table 56.

Ex-post, leakage will be monitored as described in the Section 4, and actual deforestation caused by activity displacement will be discounted from the avoided deforestation in the project area.

⁶¹ Ministry of Agriculture and Livestock, 2013. Annual Report. Improving the Livestock Industry through the Provision of Efficient and Reliable Livestock Services.
Central Statistical Office, 2011. Census of Population and Housing. Preliminary Population Figures.

Table 56: Ex ante estimated leakage due to activity displacement

Project year	Total ex ante estimated decrease in carbon stocks due to displaced deforestation		Total ex ante estimated increase in GHG emissions due to displaced fires	
	Annual $\Delta CADLK_t$ tCO ₂ -e	Cumulative $\Delta CADLK$ tCO ₂ -e	Annual $\Delta EADLK_t$ tCO ₂ -e	Cumulative $\Delta EADLK$ tCO ₂ -e
2013	-45,349	-45,349	2,303	2,303
2014	-63,415	-108,764	3,054	5,357
2015	-76,074	-184,838	3,475	8,832
2016	-87,267	-272,106	3,792	12,623
2017	-98,751	-370,856	4,100	16,723
2018	-108,423	-479,279	4,294	21,017
2019	-115,178	-594,457	4,326	25,342
2020	-121,763	-716,220	4,346	29,689
2021	-129,984	-846,204	4,449	34,137
2022	-139,022	-985,226	4,585	38,722

Ex ante estimation of total leakage

Ex ante estimation of total leakage is summarised in Table 57.

Table 57: Ex ante estimated total leakage

Project year	Total ex ante GHG emissions from increased grazing activities		Total ex ante increase in GHG emissions due to displaced forest fires		Total ex ante decrease in carbon stocks due to displaced deforestation		Carbon stock decrease due to leakage prevention measures		Total net carbon stock change due to leakage		Total net increase in emissions due to leakage	
	Annual $EgLK_t$ tCO ₂ -e	Cumulative $EgLK$ tCO ₂ -e	Annual $\Delta EADLK_t$ tCO ₂ -e	Cumulative $\Delta EADLK$ tCO ₂ -e	Annual $\Delta CADLK_t$ tCO ₂ -e	Cumulative $\Delta CADLK$ tCO ₂ -e	Annual $\Delta CLPMLK_t$ tCO ₂ -e	Cumulative $\Delta CLPMLK$ tCO ₂ -e	Annual ΔCLK_t tCO ₂ -e	Cumulative ΔCLK tCO ₂ -e	Annual ΔELK_t tCO ₂ -e	Cumulative ΔELK tCO ₂ -e
2013	0	0	2,303	2,303	-45,349	-45,349	0	0	-45,349	-45,349	47,652	47,652
2014	0	0	3,054	5,357	-63,415	-108,764	0	0	-63,415	-108,764	66,469	114,121
2015	0	0	3,475	8,832	-76,074	-184,838	0	0	-76,074	-184,838	79,549	193,670
2016	0	0	3,792	12,623	-87,267	-272,106	0	0	-87,267	-272,106	91,059	284,729
2017	0	0	4,100	16,723	-98,751	-370,856	0	0	-98,751	-370,856	102,850	387,579
2018	0	0	4,294	21,017	-108,423	-479,279	0	0	-108,423	-479,279	112,717	500,296
2019	0	0	4,326	25,342	-115,178	-594,457	0	0	-115,178	-594,457	119,503	619,799
2020	0	0	4,346	29,689	-121,763	-716,220	0	0	-121,763	-716,220	126,109	745,909
2021	0	0	4,449	34,137	-129,984	-846,204	0	0	-129,984	-846,204	134,432	880,341
2022	0	0	4,585	38,722	-139,022	-985,226	0	0	-139,022	-985,226	143,608	1,023,949

3.4 Net GHG Emission Reductions and Removals

Net GHG emission reductions and removals are calculation separated for the SALM and REDD+ components, then summed up.

3.4.1 SALM component

Ex ante estimation of total net GHG emissions reductions were calculated according to the methodology applying the following equation, and the results are presented in Table 58.

Table 58: Ex ante estimation of total net GHG emissions reductions of the SALM component

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
2013	756	-6,954	0	7,710
2014	756	-7,053	0	7,809
2015	756	-7,089	0	7,846
2016	1,311	-12,345	0	13,655
2017	1,865	-17,653	0	19,518
2018	2,419	-23,015	0	25,433
2019	2,973	-28,429	0	31,402
2020	2,973	-28,572	0	31,544
2021	2,973	-28,569	0	31,541
2022	2,973	-28,566	0	31,538
2023	2,973	-28,563	0	31,535
2024	2,973	-28,560	0	31,532
2025	2,973	-28,557	0	31,529
2026	2,973	-28,553	0	31,526
2027	2,973	-28,550	0	31,523
2028	2,973	-28,547	0	31,520
2029	2,973	-28,544	0	31,517
2030	2,973	-28,541	0	31,514
2031	2,973	-28,538	0	31,511

2032	2,973	-28,535	0	31,508
Total	49,483	-473,732	0	523,216

3.4.2 REDD+ component

Ex ante estimation of total net GHG emissions reductions were calculated according to the methodology applying the following equation, and the results are presented in Table 59.

$$\Delta REDD_t = (\Delta CBSLPA_t + EBBBSLPA_t) - (\Delta CPSPA_t + EBBPSPA_t) - (\Delta CLK_t + ELK_t)$$

Where:

$\Delta REDD_t$ = Ex ante estimated net anthropogenic greenhouse gas emission reduction attributable to the AUD project activity at year t ; tCO₂-e.

$\Delta CBSLPA_t$ = Sum of baseline carbon stock changes in the project area at year t ; tCO₂-e.

$EBBBSLPA_t$ = Sum of baseline emissions from biomass burning in the project area at year t ; tCO₂-e.

$\Delta CPSPA_t$ = Sum of ex ante estimated actual carbon stock changes in the project area at year t ; tCO₂-e.

$EBBPSPA_t$ = Sum of (ex ante estimated) actual emissions from biomass burning in the project area at year t ; tCO₂-e.

ΔCLK_t = Sum of ex ante estimated leakage net carbon stock changes at year t ; tCO₂-e.

ELK_t = Sum of ex ante estimated leakage emissions at year t ; tCO₂-e.

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

Table 59: Ex ante estimation of total net GHG emissions reductions of the REDD+ component*

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
2013	238,262	210,861	47,652	-20,252
2014	332,343	255,904	66,469	9,970
2015	397,745	260,523	79,549	57,673
2016	455,294	245,859	91,059	118,376
2017	514,252	218,557	102,850	192,845
2018	563,584	174,711	112,717	276,156
2019	597,517	185,230	119,503	292,783
2020	630,547	195,469	126,109	308,968
2021	672,162	208,370	134,432	329,359
2022	718,038	222,592	143,608	351,838
Total	5,119,743	2,178,077	1,023,949	1,917,717

*Note that ex-ante estimations for the REDD+ component have been done for the first 10 years i.e. for the fixed baseline period.

Project net ex-ante estimation of total net GHG emissions reductions

The overall project net ex-ante estimation of total net GHG emissions reductions were obtained by summing the respective values of the REDD+ for the first 10 years and the SALM component; the results are presented in Table 60.

Table 60: Ex ante estimation net GHG emissions reductions of the entire project

Year	Estimated net GHG emission reductions or removals (tCO ₂ e)
2013	-12,542
2014	17,780
2015	65,519
2016	132,031
2017	212,362
2018	301,590
2019	324,185
2020	340,512

2021	360,901
2022	383,377
2023	31,535
2024	31,532
2025	31,529
2026	31,526
2027	31,523
2028	31,520
2029	31,517
2030	31,514
2031	31,511
2032	31,508
Total	2,440,933

4 MONITORING

4.1 Data and Parameters Available at Validation

4.1.1 SALM component

Data / Parameter	Unit	Description	Source of data	Value applied	Purpose of data
$BSN_{t=0}$	kg/ha	Synthetic fertilizer use	Studies: Jha and Hojjati, 1993 ⁶² , and Ariga, 2013) ⁶³	120	Baseline GHG emissions/removals estimation
$Crop_{i,t=0}$	kg d.m./ha	Harvested seasonal dry matter yield for crop i	Baseline survey	See Project MIS	Baseline GHG emissions/removals estimation
$Area_{i,t=0}$	ha	Total annual area harvested of crop i or N-fixing trees i	Baseline survey	See Project MIS	Baseline GHG emissions/removals estimation
$Areaburnt_{i,t=0}$	ha	Annual area of crop i or N-fixing trees i burnt	Baseline survey	See Project MIS	Baseline GHG emissions/removals estimation
$MB_{C,t=0}$	t.d.m.	Mass of crop residues burnt	Baseline survey	See Project MIS	Baseline GHG emissions/removals estimation
C_F	unit less	Combustion factors that depend on vegetation type	IPCC 2006 Table 2.6	0.8	Baseline GHG emissions/removals estimation
$BA_{C,m_c,t=0}$	ha	Baseline areas in cropland with management practice, m_c	Baseline survey	See Project MIS	Baseline GHG emissions/removals estimation
$SOC_{C,m_c,t=0}$	tC/ha	Soil organic carbon density, to a depth of 30 cm, at equilibrium for cropland with management practice, m_c	Modelled	See RothC model	Baseline GHG emissions/removals estimation
$BP_{C,m_c,t=0}$	t/ha/season	Baseline production in cropland per month with management practice from within the project, m_c	Baseline survey	See Project MIS	Baseline GHG emissions/removals estimation

⁶² Jha and Hojjati, 1993. Fertilizer use on smallholder farms in eastern province, Zambia. Accessed [here](#).

⁶³ Ariga, 2013. Zambia Fertilizer Assessment. Accessed [here](#).

$BR_{C,m_C,t=0}$	t/t prod/month	Baseline fraction of production returned as residues per month (calculated from $BP_{C,m_C,t=0}$) in cropland with management practice, m_C	Baseline survey	See Project MIS	Baseline GHG emissions/removals estimation
$BM_{C,m_C,t=0}$	t/ha/month	Baseline manure input in cropland per month with management practice, m_C	ILUA I survey & IPCC default factors	See Excel: <i>COMACO_compost_input</i>	Baseline GHG emissions/removals estimation
$BCC_{C,m_C,t=0}$		Baseline cover crop flag per month in cropland per month with management practice, m_C	Baseline survey	See Project MIS	Baseline GHG emissions/removals estimation
$\overline{Temp}_m$	°C	Average temperature per month	Local weather records	See Excel file 'Monthly Max-Min Temp_1998-2014'	Baseline GHG emissions/removals estimation
$\overline{Prec}_m$	mm	Average precipitation per month	Local weather records	See Excel file 'monthly Rainfall_1998-2014'	Baseline GHG emissions/removals estimation
$\overline{Evap}_m$	mm/day	Average evapotranspiration per month	Calculated	See RothC model	Baseline GHG emissions/removals estimation

4.1.2 REDD+ component

Data / Parameter	Unit	Description	Source of data	Value applied	Purpose of data
Forest Cover Benchmark	Map	Digital map showing the location of forest within the project area at the project start sensing analysis	LANDSAT satellite images of 2013	See supporting documentation	Baseline GHG emissions/removals estimation

Reference region	Map	Digital map showing the boundary of the reference region	Mapping by government	See supporting documentation	Baseline GHG emissions/removals estimation
Leakage belt	Map	Digital map showing the boundary of the leakage belt	Leakage analysis (see section 2.3: part 1.1.3 Leakage belt)	See supporting documentation	Baseline GHG emissions/removals estimation
Project area	Map	Digital map showing the boundary of the project area	Analysis of LANDSAT satellite images of 2002 and 2013	See supporting documentation	Baseline GHG emissions/removals estimation
Annual areas of baseline deforestation in the reference region	Ha	Annual areas deforested each year from 2013 to 2022 in the reference region	Analysis of future deforestation (see section 3.1: Step 4: Projection of future deforestation)	See supporting documentation	Baseline GHG emissions/removals estimation
Annual areas of baseline deforestation in the project area	Ha	Annual areas deforested each year from 2013 to 2022 in the project area	Analysis of future deforestation (see section 3.1: Step 4: Projection of future deforestation)	See supporting documentation	Baseline GHG emissions/removals estimation
Annual areas of baseline deforestation in the leakage belt	Ha	Annual areas deforested each year from 2013 to 2022 in the leakage belt	Analysis of future deforestation (see PD section 3.1: Step 4: Projection of future deforestation)	See supporting documentation	Baseline GHG emissions/removals estimation
Carbon stocks per hectare of initial forest classes, <i>icl</i>	tCO ₂ e/ha	Average carbon stock per hectare in all carbon pools before deforestation	Existing forest inventory study (Kamelarczyk (2009) ⁶⁴ ,)	See Excel file: COMACOPER calculations_REDD	Baseline GHG emissions/removals estimation

⁶⁴ Kamelarczyk, K. B. F., 2009. Carbon Stock Assessment and Modelling in Zambia. A UN-REDD programme study. Accessed [here](#).

Carbon stocks per hectare of final classes, <i>fcl</i>	tCO ₂ e/ha	Average carbon stock per hectare in all carbon pools of the land use after deforestation	Existing forest inventory study (Kamelarczyk (2009) ⁶⁵ .)	See Excel file: <i>COMACO ER calculations_REDD</i>	Baseline GHG emissions/removals estimation
Carbon stock changes factors for initial forest class, <i>icl</i>	tCO ₂ e/ha	Average carbon stock decay rate for all carbon pools before deforestation	Calculation, according to the methodology – section 6.1.2	See Excel file: <i>COMACO ER calculations_REDD</i>	Baseline GHG emissions/removals estimation
Carbon stock changes factors for final forest class, <i>fcl</i>		Average carbon stock decay rate for all carbon pools after deforestation	Calculation, according to the methodology – section 6.1.2	See Excel file: <i>COMACO ER calculations_REDD</i>	Baseline GHG emissions/removals estimation
Carbon fraction, CF	Unitless	Average carbon content of dry matter	IPCC 2006 default	0.5	Baseline GHG emissions/removals estimation
Average proportion of forest area burned during the historical reference period in the forest class, <i>icl</i>	%	Proportion of forest area burned during the historical reference period	Analysis of deforestation drivers and agents	100%	Baseline GHG emissions/removals estimation
Average proportion of mass burnt in the carbon pool <i>p</i> in the forest class, <i>icl</i>	%	Proportion mass burnt in the carbon pool in the forest	Published study ⁶⁶	60%	Baseline GHG emissions/removals estimation
Average combustion efficiency of the carbon pool <i>p</i> in the forest class, <i>icl</i>	%	Proportion of available fuel actually burnt	IPCC 2003 Table 3.A.14 (Combustion efficiency of Tropical dry mixed forests)	90%	Baseline GHG emissions/removals estimation

⁶⁵ Kamelarczyk, K. B. F., 2009. Carbon Stock Assessment and Modelling in Zambia. A UN-REDD programme study. Accessed [here](#).

⁶⁶ Minishi *et al.*, 2010. The role of the Miombo Woodlands of the Southern Highlands of Tanzania as carbon sinks. Accessed [here](#).

4.2 Data and Parameters Monitored

4.2.1 SALM component

Data Unit / Parameter:	PSN_t
Data unit:	kg/ha
Description:	Synthetic fertilizer use per season/year
Source of data:	Post-harvest survey
Description of measurement methods and procedures to be applied:	The farmers report the use of fertilizers on a particular crop land and the quantities.
Frequency of monitoring/recording:	Annually
Value monitored:	See project MIS
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 are 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 emissions calculations
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
Any comment:	n.a

Data Unit / Parameter:	$PA_{C,t}$
Data unit:	ha/season
Description:	Areas in cropland
Source of data:	Post-harvest survey
Description of measurement methods and procedures to be applied:	Interviews using questionnaires. Farmers report the cropland in local units under different crops.
Frequency of monitoring/recording:	Annually
Value monitored:	See Project MIS
Monitoring equipment:	Digital data logger/tablet; GPS, Quantum GIS, MIS
QA/QC procedures to be applied:	Pre-testing and retesting of questionnaires. Review of collected data by data analysts before analysis. Use of

	trained enumerators. Comparison of reported sizes of cropland with samples of mapped croplands
Purpose of data:	Project emissions calculations
Calculation method:	Database calculation functions
Any comment:	n.a

Data Unit / Parameter:	$Crop_{i,t}$
Data unit:	kg d.m./ha/season
Description:	Harvested annual dry matter yield for crop i
Source of data:	Post-harvest survey
Description of measurement methods and procedures to be applied:	Interviews using questionnaires. Farmers report yields and field sizes for different crops.
Frequency of monitoring/recording:	Annually
Value monitored:	See Project MIS
Monitoring equipment:	Digital data logger/tablet;
QA/QC procedures to be applied:	Pre-testing and retesting of questionnaires. Review of collected data by data analysts before analysis. Integrated quality controls in database for unrealistic values. Use of trained enumerators.
Purpose of data:	Project emissions calculations
Calculation method:	Farmers report the crop yields in local units (# of 50kg bags harvested) and plot size in lima, which is then converted to per unit area.
Any comment:	n.a

Data Unit / Parameter:	$Area_{i,t}$
Data unit:	Ha/season
Description:	Total seasonal area harvested of crop i or N-fixing trees i
Source of data:	Post-harvest survey
Description of measurement methods and procedures to be applied:	Interviews using questionnaires. Farmers report field sizes for different crops grown/harvested.
Frequency of monitoring/recording:	Annually
Value monitored:	See project MIS
Monitoring equipment:	Digital data logger/tablet; GPS, Quantum GIS, MIS
QA/QC procedures to be applied:	Pre-testing and retesting of questionnaires. Review of collected data by data analysts before analysis. Use of trained enumerators.
Purpose of data:	Project emissions calculations
Calculation method:	Sum functions in the project MIS

Any comment:	n.a
--------------	-----

Data Unit / Parameter:	$Areaburnt_{i,t}$
Data unit:	Ha/ season
Description:	Seasonal area of crop i or N-fixing trees i burnt
Source of data:	Post-harvest survey
Description of measurement methods and procedures to be applied:	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 monitored:	See Project MIS
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 emissions calculations
Calculation method:	Database calculation functions
Any comment:	n.a

Data Unit / Parameter:	$MB_{C,t}$
Data unit:	t d.m./year
Description:	Mass of crop residues burnt
Source of data:	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 $Areaburnt_{i,t}$ and crop yield $Crop_{i,t}$.
Frequency of monitoring/recording:	Annually
Value monitored:	See Project MIS
Monitoring equipment:	Digital data logger/tablet
QA/QC procedures to be applied:	QC/QA procedures for estimating $Areaburnt_{i,t}$ and crop yield $Crop_{i,t}$ apply.
Purpose of data:	Project emissions calculations
Calculation method:	Database calculation functions
Any comment:	n.a

Data Unit / Parameter:	$PA_{C,m_C,t}$
Data unit:	ha
Description:	Project areas in cropland with management practice, m_C
Source of data:	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 monitored:	See Project MIS
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.
Any comment:	-

Data Unit / 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, m_C
Source of data:	Modelling with Roth C carbon model
Description of measurement methods and procedures to be applied:	See modelling description in section 3.2
Frequency of monitoring/recording:	Every verification event
Value monitored:	See Roth C model worksheet ' <i>Results</i> '
Monitoring equipment:	Excel version of the RothC model
QA/QC procedures to be applied:	Use of site-specific input parameters where possible. Checking which parameters are causing the largest uncertainty in the model outputs. 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 emissions calculations
Calculation method:	Modeled with RothC using respective input values
Any comment:	n.a

Data Unit / Parameter:	$PP_{C,m_C,t}$
Data unit:	t/ha/season
Description:	Production in cropland per season with management practice from within the project, m_C
Source of data:	Post-harvest survey
Description of measurement methods and procedures to be applied:	Estimated using equations from Table 11.2 of Volume 4 of the 2006 IPCC Guidelines for major crops
Frequency of monitoring/recording:	Annually
Value monitored:	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 emissions calculations
Calculation method:	See equations in Table 11.2 of Volume 4 of the 2006 IPCC Guidelines
Any comment:	n.a

Data Unit / 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
Source of data:	Post-harvest survey
Description of measurement methods and procedures to be applied:	Calculated from $PP_{C,m_C,t}$ and areas under practices ($PA_{C,m_C,t}$)
Frequency of monitoring/recording:	Annually

Value monitored:	See the Project
Monitoring equipment:	Project MIS
QA/QC procedures to be applied:	Pre-testing and retesting of questionnaires. Review of collected data by data analysts before analysis. Use of trained enumerators for data collection
Purpose of data:	Project emissions calculations
Calculation method:	
Any comment:	n.a

Data Unit / Parameter:	$PM_{C,m_C,t}$
Data unit:	tC/ha/season
Description:	Project composted manure input in cropland per season with management practice, m_C
Source of data:	Post-harvest survey IPCC default factors
Description of measurement methods and procedures to be applied:	Calculated using IPCC default volatile solids in kg dm/animal/day manure defaults based on animal numbers recorded in survey.
Frequency of monitoring/recording:	Annually
Value monitored:	See Project MIS
Monitoring equipment:	Digital data logger/tablet
QA/QC procedures to be applied:	Pre-testing and retesting of questionnaires. Review of collected data by data analysts before analysis. Use of trained enumerator for data collection.
Purpose of data:	Project emissions calculations
Calculation method:	Use of IPCC decomposition equation/local equations when available.
Any comment:	n.a

Data Unit / 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, m_C
Source of data:	Compliance Survey
Description of measurement methods and procedures to be applied:	Compliance Survey interviews and direct observations
Frequency of monitoring/recording:	Annually
Value monitored:	See Project MIS

Monitoring equipment:	Digital data logger
QA/QC procedures to be applied:	Pre-testing and retesting of questionnaires. Observations and capture of practices using tablet camera and the GPS point
Purpose of data:	Project emissions calculations
Calculation method:	n.a
Any comment:	-

Data Unit / Parameter:	$\overline{Temp}_m$
Data unit:	°C (degree Celcius)
Description:	Average temperature per month
Source of data:	Local weather records:
Description of measurement methods and procedures to be applied:	5 year-averages are used in the RothC model to calculate $SOC_{C,m_C,t}$
Frequency of monitoring/recording:	Annually values are recorded by weather stations, values are used at every verification event
Value monitored:	See Roth C model
Monitoring equipment:	n.a
QA/QC procedures to be applied:	Use of local weather data. Uncertainty of $\overline{Temp}_m$ estimate is also included in overall uncertainty of model.
Purpose of data:	Project emissions calculations
Calculation method:	Average
Any comment:	n.a

Data Unit / Parameter:	$\overline{Prec}_m$
Data unit:	mm
Description:	Average precipitation per month
Source of data:	Local weather records
Description of measurement methods and procedures to be applied:	5 year-averages are used in the RothC model to calculate $SOC_{C,m_C,t}$
Frequency of monitoring/recording:	Annually values are recorded by weather stations, values are used at every verification event
Value monitored:	See Roth C model
Monitoring equipment:	n.a
QA/QC procedures to be applied:	Use of local weather data. Uncertainty of $\overline{Prec}_m$ estimate is also included in overall uncertainty of SOC model.
Purpose of data:	Project emissions calculations
Calculation method:	Average

Any comment:	n.a
--------------	-----

Data Unit / 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. The average solar radiation is calculated based simple geometry.
Frequency of monitoring/recording:	Annually values are recorded by weather stations, values are used at every verification event
Value monitored:	See Roth C model
Monitoring equipment:	n.a
QA/QC procedures to be applied:	Use of relevant local data. Uncertainty of $\overline{Evap}_m$ estimate is also included in overall uncertainty of SOC model.
Purpose of data:	Project emissions calculations
Calculation method:	Average
Any comment:	n.a

Data Unit / Parameter:	D
Data unit:	Years
Description:	Transition period
Source of data:	IPCC default value
Description of measurement methods and procedures to be applied:	n.a
Frequency of monitoring/recording:	Once at project start. Value is used at every verification event
Value monitored:	20
Monitoring equipment:	n.a
QA/QC procedures to be applied:	The RothC models are standardized and semi-automatic, which ensures that only input values for a specific monitoring period are entered and that the parameterized models are not accidentally changed
Purpose of data:	Project emissions calculations
Calculation method:	n.a
Any comment:	n.a

Data Unit / Parameter:	$PT_{C,t}$
------------------------	------------

Data unit:	tC/ha/season
Description:	Project fraction of tree biomass from pruning returned as organic input per season
Source of data:	Published (peer-reviewed) study
Description of measurement methods and procedures to be applied:	n.a
Frequency of monitoring/recording:	Default value used annually for each
Value monitored:	Not yet available
Monitoring equipment:	n.a
QA/QC procedures to be applied:	Use of relevant local data. Uncertainty of the estimate is also included as in overall uncertainty of SOC model.
Purpose of data:	Project emissions calculations
Calculation method:	n.a
Any comment:	

4.2.2 REDD+ component

Data / Parameter	Forest Cover maps
Data unit	Maps
Description	Digital maps showing the location of forest within the project area at the project start and end of each monitoring periods
Source of data	LANDSAT satellite images of 2013
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 4.2.8.
Purpose of Data	Project GHG emissions and removals
Comments	-

Data / Parameter	Deforestation maps
Data unit	Maps
Description	Digital map showing locations of deforestation during the fixed baseline period.
Source of data	Satellite images: LANDSAT
Value applied:	See supporting documentation
Justification of choice of data or description of	Analysis of satellite images

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

Data / Parameter	Annual areas of deforestation in the reference region
Data unit	ha
Description	Areas deforested between start and end of this monitoring period in the reference region
Source of data	Satellite images: LANDSAT
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Analysis of satellite images.
Purpose of Data	Baseline GHG emissions and removals
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	Satellite images: LANDSAT
Value applied:	See supporting documentation
Justification of choice of data or description of measurement methods and procedures applied	Analysis of satellite images.
Purpose of Data	Project GHG emissions and removals
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	Satellite images: LANDSAT
Value applied:	See supporting documentation
Justification of choice of data or description of	Analysis of satellite images.

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

Data / Parameter	Carbon decrease due to catastrophic events
Data unit	tCO ₂ e
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.
Purpose of Data	Project GHG emissions and removals
Comments	-

4.3 Monitoring Plan

The project will be monitored in a manner that integrates the SALM and REDD+ component data collection process as much as possible.

The monitoring plan primarily aims to 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 other 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.

The SALM methodology requires that at the start of the project, the project proponent shall establish an Activity Baseline and Monitoring Survey (ABMS) to identify the dominant agricultural management practices for croplands. The methodology lists all parameters to be surveyed. The

first ABMS survey representing the baseline conditions at the start of the project survey is referred to as $t=0$ in the Methodology against which all future emission reductions and removals will be compared to. Therefore the establishment of the $t=0$ baseline emissions and removals is crucial for calculating real and verifiable project carbon benefits. As a consequence the ABMS survey must adhere to the uncertainty requirements of the Methodology, i.e. all parameters need to follow a precision of 15% at the 95% confidence interval.

The COMACO landscape project builds project monitoring upon existing M&E structures within the overall COMACO M&E system. It integrates two major structured annual surveys; the Post-harvest (PHS) and Compliance Surveys (CS) to monitor carbon for SALM (Figure 22):

The purpose of the CS is principally 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 it 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 emissions estimation, while the CS is meant to gather information for comparing with the information from the PHS. Both surveys are conducted annually.

In addition to the two annual surveys, the farmer registration process records vital information about the farmers that become COMACO members. Information collected about a farmer includes; name, location, year of registration and demographic information. The farmers are then organized into Producer Groups (PGs) who then sign a PG pledge agreement form (an agreement document between COMACO and PG members that outlines the by-laws of conservation farming which the PGs pledge to adopt). The farmer register becomes the basis for linking back almost every other process to the farmer, household, and producer group level, including monitoring of environmental and socio-economic activities.

The sample frame for both surveys is the list of farms from the farm registry 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.

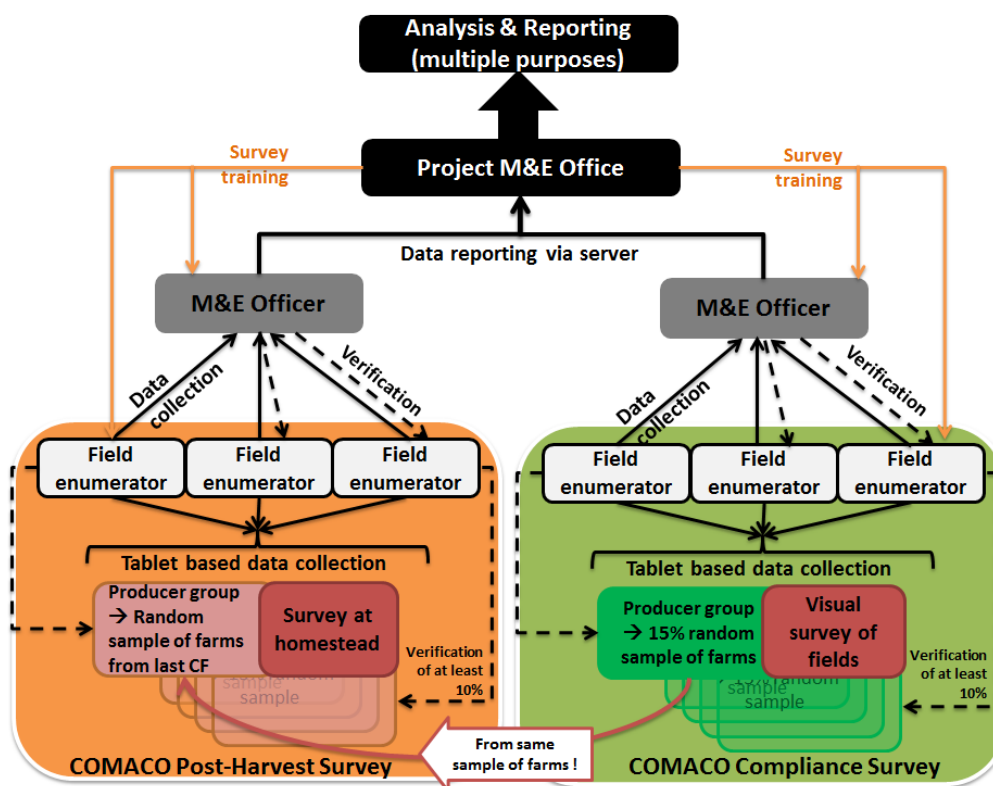


Figure 22: COMACO 2-tiered survey system for annual SALM monitoring

Sampling Plan

Target population and sampling frame

The SALM component of the project targets rural small holder farmers in the 9 chiefdoms along the Luangwa valley in the Eastern Province of Zambia. The targeted farmers are especially vulnerable to increasing variability of rainfall patterns that affect their agricultural productivity leading to low levels of food security and house hold in-come. Small holder farmers along the Luangwa valley lack access to energy-efficient technologies resulting in the unsustainable usage of natural resources.

The SALM project will utilize the COMACO SALM register as its sampling frame from which sub-samples for the compliance and post-harvest surveys are drawn. The register consists of only COMACO registered farmers and it includes demographic information and geographical location of farmers with farmer IDs that uniquely identify farmers. Note that several fields under SALM recruited into the project can belong to the same farmer.

Sampling method

The SALM project will adopt “simple random sampling” stratified by producer groups for both the post-harvest and compliance survey. The sampling unit is the farm field under SALM. The 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, this 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.

According to the SALM methodology, the ABMS approach combines the baseline and the monitoring assessment of the project. The baseline survey data from 2012 serve to determine the existing land use practices, to parameterize the carbon model and to anticipate commitment to adopt SALM practices. Subsequent annual surveys aim to monitor the adoption and maintenance of SALM practices. The monitoring of the sample farmers has to be repeated annually throughout the lifetime of the project.

Based on the existing COMACO M&E procedures for the two surveys, a fixed sample size is randomly selected each year from the SALM register:

- About 15% of the farms of the farms are randomly sampled annually from the SALM register for the post-harvest survey.
- While in the Compliance survey about 10% of the farms are randomly sampled annually from the farmer register.
- The actual sample size shall be determined based on the variation in the data collected (see below).
- The surveys are linked (for the 9 carbon project area chiefdoms) such that, all farmers surveyed in the compliance survey are automatically included in the post-harvest survey.

If the fixed sample size mentioned above does not satisfy the specific precision requirements of the methodology, the actual sample size of a particular year is determined based on the variation in the data. In this case, 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 weighted 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 deviation 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 practices⁶⁷, as well as the COMACO Operational Plan.

Data collection, recording, and analysis

While all parameters in the post-harvest survey are collected at a homestead, the compliance survey is more observational, where enumerators conduct a physical field by field inspection to verify and confirm the farming practices being practiced on each field. Each registered farmer group is trained, in particular the farmer group resource person (FGRP) to estimate monitoring parameters such as crop areas and yield. The PHS is conducted post crop harvest around May/ June where enumerators trained by COMACO field staff visits selected farmer. Each enumerator is equipped with tablet with pre-loaded questionnaire using Open Data Kit (ODK) software. This data collection tool is used in both surveys and the data collection software (ODK collect) has pre-programmed validity control checks. The Compliance survey is implemented in the month of October/ November in order to directly observe farming practices during the cropping season. The data collected on tablet is then transferred, stored and analysed using the project web-based Management Information System (Project MIS).

The Project MIS has been developed particularly for the PHS – 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 23. All the calculations to monitor the project performance as a whole, and to provide the parameters needed for the RothC soil modelling and other calculations related to the methodology are integrated into the MIS.

⁶⁷Seebauer and Tennigkeit, 2012. Activity baseline and monitoring survey guideline for Sustainable Agricultural Land Management practices (SALM), Version 2 (developed for the World Bank)

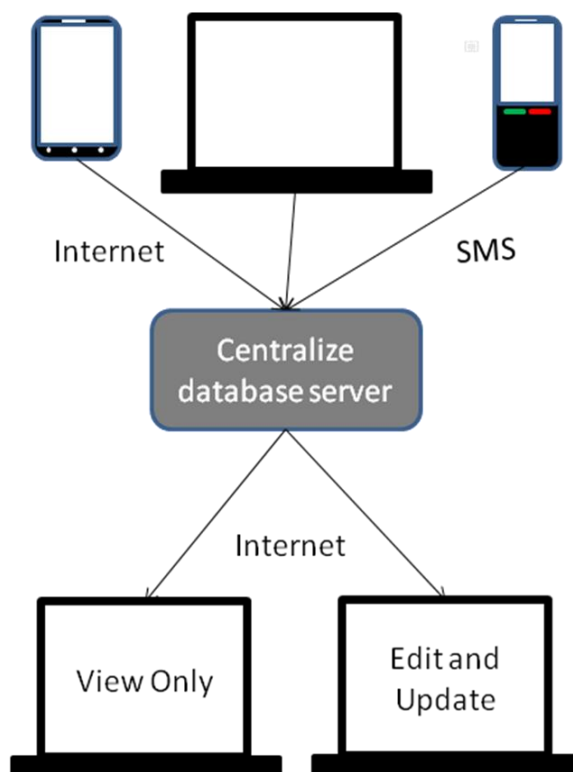


Figure 23: Project MIS data flow concept

The key features of the Project MIS are:

- 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)
- Centralized online database
- Dashboard to monitor the progress
- Login

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

- COMACO staff, enumerators and 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 enumerators and COMACO M&E staff verifies/ cross-checks data, and assists farmers to fill the questionnaire/SALM pledge forms;
 - COMACO supports the entire process, and makes a follow up if there are inconsistencies/errors in the documentation/data. For this, the 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 surveys, in particular the PHS monitor all data required to estimate GHG emissions, e.g.:

- Input values for the SOC modelling, i.e. crop yields and yield increase over time. Only the most dominant crops are used for the modelling to reduce uncertainty of the modelling.
- 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 surveys monitor 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
- Overall project compliance

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 records in general.

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 section to 2.4.2 (Step 2: Analysis of historical land-use and land-cover change). The only difference is that satellite images acquired in the respective monitoring periods are used. The steps can be 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 will use primarily use LANDSAT images of good quality, unless they are not available – in which case alternatives will 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 to be 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 61). 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 to be undertaken.

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 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:

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

For the calculations of non-CO₂ emissions, refer to section 4.2.2 (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.

Table 61: 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.	Mandatory	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	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.

possible after the catastrophic event.			
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 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	Mandatory	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.

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. Estimation the carbon stock per unit area, i.e., per ha (emission factor) of the catastrophic event.
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.

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 section 2.4.2, except satellite images acquired in the respective monitoring periods are used. 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 in the leakage belt and the deforestation quantified 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. When the deforestation 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 is to 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 validator. 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 components

For the SALM component, both surveys are initially conducted by COMACO through trained enumerators. This is applicable for the first monitoring period. During this time COMACO is 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 CS only, and overall responsibility for both surveys. Hence, the PHS will become a farmer-self assessment, which is cross-checked against the CS. 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 data⁶⁸ are sourced for modelling of soil carbon sequestration with the Roth C model.

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.,

⁶⁸ 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/>

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 62 below, the entities involved and their roles and responsibilities in implementing the monitoring surveys are described.

Table 62: 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	1) Trains field extension/survey team on project implementation and monitoring 2) Plans and undertakes monitoring including mobilizing human and financial resources for monitoring 3) 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
--	--	--

Quality control and quality assurance procedures for monitoring of the project

The project follows 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 technical guidelines for SALM projects' 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 GOFC-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 stakeholder – 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 step-wise 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 farmers 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 acknowledge 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 guidelines have been developed in a participatory process based on the first survey experiences among selected field extension staff, and reflect the findings of several pre-test 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 is 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 step-wise 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, analyse 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, analysing 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 new 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 validator.

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 2.4: Step 2: Analysis of historical land-use and land-cover change. The pre-processing tasks ensures 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.

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 at the of the last crediting period: in 2032.

5 ENVIRONMENTAL IMPACT

Project activities under both the SALM and REDD+ components of the project will be implemented in the framework of Zambia's National Agriculture Policy (2012) and Forestry Bill (2015) frameworks respectively. The provincial agriculture and forestry offices ensure that the legal frameworks are followed.

Implementation of this project may result in environmental and social impacts in areas of operation. In addition, the impacts could either be positive or negative. Thus, this in line with both the World Bank and Zambia environmental regulations necessitated the need for COMACO to develop the Environmental and Social Management Plan (ESMP), a framework under which the project will manage both potential positive and negative impacts of the project.

Further, The ESMP proposes procedures that are practical and implementable and not unduly complicated or time-consuming. This 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. This ESMP is therefore a methodology designed to streamline appropriate steps that enhance environmental and social planning impacts in the COMACO Landscape Management project. Most specifically, the ESMP seeks to incorporate underlying principles of land and natural resource management, as well as lessons and experiences from work currently in practice in the Project area that will enhance the level of cooperation among community stakeholders to support improved protected area management.

The World Bank has set safeguard policies covering various aspects of the environment. It has been determined that this project will trigger six World Bank Safeguards Operational Policies (OPs): Environmental Assessment (OP/BP 4.01), Natural Habitats (OP/BP 4.04), Pest Management (OP/BP 4.09), Forests (OP/BP 4.36) Involuntary Resettlement (OP 4.12) and Physical Cultural Property (OPN 11.03).

In order to fulfil requirements for these policies (1) an Environmental and Social Management Plan (ESMP) which satisfies the requirements of World Bank Safeguard Policies OP/BP 4.01, OP/BP 4.04 and OP/BP 4.36, as well as (2) a Resettlement Policy Framework (RPF) to satisfy OP/BP 4.12 on Involuntary Resettlement have been prepared. These documents are attached to the PDD as supporting documentation.

In addition, the Zambia Environmental Management Agency (ZEMA) based in Lusaka is responsible for approving and monitoring the effects of proposed projects on the environment. An environmental project brief was conducted for the project and submitted to ZEMA. They approved the project. (Approval Letter is available to the validators)

The COMACO Landscape Management Project regularly participates in the GIS and REDD+ working group for Zambia with various stakeholders including government representatives and USAID.

6 STAKEHOLDER COMMENTS

The COMACO Landscape Management Project (CLMP) is working with COMACO farmers and COMACO/non-COMACO farmers to implement the project's SALM and REDD+ components respectively. Because of the long-term duration of the carbon sub-agreements and the complex nature of the CLMP, COMACO engaged various stakeholders through the Free, Prior, and Informed Consent (FPIC) process to ensure that COMACO/non-COMACO farmer, and the traditional leadership clearly understood the project before they gave their consent for participation. In order to ensure full and effective participation of the target group, COMACO engaged local government authorities, traditional leadership and villages during the FPIC process. This process accomplished three main aims:

1. Informed local government and communities (including the poor and marginalized members of society) about climate change, its effect on the environment and the critical role that CSA and forests can potentially play in mitigating and adapting against climate change;
2. Ensured that villagers had an informed view of the costs and benefits associated with the project in order for them to make informed decisions about if/how they wanted to design and implement the project
3. Provided a platform for villages to contribute to the project through the participation of village stakeholder groups in project design and the development of grievance mechanisms to address concerns raised by people.

Community wide meetings were conducted in the various areas where the project is to be implemented. These meetings were initially done with Chiefs and their advisors, and eventually community members. The concerns raised and proposals that were developed in consultation with the communities, helped to fully integrate rural people in the area into the project. After various meetings, Chiefs, community members and COMACO farmers welcomed the project and were willing to be part of the efforts to conserve natural resources in their respective areas. Furthermore, government officials at national, provincial and local level are also an integral part of the consultation process in the implementation process of the project. Their suggestions and technical advice have also been taken board to ensure effective and efficient implementation of the project.

Thus, COMACO has taken a multi-stakeholder and holistic approach in the setting up of the project for implementation.

APPENDIX: CHIEFDOMS CONSTITUTING THE OUTER PROJECT BOUNDARY

Chiefdom	District	Province
1. Chikomeni *	Lundazi	Eastern
2. Chikuwe *	Chipata	Eastern
3. Jumbe *	Mambwe	Eastern
4. Luembe *	Nyimba	Eastern
5. Magodi *	Lundazi	Eastern
6. Mwasemphangwe *	Lundazi	Eastern
7. Mwape *	Petauke	Eastern
8. Nyamphande *	Nyimba & Petauke	Eastern
9. Zumwanda *	Lundazi	Eastern
10. Chinunda	Chipata	Eastern
11. Mnukwa	Chipata	Eastern
12. Sandwe	Petauke	Eastern
13. Ndake	Nyimba	Eastern
14. Nyalugwe	Nyimba	Eastern
15. Shikabeta	Rufunsa	Lusaka
16. Mphanshya	Rufunsa	Lusaka
17. Kambombo	Chama	Eastern
18. Tembwe	Chama	Eastern
19. Mafuta	Chipata	Eastern
20. Chanje	Chipata	Eastern
21. Kalindawalo	Petauke	Eastern
22. Mbangombe	Katete	Eastern
23. Nzamane	Chipata	Eastern
24. Mpezeni	Chipata	Eastern
25. Mumbi	Petauke	Eastern
26. Msoro	Mambwe	Eastern
27. Mwanjawuntu	Petauke	Eastern
28. Nyanje	Petauke	Eastern
29. Katumba	Katete	Eastern
30. Serenje	Serenje	Central
31. Mphumba	Serenje	Central
32. Mukungule	Mpika	Muchinga
33. Nkweto	Chinsali	Muchinga
34. Mukwikile	Chinsali	Muchinga
35. Chitambo	Serenje	Central
36. Chibale	Serenje	Central

Asterisk (*) indicates chiefdoms where project activities for the first project activity instances have already begun.