Carbon removal Methodology of Mangrove Conservation Project

May, 2023

Preparation instructions

As an important part of the coastal ecosystem, mangrove plays an extremely important ecological role in regulating regional water quality, resisting storm surge, slowing down sea level rise, capturing sediment, storing carbon and storing material, and providing habitat for coastal organisms. The international community has made more and more efforts to protect mangroves. But as urbanization intensifies, the global mangrove area is still decreasing at a rate of 0.7% per year. In the context of increasingly severe global climate problems, the use of an exchange mechanism to encourage mangrove ecosystem carbon sequestration and sequestration has become an important choice for international organizations and their distribution countries to formulate strategies and paths to deal with climate change.

It is of great significance to achieve the goal of "double carbon" and to bring into play the capacity of carbon consolidation and energy exchange increase of mangrove ecosystem. In October 2021, The State Council issued the Action Plan for reaching the Carbon Peak by 2030, which mentioned that the protection and restoration of Marine ecosystems should be promoted as a whole, and the carbon sequestration capacity of mangrove forests and other ecosystems should be improved. Under the guidance of national policies, different subjects will continue to carry out mangrove protection activities in the future. In order to scientifically and reasonably measure carbon sinks generated by mangrove conservation projects, guide and standardize the preparation of domestic mangrove conservation carbon sink project design documents, effective allocation of resources and further protect mangrove ecosystem, the Mangrove Conservation Carbon Sink Project (version no. V01) is specially prepared.

This methodology is the latest version of REDD + methodology filed by the Voluntary Carbon Standards (VCS) Management Committee, Referring to the relevant modules and tools of VCS REDD + methodology, the Intergovernmental Panel on Climate Change (IPCC) National Greenhouse Gas Inventory Guide 2006 (2019 Revision) and the Guide to Land Use, Land Use Change and Good Practices in Forestry, Drawing on the Climate, Community and Biodiversity Standards (CCB) and Plan Vivo standards for the conservation of biodiversity and promoting the sustainable development of rural communities, Combined with the country's mangrove protection experience, After repeated discussion by experts, scholars and stakeholders in relevant fields. This methodology not only follows the international rules but also conforms to the forestry reality of the country, and pays attention to the scientific nature, rationality and operability of the methodology.

Compared with the existing similar methods, this methodology has the following characteristics:

1. This methodology takes into account carbon benefits, regional status and biodiversity status, and corresponds to the three sustainable development goals of

climate change, biodiversity conservation and poverty eradication proposed in the United Nations 2030 Agenda for Sustainable Development. Therefore, the carbon credit generated by the mangrove conservation carbon sink project developed based on this methodology can highlight the contribution of the project to the sustainable development of the region, be in line with the multiple goals of the country'secological civilization construction, climate change, biodiversity conservation and common prosperity, and meet the inherent requirements of sustainable development.

2. This methodology takes into account the historical contribution of mangrove conservation, reflects the ecological value of mangrove conservation activities and the contribution of the project to the coordinated implementation of the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity. Based on the actual situation of mangrove protection in the country, the starting time of the project is specified as the start date of mangrove protection activities, and the starting date of the carbon credit inclusion period is specified as after 2010 (i. e., after the beginning year of the joint implementation mechanism between UNFCCC and CCB), which can highlight the role of the project on the synergistic efficiency of the environmental convention.
3. According to the characteristics of mangrove conservation activities and the structure and composition of mangrove ecosystem, and based on the principles of operability and cost effectiveness, the process and steps of CDM, VCS and C CER forestry projects, ensuring the generalizability of this methodology.
4. This methodology collects and sorts out the research results published in domestic and foreign literature, and gives the default values of various related parameters and the regression model of the main mangrove composition tree species in the attachment for users' reference.

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1 Introduction

In order to promote mangrove protection activities with the main purpose of protecting carbon sequestration and increasing sink functions of mangrove ecosystem, To guide the quantification of multiple benefits of climate, community and biodiversity generated by domestic mangrove conservation carbon sink projects, To ensure that the combined climate, community, and biodiversity benefits generated by the project are measurable, reportable, verifiable, Strive for the advanced nature, scientific nature and operability of methodology, This methodology is based on the Intergovernmental Panel on Climate Change (IPCC) National Greenhouse Gas Inventory Guidelines 2006 (2019 Revision), and the IPCC Guide to Good Practices on Land Use, Land Use Change and Forestry (IPCC LULUCF GPG), climate, community and biological diversity alliance (CCBA) development project design standards (CCB), climate organization (CG), international emissions trade union (IETA) and the world economic forum (WEF) jointly developed the mangrove conservation reduction standards (VCS) and the United Nations framework convention on climate change (UNFCCC) on the clean development mechanism (CDM) under the degraded mangrove habitat afforestation reforestation methodology (AR-AM0014, V3.0) and the research and analysis of its tools, Combined with the work practice and experience of mangrove protection in the country, After repeated discussion by experts and scholars and stakeholders in relevant fields.

This methodology refers to the following methodological, guidelines, and methodological tools:

（1） I PCC 2006 (2019 Revision)

（2） I PCC A Guide to Land Use, Land Use Change and Good Forestry Practices (IPCC, 2003)

（3） C CBA Design Standards for Climate and Community and Biodiversity Project (CCBA, 2013)

（4） VCS R EDD + Methodological Framework (VM0007, V 01.6)

（5） VMD0001-CP-AB: Estimation of above-ground and below-ground biomass carbon reserves in woodland and without woodland (CP-AB)

（6） VMD0006-BL-PL: Estimation of baseline carbon reserve changes and greenhouse gas emissions from planned deforestation and forest degradation (BL-PL)

（7） VMD0007-BL-UP: Estimation of greenhouse gas emissions from unplanned logging (BL-UP)

（8） VMD0042-BL-PEAT: Estimation of baseline soil carbon reserves changes and greenhouse gas emissions during peat land rewetting and conservation project activities (BL-PEAT)

（9） VMD0046-M-PEAT: Monitoring of soil carbon reserve changes and greenhouse gas emissions and clearance during peatland rewetting and conservation project activities

（10） VMD0004-CP-S: Estimation of soil organic carbon reservoir reserves (CP-S)

（11） VMD0016-X-STR: Stratification approach within the project area (X-STR)

（12） VMD0002-CP-D: Estimation of carbon reserves of dead wood carbon bank (CP-D)

（13） VT0001 ADD-RAM: A VT0001 tool for demonstrating and evaluating additional in VCS agricultural, forestry and other land use (AFOLU) project activities

（14） Methodology of reforestation in degraded mangrove habitats of CDM (AR-AM0014, V03.0)

（15） CDM project Basbaseline determination and additional tool for project activity (V 01, EB 35)

（16） Estimation tool for active carbon reserves of trees and shrubs and their change in CDM project (V04.2, EB 85)

（17） Estimation tool for carbon reserves of dead wood and litter in CDM project (V 03.1 EB 85)

（18） Estimating tool for the non-carbon dioxide greenhouse gas emissions resulting from active biomass combustion in the CDM project (V04.0, EB 65)

2 Applicable conditions

This methodology applies to the project activities with the main purpose of protecting the mangrove ecosystem, avoiding the carbon emission and biodiversity reduction caused by the reducing/degrading mangrove areas, as well as revitalizing the rural areas. The applicable conditions include:

（a） The project activities shall comply with the laws, regulations, policies and measures concerning mangrove protection promulgated by the national and local governments, as well as the relevant technical standards or regulations;

（b） The land ownership of the project activities shall be clear, with ownership certificate issued by the people's government at or above the county level;

（c） In the absence of project activities, some or all of the mangrove areas within the project boundary would change in land type;

（d） Project activities will not cause the transfer of activities in the project area prior to the project start;

（e） Project activities will not remove dead trees, tree roots and fruits;

In addition, other applicable conditions contained in this methodology must be met when applying this methodology.

3. Normative references

This methodology follows the provisions of the national documents.

4 Definition

The relevant terms used in the methodology are defined as follows:

Mangrove

Wetland woody plant communities with mangrove plants as the main body growing in the coastal intertidal zone between land and sea or the river estuary where the sea tide can reach, include both single species mangrove and mangrove community with multiple species.

Baseline scenario

An assumed scenario that reasonably represents the most likely future land use and management in the project area in the absence of a forestry carbon sink project.

Project scenario

The use and management scenario occurs within the project boundary with project activities.

Project boundary

The geographical scope of the carbon sink project activities implemented by the project participants or other project participants with land ownership or land use right. A project activity can be conducted on several different plots, but each plot should have specific geographic boundaries. These boundaries does not include wetlands located between two or more plots.

Crediting period

The time interval in which additional GHG emissions reductions generated under project scenario relative to the baseline scenario.

Baseline carbon removal by sinks

The sum of changes in carbon stocks in each carbon pool within the project boundary subtracts the increase amount of greenhouse gas emissions within the project boundary due to land use changes under the baseline scenario.

Project carbon removal by sinks

In the project scenario, the variation in carbon stocks in the selected carbon pool within the project boundary subtracts the increase in greenhouse gas emissions within the project boundary caused by the proposed carbon sink project activities.

Leakage

A measurable increase in greenhouse gas source emissions that occur outside the project boundaries caused by the proposed project activities.

Project emission reduction

The net carbon removal generated by the proposed project activities. The project emission reduction is equal to the project carbon removal minus the baseline carbon removal, and then minus the leakage amount.

Additionality

A situation where the project carbon removal is higher than the baseline carbon removal, and the additional carbon removal would not have been generated without the proposed project activity.

Carbon pool

During the carbon cycle, mangrove ecosystems store the various components of carbon, including above-ground living biomass, below-ground biomass, litter, dead wood and soil organic carbon.

Above-ground biomass

The biomass of various organs of living mangrove plants above the soil layer, including trunks, stems, branches, aerial roots, barks, flowers, fruits, seeds and leaves.

Below-ground biomass

The biomass of all living mangrove plants below the soil layer, but usually does not include fine roots (2.0 mm in diameter) that are difficult to distinguish from soil organic components or litter.

Litter

All dead biomass above soil layer in different decomposition states with diameter less than 5.0cm, including litter, humus, and fine roots that are difficult to distinguish from below-ground biomass.

Dead wood

All dead biomass above the soil layer except for litter, including dead standing wood, dead log, dead branches, dead roots and stumps ≥5.0cm in diameter.

Soil organic matter

Organic matter in mineral and organic soils (including peat soils) at a given depth (usually 1.0 m), including fine roots that are difficult to distinguish from subsurface biomass..

Climate change response community

It refers to the community formed by the interrelated groups of people who may be affected by the project activities and its activity area within the project boundaries.

5 Baseline and carbon metering method

5.1 Determination of the project boundaries

The "project boundaries" of mangrove conservation project activities can be determined by one of the following methods:

(a) Taking the advantage of the Global positioning system (GPS), Beidou navigation Satellite system (Compass) or other satellite navigation systems, use single point positioning or differential technology to directly determine the inflection point coordinates of the boundary of the project plot, and the positioning error should be lower than 5 meters.

(b) Use high-resolution geospatial data (eg. satellite images, aerial photos, mangrove distribution map, etc.) to directly read the boundary coordinates of the project plot directly read with the aid of geographic information system (GIS).

The post-project boundary can be performed by the above method (a) or (b), and the area measurement error shall not exceed 5%.

During the project validation and verification, the project participant shall submit the vector graphics file of the project boundary produced by the Geographic Information System (GIS). During the validation of the project, the project participants shall provide evidence of the ownership or use right of two-thirds or more of the project (mangrove) land. In the first verification, the project participant shall provide the evidence of the land ownership or use right of all the project lands, like the land ownership certificate issued by the people's government at or above the county (including county) level or other valid certification materials.

5.2 Carbon pools and greenhouse gas emission sources

The carbon pool selection of project activities is shown in Table 5-1. Above-ground and below-ground biomass carbon pools are the carbon pools that must be selected. The carbon pool of mangrove litter is affected by tidal flow, so it has a high turnover rate. And the protection activities will not reduce the accumulation rate of litter. As a result, the carbon pool is conservatively neglected. In addition, the implementation of the project activities will increase the soil organic carbon pool, neglecting the carbon pool is also in line with the conservative principle. What's more, project participants can choose whether to neglect the dead wood carbon pool according to the principles of availability, cost effectiveness and conservatism of actual data.

Table 5-1 Selection of carbon pools

Carbon pool	Whether to select	Reason or explanation
Above-ground Biomass	yes	The main carbon pool that produces carbon removals by sinks
Below-ground biomass	yes	The main carbon pool that produces carbon removals by sinks
Dead wood	optional	Project participants can selectively measure the carbon pool; Depending on the applicable conditions of the methodology, the implementation of the project activities will increase this carbon pool, or the project participants may choose to neglect this carbon pool in accordance with the conservative principle of emission reduction calculations.
Litter	no	Tidal currents cause high turnover rate and displacement of litter, and project activities do not reduce the accumulation rate of litter. So selectively ignoring this carbon pool does not lead to overestimation of project emissions reductions.
Soil organic carbon	no	The implementation of the project activities will increase this carbon pool according to the applicable conditions of the methodology, and it is conservative to neglect this carbon pool.

Greenhouse Hemission emissions within project boundaries are shown in Table 5-2:

Table 5-2 Selection of greenhouse gas emission sources

Scenario selection	GHG emission source	Gas	Whether to select	Reason or explanation
Baseline scenario	Land use change	CO_2	optional	Turning mangroves into other land use within the project boundary would result in carbon emissions, according to applicable conditions of the methodology. In order to avoid overestimating the emission reduction, only the emissions generated by changing the mangrove to other land types should be calculated. The emissions from human activities after the conversion are not measured,but can be optionally measured by the project participants.

				Project participants may also choose, more conservatively, not to calculate this emission.
	Mangrove ecosystem	CH_4	yes	Microorganisms in mangrove ecosystems perform anaerobic decomposition of soil organic matter and release methane.
Project scenario	Natural hazard	CO_2	no	CO_2 emissions caused by natural hazards such as tsunami, insect attack emissions have been considered in carbon stock changes.
	Mangrove ecosystem	CH_4	yes	Microorganisms in mangrove ecosystems perform anaerobic decomposition of soil organic matter and release methane.

5.3 Project duration and crediting period

The project participant or other project participants must accurately state the start time, crediting period and project duration of the project activities, and explain the reasons for the choice.

The start time of the Mangrove Conservation Carbon Removal Project is the date of initiating mangrove conservation performance. The project participants shall provide transparent and verifiable evidence that the main purpose of the project activities is to protect the ecosystem service function of the mangroves and achieve the local sustainable development goals.

The crediting period is the time period in which project activities generate additional GHG emissions reductions, biodiversity conservation, and promote community development benefits against climate change relative to the baseline scenario. Crediting period of projects applying this methodology should not start earlier than 2010. The minimum crediting period is 20 years, and the maximum crediting period should not be more than 60 years.

Project duration refers to the interval between the start date and the end date of the mangrove conservation carbon removal project activity.

5.4 Baseline scenario identification and additionality demonstration

The identification of baseline scenarios of mangrove conservation carbon removal project activities should base on principles of transparency and conservatism to determine the baseline carbon removal amount, community development status and biodiversity status.

The project owner or other project participants shall provide all data, principles, assumptions, reasons and texts related to the baseline scenario identification and additionality demonstration (e. g., approval of the relevant official documents, original data sets using the model for simulation prediction, etc.), which shall be evaluated by an independent third party. The project owner or other project participants may choose the following simplified method to identify the baseline scenario of the mangrove conservation carbon removal project activities and demonstrate its additionality. For projects with an average annual emission reduction of less than 60000 tCO_2 equivalent, no additionality demonstration is required.

5.4.1 Baseline scenario

As this methodology provides in the applicable conditions, mangroves within the project boundary will be progressively converted to other land types in absence of the project activities. Therefore, the methodology assumes that the baseline scenario for a mangrove conservation carbon sink project is a land use scenario that converts to other non-mangrove forests (including construction land, arable land, aquaculture facilities and other non-mangrove land types). Project participants can conduct baseline scenario identification through the following methods from good to inferior:

Project participants can select areas with similar socio-economic and ecological conditions to the project area as control areas. The change of land use pattern in the control area is taken as the change of land use pattern in the project area under the baseline scenario to determine the reduction or degradation rate of mangrove forest and the change to other land types under the baseline scenario. The selection of control areas may not be limited by the area factor. The specific methods are as follows:

a、 Collect Landsat TM/ETM/OLI remote sensing images as well as raster and vector datasets of land use types in the control area to reflect the historical land use situation in the control area. The remote sensing monitoring database of land use status can be selected as the data source (the database is currently the most accurate remote sensing monitoring data product of land use).;

b、 Analyze and treat the collected multi-period historical land use data obtained by the land use transfer matrix method, then obtain the change of the area transformation between different regions;

c、 Based on the analyzed and processed historical data, use the appropriate model (such as CLUE-S, CA-Markov, GeoSOS, FLUS, etc.) to predict the type and area of mangrove areas into other land types in the future.

Project participants can also identify land use situations that may occur within the project boundaries in the absence of the proposed mangrove conservation carbon removal project activities through relevant policy documents such as territorial spatial planning and ecological conservation redlining.

In the case where the relevant information is limited, the project participants can also identify the possible land use situations based on local land use records, field survey data, data and feedback from stakeholders, etc. It is also an option that interviewing local experts and surveying landowners or users about their plans for land management or land investment during the operation of the proposed project. From the above identified land use situations, select those do not violate any existing laws and regulations, other mandatory provisions, and national or local technical standards

5.4.2 Additionality

This methodology uses an activity method for the demonstration of additionality of tidal wetlands conservation and restoration project activities. For such project activities, use Module VDM0052 Demonstration of Additionality of Tidal Wetland Restoration and Conservation Project Activities.

5.5 Stratification

The distribution of carbon biomass is often not homogeneous. In order to improve the accuracy of carbon accounting and reduce the cost, the project area needs to be stratified. Stratification is divided into "pre-stratification" and "post-stratification", in which pre-stratification is divided into "pre-project baseline stratification" and "pre-project project stratification".

"Pre-project baseline stratification" can be stratified according to the major vegetation type, vegetation canopy cover, or land use type.

"Pre-project project stratification" is mainly divided according to the constituent tree species and life-forms."Post-project stratification" is mainly based on the actual situation of natural or human disturbance occurring within the boundaries of project activities. If there is a significant change in the heterogeneity of the project due to natural or human disturbance or other causes, the post-project stratification should be adjusted accordingly.

5.6 Baseline scenario

5.6.1 Baseline carbon removals by sinks

The carbon removals by sinks in baseline scenario of the mangrove conservation carbon removal project should mainly consider the changes of forest biomass, shrub biomass, vine biomass and carbon stocks of dead wood carbon pool in the mangrove ecosystem under the baseline scenario. The carbon removals should also consider the increase in greenhouse gas emissions from the degradation, reduction or even disappearance of mangroves due to land use change (conversion of mangroves to arable land, construction land and other land types), as well as the increase in greenhouse gas emissions produced from the mangrove ecosystem itself. The carbon removal calculation method of baseline scenario is shown in Annex 1.

5.6.2 Climate change response community status under baseline scenario

The descriptions of the situation of the climate change response community in the baseline scenario and the investigation methods are shown in Table 5-3.

Table 5-3 Description of community status

Status assessment elements	Describe the content and its survey methods

Status of climate change response communities in and around the project	Using participatory village assessment and livelihood framework to investigate and assess the situation of climate change response communities in and around the project area, including the basic information of residents in the project area, such as population size, age structure, family structure, gender ratio, educational background, annual income and source, and expenditure use. It also provides information on the types, distribution and extent of resources currently used or potentially used by residents of the project area to address climate change.
Land use and ownership status of the project land before the implementation of the project	Investigate and describe the land use situation of the project site and the land ownership, use right and use period.
The impact of wildlife on the climate change response community before the project began	Investigate and describe the impact of wildlife on the climate change response community in and around the project area in terms of economic development and personal safety.

5.6.3 Biodiversity status of the baseline scenario

Describe the state of biodiversity involved in the project activities under the baseline scenario. The description contents and survey methods are shown in Table 5-4.

Table 5-4 Biological assessment indicators for baseline scenarios

Status description elements	Describe the content and its survey methods
The survival status and threats of wildlife in the project area before the project began	Use key species habitat analysis, channel analysis and other methods are applied to describe the survival status of wildlife within the project boundary and its threats before the start of the project.
Within the project area, species listed on the IUCN Red List of Threatened Species (including endangered and vulnerable species), as well as species listed on the list of rare and endangered species under national and local protection	Conduct endangered species surveys. Existing historical documents and scientific research results can be used to conduct literature research and field interviews to investigate whether the project area has been listed in the IIUCN Red List of Threatened Species or listed as a rare and endangered species under national and local key protection before the project starts.
What factors will threaten the biodiversity of the project area in the baseline scenario	Through collecting historical documents, field interviews, and aerial images, we investigate, for example, the following threats to biodiversity in the project area: A Residential and commercial development: investigate the situation and scope of land for commercial service industry, industrial and mining land, residential land, public administration and public service land, special land and transportation land;

	b Energy production and mining: Surveys of mining, quarrying, oil and gas drilling and exploration; C Biological resource utilization: investigate human utilization and gathering for the purposes of business, entertainment and research; d Human disturbance: investigate recreational activities (tourism, camping, carrying pets, etc.), military drills, etc. E Changes in natural ecosystem: fire situation, dam construction and use condition, etc. According to the actual situation, project participants may also carry out an investigation on the introduction of alien invasive species, and investigate whether the site of the project has been included in the list of alien invasive species, quarantine pests, dangerous pests or other pest lists , international organizations, other countries or regions. At the same time, all possible ways of introducing alien species in the social and economic activities of the project area are investigated, including the introduction, production, processing, management, import and export of alien species, as well as other trade, transportation and tourism.
Overall assessment of biodiversity within the project area in the baseline scenario	Use species richness and diversity, landscape connectivity, habitat fragmentation, habitat and its diversity to evaluate the biodiversity status in the project area under the baseline scenario.

5.7 Project Scenario

5.7.1 Scenario carbon removal amount of the project

The project carbon removal equals to the sum of changes of carbon stocks in carbon pools within the project boundary minus the increase in greenhouse gas emissions generated within the project boundary. Under the project scenario, the greenhouse gas emission of mangroves within the project boundary is mainly the increase of greenhouse gas emission produced by the methane emission of mangrove ecosystem itself. See Annex 2 for the specific calculation method of the project's carbon sink amount.

5.7.2 Leakage

According to the applicable conditions of this methodology, the project activities will not result in the diversion of future land use patterns within the project boundaries, and also do not include the emissions caused by the use of transport vehicles and fuel oil machinery in the project activities. Therefore, under this methodology there is no potential leakage, i.e. LK_t=0, where LK_t is the leakage generated by project activities in year t.

5.7.3 Project Emission reduction

The project emission reduction is equal to the project scenario carbon sink minus the baseline scenario carbon sink, and then minus the leakage. See Annex 3 for the calculation method of the project emission reduction.

5.7.4 Assessment on status of climate change response communities under project scenario

The project should have a positive economic impact on the society and economy of the communities involved in the project activities during its operational life. The wishes and difficulties of local climate change communities and other stakeholders should be taken into account during the project design phase, and the corresponding solutions should be reflected in the design plan. In addition to completing the following basic indicators, project owners can also conduct capacity building and further develop training programs for community personnel in the communities to improve the ability of community residents to participate in and understand the project. The indicators of the assessment of climate change response communities under project scenarios are shown in Table 5-5. The project owner can use the investigation method of participatory village assessment or semi-structured interview to carry out the investigation of residents' management ability in the project area, the investigation of residents' right to know, the investigation of women's rights, the investigation of key person interview and other necessary investigations to prove that the project activities meet the following indicators.

Table 5-5 Community assessment assessment on climate change

Basic indicators	Extra indicators

Project activities will bring net benefits to the climate change communities, which improving the local social and economic conditions.	Capacity building targets a wide range of groups within climate change communities.
Compared to the baseline scenario, the implementation of the project alleviates the factors limiting the economic development of communities addressing climate change.	Capacity-building targets women and promotes their participation.
Detailed description of the participation of local stakeholders in the project design.	Capacity building has strengthened the participation of communities on climate change.
Develop standardized management measures to deal with conflicts and opinions during project design and implementation.	The project design fully understands the local customs, and the related project activities are compatible with the local customs.
Identified the potential negative impact the project may have on climate change communities outside the project area.	Local stakeholders will receive all jobs (including management positions) generated by the project activities.
The project plan is developed to reduce the negative impact on the climate change response communities outside of the project area.	The participants of the project have clearly informed the employee of their rights, and these rights do not violate the relevant laws and regulations.
If the negative social and economic impact on the project area that cannot be alleviated, demonstration materials are provided to compare the positive impact of the project in the project area, and prove that the impact of the project on the society and economy is positive.	It comprehensively evaluates the environment and occupations that pose risks to employee safety and explicitly informs the employee of possible risks and explains how the risks will be minimized.

After the project is implemented, the impact of the project in responding to climate change in the community is rated. According to the number of indicators achieved by the project, the project is divided into four levels: excellent, good, qualified and basically qualified:

Excellent: complete all the basic indicators, and complete more than 4 extra indicators.

Good: complete all the basic indicators, and complete 1-4 extra indicators.

Qualified: only complete all the basic indicators.

Basically qualified: have not completed all the basic indicators.

5.7.5 Assessment on biodiversity status under project scenario

During its operational life, the project must have a positive impact on biodiversity within the project boundaries compared to the baseline scenario. The project shall qualitatively describe and take necessary measures to mitigate the possible negative impacts on biodiversity outside the project boundaries, i.e. the reduction of biodiversity outside the project boundaries as a result of the implementation of project activities. In addition to the following basic indicators, compared to the baseline scenario, the project should also improve the efficiency of soil and water conservation, enhance the quality of the stand, and repair the broken biogenic environment. The assessment indicators of biodiversity status under the project scenario are shown in Table 5-6. Project participants may undertake the necessary biodiversity status surveys using appropriate methodologies to demonstrate that project activities meet the following indicators.

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Table 5-6 The biodiversity status of the project

Basic indicators	Extra indicators
Biodiversity increased after the project implementation compared to the baseline scenario	Only native species are used in the project activities, or any alien species used in the project could be demonstrated to be superior to native species in terms of biodiversity benefits
Project activities contribute to the mitigation of endangered flora and fauna in the project area compared to the baseline scenario.	The project activities effectively reduce the harm of foreign invasive species
The potential negative effects of the project on biodiversity outside the project boundary are identified.	Project activities can enhance the soil and water conservation in the project area.
Project develops plans to reduce the negative impact on biodiversity outside the project boundaries.	Project activities can help to enhance the forest stand quality of the project area.
If there is an irreducible negative impact on biodiversity outside the project area, evidence can be provided to prove that the project has a positive impact on biodiversity conservation compared with the biodiversity benefits generated by the project within the project area.	Describing project implementation facilitates restoration of fragmented habitat and enhanced landscape connectivity.

After the project is implemented, the methodology will rate the impact of the project on biodiversity. According to the number of indicators achieved by the project, the project is divided into four levels: excellent, good, qualified and basically qualified:

Excellent: complete all the basic indicators, and complete more than 2 extra indicators.

Good: complete all the basic indicators, and complete 1-2 extra indicators.

Qualified: only complete all the basic indicators.

Basically qualified: have not completed all the basic indicators.

5.7.6 Project evaluation

Projects are classified into the following types based on their climate change response community benefits and biodiversity benefits (see Table 5-7). Projects are classified into four categories, A, B, C, and D, based on the scores of the assessment of the status of climate change response communities and biodiversity status after the implementation of the project.

Table 5-7 Evaluation of item categories

Biodiversity / climate change response communities	Excellent	Good	Qualified	Basically qualified
Excellent	Class A project	Class B project	Class C project	Class D project
Good	Class B project	Class B project	Class C project	Class D project
Qualified	Class C project	Class C project	Class C project	Class D project
Basically qualified	Class D project	Class D project	Class D project	Class D project

6 Monitoring procedures

In the preparation of the project design document, the project participants must develop a detailed monitoring plan, provide monitoring reports and verify all necessary relevant supporting materials and data. Unless otherwise specified in the monitoring data/parameter table, comprehensive monitoring and measurement shall be carried out according to the relevant criteria. All data collected during the monitoring must be archived in electronic and paper form until at least two years after the end of the crediting period.

6.1 Monitoring of carbon benefits

6.1.1 Monitoring of the baseline carbon sink volume

Baseline carbon removals are determined by ex ante measurement during the preparation of project design documents. Once the project is validated, it is valid during the project crediting period, so there is no need to monitor the baseline carbon removals.

6.1.2 Monitoring of project boundaries

(1) Any boundary changes should adopt the Global Positioning System (GPS), Beidou navigation Satellite system (Compass) or other satellite navigation systems to conduct single point positioning or differential technology to directly determine the inflection point coordinates of the project land boundary. High-resolution geospatial data (such as satellite images and aerial photos) can also be used to directly read the boundary coordinates of the project plot with the aid of Geographic Information system (GIS). Describe the coordinate system used and the accuracy of the instruments used in the monitoring report;

(2) Check whether the actual boundary coordinates are consistent with the boundaries described in the project design document;

(3) If the actual boundary is located outside the boundary described in the project design document, the part located outside the boundary identified in the project design document will not be included in the monitoring scope;

(4) If the actual boundary is within the boundary described in the project design document, the actual boundary shall prevail;

(5) Enter the measured inflection point coordinate or project boundary into the geographic information system to calculate the area of the project plot and each carbon layer;

(6) The project boundary shall be monitored regularly during the crediting period, and if there is any change in the project boundary, like deforestation, the geographical coordinates and area of deforestation shall be determined and explained in the next verification. Deforestation plots will be removed outside the project boundary,

and will not be monitored later, and can not be re-included in the project boundary again. However, if these plots have been checked before moving out of the project boundary, the previously verified carbon stocks should remain unchanged and be included in the calculation of carbon stock changes.

6.1.3 Strata renewal

During the execution of the project, the pre-project stratification or strata of the last monitoring period needs to be updated at each monitoring period due to the following reasons:

(1) Unpredictable disturbance may occur during the crediting period, thus increasing the variability within the strata;

(2) Land use change occurs (the project land is converted into other land use type);

(3) Past monitoring has found variability in carbon stocks of strata;

(4) The strata assigned by pre-project stratification or stratified at the last monitoring period may no longer exist.

6.1.4 Sampling design

The method requires 90% accuracy at 90% reliability level. If the accuracy of the measurement is lower than this value, the project participant can increase the number of sample plots to make the measurement result meet the accuracy requirements. The calculation method for the number of plots required for project monitoring is shown in Annex 4.

6.1.5 Plot setting

Project participants are required to measure and estimate changes in carbon stocks in the relevant carbon pool by using the carbon stock change method based on the continuous measurement of fixed sample plots. In the strata of each project, the spatial distribution scheme of random starting point and systematic layout is adopted.

To avoid marginal effects, the plot edge should be at least 10m away from the plot boundary. Rectangular or circular plots can be used to measure and monitor changes in carbon stocks within project boundaries. The horizontal area of the sample plot is 100-600m^2. In the same mangrove conservation carbon removal project, all sample plots shall have the same area.

The selected plots shall ensure that the mangrove protection activities within the plots are completely same with those outside the plots within the project boundary, and that the plots are evenly distributed within the strata as far as possible.

6.1.6 Monitoring Frequency

The first monitoring is carried out before the project starts, and the first verification is carried out simultaneously with the validation. After the project starts, the mangrove ecosystem carbon stocks will be monitored every five years, and the monitoring frequency can be increased when unexpected or occasional events occur, such as strong tropical storms, rapid sea level rise or land use changes.

6.1.7 Determination of biomass carbon stocks of the tree

See Annex 5 for the determination of the carbon stocks of biomass in the forest.

6.1.8 Determination of carbon stocks of shrub biomass

The shrub biomass carbon stocks and their changes within the project boundary are estimated during the pre-project phase of the project. According to the principle of conservatism and cost-effectiveness, the project participants can choose not to monitor them. However, if the project activity or project boundary changes, the project participants shall recalculate the shrub biomass carbon stocks and their changes within the project boundary and adopt the default method of pre-project measurement according to the adjusted project boundary and post-project stratification. Project participants may also conduct field monitoring using the method of Annex 6.

6.1.9 Determination of carbon stocks of vine biomass

Vine biomass carbon stocks and their changes within the project boundary are estimated during the ex ante estimation. According to the principle of conservatism and cost-effectiveness, the project participants can choose not to monitor them. However, if the project activity or project boundary changes, the project participants should recalculate the biomass carbon stocks within the project boundary and the change according to the adjusted project boundary and post-project stratification. Project participants can also choose to actually measure vine biomass carbon stocks, see Annex 7.

6.1.10 Determination of carbon stocks of dead wood biomass

For the determination of dead wood biomass carbon stocks within the project boundary, project participants may choose to multiply the measured results of tree biomass carbon stocks by default factors to determine, also can choose and measure the estimated biomass carbon stocks of dead wood. When taking actual measurement, dead standing wood and dead downed wood should be measured and calculated respectively (for the wood stumped by the roots, it should be calculated as dead standing wood). See Annex 8 for the specific monitoring method.

6.1.11 Accuracy control and correction

The methodology requires that carbon stocks be determined with 90% accuracy at a 90% reliability level..

If the uncertainty of the measurement is greater than 10%, the project participants can increase the number of samples to achieve the accuracy of the measurement results. Project participants can also choose the following discount method.

If $\Delta C_{PROJ,t} > 0$, then $\Delta C_{TOTAL,t} = \Delta C_{PROJ,t} \cdot (1 - DR)$

If $\Delta C_{PROJ,t} < 0$, then $\Delta C_{TOTAL,t} = \Delta C_{PROJ,t} \cdot (1 + DR)$

In the formula:

$\Delta C_{TOTAL,t}$ = In year t, the estimated annual variation of carbon stocks of the selected carbon pool within the project boundary; $tCO_2e\ a^{-1}$

$\Delta C_{PROJ,t}$ =In year t, the annual variation of carbon stocks of the selected carbon pool within the project boundary; $tCO_2e\ a^{-1}$

DR= Reduction factors based on the uncertainty of monitoring results, as shown in Table 6-1

Table 6-1 Deduction rate

Uncertainty (%)	DR(%)
≤10%	0%
> 10% and ≤20%	6%

> 20% and ≤30%	11%
>30%	Increase the number of monitoring plots

6.2 Monitoring of community impacts on climate change

Project participants must develop an initial monitoring plan to quantify and record changes in social and economic conditions caused by project activities (both inside and outside the project boundaries). The monitoring plan should indicate the data to be measured and collected, as well as the sampling method to be used.

The project must develop an initial plan for how to select the climate change response community and frequency of monitoring. Potential variables include income, health, roads, schools, food security, and education. Variables about climate change response community that are negatively affected by project activities should also be monitored.

6.3 Monitoring of biodiversity

Project participants must develop an initial monitoring plan to quantify and document changes in biodiversity within and outside the project boundaries resulting from project activities. The monitoring plan should clearly state the data to be measured and collected, as well as the sample survey method to be used.

The project must develop an initial plan on how to select the biodiversity indicators and monitoring frequencies. Potential indicators include species richness and diversity, landscape connectivity, forest fragmentation status, habitats and their diversity. Other biodiversity indicators that are negatively affected by project activities should also be monitored.

6.4 Data and parameters not requiring monitoring

Data and parameters need not to monitor are shown in Annex 9.

6.5 Data and parameters required to be monitored

Data and parameters need not to monitor are provided in Annex 10.

7 Sustainable development of carbon credit accounting

According to the project evaluation results, the project emission reduction is adjusted according to the conversion coefficient of Table 7-1 to obtain the sustainable development carbon credit ($\Delta C_{SD,t}$), The calculation method is performed as follows:

If the project is a class A project, the emission reduction of the project will not be adjusted, namely: $\Delta C_{SD,t} = \Delta C_{NET,t}$

If the project is a class B project, the project emission reduction will be deducted by 1%, namely: $\Delta C_{SD,t} = \Delta C_{NET,t} - \Delta C_{NET,t} * 0.01$

If the project is a class C project, the project emission reduction will be deducted by 5%, namely: $\Delta C_{SD,t} = \Delta C_{NET,t} - \Delta C_{NET,t} * 0.05$

If the project is a class D project, the project emission reduction will be deducted by 10%, namely: $\Delta C_{SD,t} = \Delta C_{NET,t} - \Delta C_{NET,t} * 0.1$

Table 7-1 Conversion coefficient

Project level	Conversion coefficient
Class A	1
Class B	0.01
Class C	0.05
Class D	0.1

8 Annex

8.1 Annex1 Baseline carbon removal calculation method

This annex corresponds to Section 5.6.1 of the main text.

$\Delta C_{BSL,t} = \Delta C_{BIO\_BSL,t} - GHG_{BSL,t}$		Equation(1)
$\Delta C_{BIO\_BSL,t} = \Delta C_{TREE\_BSL,t} + \Delta C_{SHRUB\_BSL,t} + \Delta C_{VINE\_BSL,t} + \Delta C_{DW\_BSL,t}$		Equation(2)
Where：		
$\Delta C_{BSL,t}$	=	Baseline carbon removals in year t；tCO_2-e·a^{-1}
$\Delta C_{BIO\_BSL,t}$	=	annual variation of baseline mangrove biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{TREE\_BSL,t}$	=	annual variation of baseline tree biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{SHRUB\_BSL,t}$	=	annual variation of baseline shrub biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{VINE\_BSL,t}$	=	annual variation of baseline vine biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}

$\Delta C_{DW\_BSL,t}$	=	annual variation of baseline dead wood biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$GHG_{BSL,t}$	=	Increase of GHG emissions within the project boundary under the baseline scenario in year t；tCO_2-e·a^{-1}

8.1.1 Variation of baseline mangrove tree biomass carbon stocks

Assuming that the changes of tree biomass in each strata under the mangrove baseline scenario in a period(1 to 2 years) are linear, the changes are estimated using the "carbon stock change method". The calculation method is as follows：

$\Delta C_{TREE\_BSL,t} = \sum_{i=1} \Delta C_{TREE\_BSL,i,t}$		Equation(3)
$\Delta C_{TREE\_BSL,i,t} = \sum_{i=1} \left(\frac{C_{TREE\_BSL,i,t_2} - C_{TREE\_BSL,i,t_1}}{t_2 - t_1} \right)$		Equation(4)
Where：		
$\Delta C_{TREE\_BSL,t}$	=	annual variation of baseline tree biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{TREE\_BSL,i,t}$	=	annual variation of baseline strata i of tree biomass carbon stocks in year t；tCO_2-e·a^{-1}
$C_{TREE\_BSL,i,t}$	=	tree biomass carbon stocks of baseline strata i in year t；tCO_2-e
t_1, t_2	=	Baseline scenario year t_1 and year t_2，$t_1 \le t \le t_2$
i	=	1,2,3……the number of project strata
t	=	1,2,3……the number of years since the project began；a

The calculation method of mangrove tree biomass carbon stocks is converting the tree biomass into carbon content by using the carbon content rate, then using molecular weight ratio of CO_2 to C(44/12)to convert carbon content(tC)to carbon dioxide equivalence(tCO_2-e)：

$C_{TREE\_BSL,i,t} = \frac{44}{12} * \sum_{j=1} (B_{TREE\_BSL,i,j,t} * CF_j)$		Equation(5)
Where：		
$C_{TREE\_BSL,i,t}$	=	tree biomass carbon stocks of baseline strata i in year t；tCO_2-e
$B_{TREE\_BSL,i,j,t}$	=	Biomass of tree species j in baseline strata i in year y；td.m.
CF_j	=	Carbon content rate of tree species j biomass；tC·$(td.m.)^{-1}$
i	=	1,2,3……strata i of the baseline
j	=	1,2,3……species j in strata i of the baseline

Project participants may choose to use one of the following best to worst methods to estimate the biomass of tree species j the baseline strata i in year t：

Method I: Biomass equation

The project participants may estimate the biomass of tree species j in the baseline strata i in the year t ($BTREE\_BSL,i,j,t$)according to the biomass equation. The calculation method is as follows:

Under the estimated baseline scenario, considering the diameter at breast heigh (DBH), tree height (H) and wood density (ρ) of tree species j in strtata i in different year during the crediting period, the biomass should be calculated by using the biomass equation.

$B_{TREE\_BSL,i,j,t} = f_{AB,j}\left(DBH_{TREE\_BSL_{i,j,t}} H_{TREE\_BSL_{i,j,t}} \rho_j\right) * \left(1 + R_j\right) * N_{TREE\_BSL_{i,j,t}} * A_{BSL_i}$		Equation(6)
Where：		
$B_{TREE\_BSL,i,j,t}$	=	Biomass of species j in baseline strata i in year t；td.m.
$f_{AB,j}(DBH, H, \rho)$	=	Applicable equation of above-ground biomass and DBH, tree height and wood density of species j；td.m per plant
$DBH_{TREE\_BSL_{i,j,t}}$	=	DBH of species j in baseline strata i in year t；cm
$H_{TREE\_BSL_{i,j,t}}$	=	Height of species j in baseline strata i in year t；cm
ρ_j	=	Wood density of species j；g/cm^3
R_j	=	Ratio of below-ground biomass to above-ground biomass of species j；non-dimensional
$N_{TREE\_BSL_{i,j,t}}$	=	Number of plants per hectare of species j in baseline strata i in year t; per hm^2
A_{BSL_i}	=	Area of baseline strata i；hm^2
i	=	1,2,3……baseline strata i
j	=	1,2,3……species j in baseline strata i
t	=	1,2,3……the number of years since the project began；a

If species j whose above-ground biomass equation selected according to the above method does not include the measurement of respiratory root biomass, the respiratory root biomass can be calculated separately according to the following method. The calculation result can be added to Equation (6) to obtain the whole plant biomass of the species:

$B_{AR\_BSL,i,j,t} = f_{AR,j}(h) * N_{AR\_BSL_{i,j,t}} * A_{BSL_i}$		Equation(7)
Where：		
$B_{AR\_BSL,i,j,t}$	=	Respiratory root biomass of species j in baseline strata i in year t；td.m.
$f_{AR,j}(h)$	=	Allometric equation of respiration root biomass and respiration root height of species j；td.m per plant
h	=	Height of respiration root of species j；cm
$N_{AR\_BSL_{i,j,t}}$	=	Average number of respiration roots per hectare species j in baseline strata i in year t；per hm^2
A_{BSL_i}	=	Area of baseline strata i；hm^2
i	=	1,2,3……baseline strata i

j	=	1,2,3……species j in baseline strata i
t	=	1,2,3……the number of years since the project began；a

If the total biomass Equation of species j is available (eg.the correlation equation for total biomass per plant under ground and above ground, with the DBH, tree height and wood density), then Equation (6) can be rewritten as:：

$B_{TREE\_BSL,i,j,t} = f_{TB,j}\left(DBH_{TREE\_BSL_{i,j,t}} H_{TREE\_BSL_{i,j,t}} \rho_j\right) * N_{TREE\_BSL_{i,j,t}} * A_{BSL_i}$		Equation(8)
Where：		
$B_{TREE\_BSL,i,j,t}$	=	Biomass of species j in baseline strata i in year t；td.m.
$f_{TB,j}(DBH,H,\rho)$	=	Correlation equation for total biomass per plant under ground and above ground, with the DBH, tree height and wood density of species j；td.m·株$^{-1}$
$DBH_{TREE\_BSL_{i,j,t}}$	=	DBH of species j in baseline strata i in year t；cm
$H_{TREE\_BSL_{i,j,t}}$	=	Height of species j in baseline strata i in year t；cm
ρ_j	=	Wood density of species j；g/cm^3
$N_{TREE\_BSL_{i,j,t}}$	=	Number of plants per hectare of species j in baseline strata i in year t; per hm2
A_{BSL_i}	=	Area of baseline strata i；hm^2
i	=	1,2,3……baseline strata i
j	=	1,2,3……species j in baseline strata i
t	=	1,2,3……the number of years since the project began；a

Method II: Biomass conversion factor

Project participants may also calculate the biomass using the following method:

$B_{TREE\_BSL,i,j,t} = V_{TREE\_BSL,i,j,t} * \rho_j * BEF_j * \left(1+R_j\right) * A_{BSL_i}$		Equation(9)
Where：		
$B_{TREE\_BSL,i,j,t}$	=	Biomass of species j in baseline strata i in year t；td.m.
$V_{TREE\_BSL,i,j,t}$	=	Stock volume per unit area species j in baseline strata i in year t；m^3/hm^2
ρ_j	=	Wood density of species j；g/cm^3
BEF_j	=	Biomass expansion factor of species j；non-dimensional
R_j	=	Ratio of biomass below ground to above ground of species j；non-dimensional
A_{BSL_i}	=	Area of baseline strata i；hm^2
i	=	1,2,3……baseline strata i
j	=	1,2,3……species j in baseline strata i
t	=	1,2,3……the number of years since the project began；a

Method III: Average increment

If the mangrove or some areas within the project boundary have not entered the stable stage of tree formation, and the project participant has the data of the annual change of mangrove biomass per plant or unit area in the area, the biomass of each year after the project starts can be directly estimated according to the data until the mangrove tree enters the stable stage of tree formation. Thereafter, it is assumed that the change of mangrove biomass is 0.

$B_{TREE\_BSL,i,j,t} = B_{TREE\_BSL,i,j,t-1} + \bar{B}_{TREE\_BSL,i,j,t} * (1 + R_j) * N_{TREE\_BSL_{i,j,t}} * A_{BSL_i}$		Equation(10)
Where：		
$B_{TREE\_BSL,i,j,t}$	=	Biomass of species j in baseline strata i in year t；td.m.
$B_{TREE\_BSL,i,j,t-1}$	=	Biomass of species j in baseline strata i in year t-1；td.m.
$\bar{B}_{TREE\_BSL,i,j,t}$	=	Annual variation of aboveground biomass per plant of species j in baseline strata i in year t；td.m.·a^{-1} per plant
R_j	=	Ratio of tree biomass below ground to above ground of tree species；non-dimensional
$N_{TREE\_BSL_{i,j,t}}$	=	Number of plants per unit area of species j in baseline strata i in year t；hm^2
A_{BSL_i}	=	Area of baseline strata i；hm^2
i	=	1,2,3……baseline strata i
j	=	1,2,3……species j in baseline strata i
t	=	1,2,3……the number of years since the project began；a

8.1.2 Variation of baseline shrub biomass carbon stocks

Assuming that the variations of shrub biomass in each strata under the baseline scenario during a period of time (year t_1 to t_2) are linear, the variations are estimated using the method "carbon stock change". The calculation method is as follows:：

$\Delta C_{SHRUB\_BSL,t} = \sum_{i=1} \Delta C_{SHRUB\_BSL,i,t}$		Equation(11)
$\Delta C_{SHRUB\_BSL,i,t} = \sum_{i=1} \left(\frac{C_{SHRUB\_BSL,i,t_2} - C_{SHRUB\_BSL,i,t_1}}{t_2 - t_1} \right)$		Equation(12)
Where：		
$\Delta C_{SHRUB\_BSL,t}$	=	annual variation of baseline shrub biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{SHRUB\_BSL,i,t}$	=	annual variation of baseline strata i of shrub biomass carbon stocks in year t；tCO_2-e·a^{-1}
$C_{SHRUB\_BSL,i,t}$	=	Shrub biomass carbon stocks of baseline strata i in year t；tCO_2-e
t_1, t_2	=	Year t_1 and t_2 under baseline scenario，$t_1 \le t \le t_2$
i	=	1,2,3……number of strata
t	=	1,2,3……the number of years since the project began；a

In year t, the carbon stocks of shrub biomass in the baseline strata are calculated as follows:

$C_{SHRUB\_BSL,i,t} = \frac{44}{12} * CF_S * (1 + R_S) * B_{SHRUB\_BSL_{i,t}} * A_{BSL_i}$		Equation(13)
Where：		

$C_{SHRUB\_BSL,i,t}$	=	Carbon stock of shrub biomass of baseline strata i in year t；tCO_2-e
CF_S	=	Carbon content of shrub biomass；tC·(td.m.)$^{-1}$ or gC·(td.m.)$^{-1}$
R_S	=	Ratio of below-ground biomass to above-ground biomass of shrub；non-dimensional
$B_{SHRUB\_BSL_{i,t}}$		Average shrub biomass per hectare of baseline strata i in year t；td.m·hm^{-2}
A_{BSL_i}	=	Area of baseline strata i；hm^2
i	=	1,2,3……number of strata
t	=	1,2,3……the number of years since the project began；a
44/12	=	Molecular weight ratio of CO_2 to C；the number of years since the project began；a

The average shrub biomass per hectare can be estimated by default value,。When shrub cover is < 5%, the change of shrub biomass carbon stocks in the baseline scenario can be assumed to be 0. When shrub cover is ≥5%, estimates are made as follows：

$B_{SHRUB\_BSL_{i,t}} = BDR_{SF} * B_{TREE} * CC_{SHRUB\_BSL_{i,t}}$		Equation(14)
Where：		
$B_{SHRUB\_BSL_{i,t}}$	=	Average shrub biomass per hectare of baseline strata i in year t；td.m·hm^{-2}
BDR_{SF}	=	The ratio of average above-ground shrub biomass per hectare with shrub cover of 1.0 to average above-ground tree biomass per hectare in the project area；non-dimensional
B_{TREE}	=	Average above-ground biomass per hectare；td.m·hm^{-2}
$CC_{SHRUB\_BSL_{i,t}}$	=	Shrub cover in the baseline strata i in year t, expressed in a decimal form(If the coverage is 10%,then $CC_{SHRUB\_BSL_{i,t}}$ =0.10)；non-dimensional
i	=	1,2,3……number of strata
t	=	1,2,3……the number of years since the project began；a

8.1.3 Variation of baseline vine biomass carbon stocks

Based on the principle of cost-effectiveness and conservatism, project participants can choose not to measure vine biomass carbon stocks when the proportion of vine biomass carbon stocks within the project boundary is less than 5%. Assuming that the changes of vine biomass in each strata under the baseline scenario during a period of time (year t1 to t2) are linear, the changes are estimated using the "carbon stock change method". The calculation method is as follows：

$\Delta C_{VINE\_BSL,t} = \sum_{i=1} \Delta C_{VINE\_BSL,i,t}$	Equation(15)
$\Delta C_{VINE\_BSL,i,t} = \sum_{i=1} \left(\frac{C_{VINE\_BSL,i,t_2} - C_{VINE\_BSL,i,t_1}}{t_2 - t_1}\right)$	Equation(16)

$C_{VINE\_BSL,i,t} = \frac{44}{12} * \sum_{j=1} (B_{VINE\_BSL,i,j,t} * CF_{V,j})$		Equation(17)
Where：		
$\Delta C_{VINE\_BSL,t}$	=	annual variation of baseline vine biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{VINE\_BSL,i,t}$	=	annual variation of baseline strata i of vine biomass carbon stocks in year t；tCO_2-e·a^{-1}
$C_{VINE\_BSL,i,t}$	=	Vine biomass carbon stocks of baseline strata i in year t；tCO_2-e
$B_{VINE\_BSL,i,j,t}$	=	Biomass of vine species j in baseline strata i in year t；td.m.
t_1, t_2	=	Year t_1 and t_2 under baseline scenario，$t_1 \le t \le t_2$
$CF_{V,j}$	=	Biomass carbon content rate of vine species j；tC·$(td.m.)^{-1}$ or gC·$(td.m.)^{-1}$
i	=	1,2,3……number of strata
t	=	1,2,3……the number of years since the project began；a
44/12	=	Molecular weight ratio of CO2 to C；the number of years since the project began；a

The project participants may estimate the baseline biomass of vine species j in year t by using the following methods：

$B_{VINE\_BSL,i,j,t} = f_{VINE}(\Phi) * N_{VINE\_BSL,i,t} * A_{BSL_i}$		Equation(18)
Where：		
$B_{VINE\_BSL,i,j,t}$	=	Biomass of vine species j in baseline strata i in year t；td.m.
$f_{VINE}(\Phi)$	=	The allometric growth equation is established based on the correlation between diameter and biomass at 1.3m above ground；td.m·$株^{-1}$
Φ	=	Vine diameter 1.3m from ground；cm
$N_{VINE\_BSL,i,t}$	=	Number of plants per unit area of species j in baseline strata i in year t；株·hm^{-2}
A_{BSL_i}	=	Area of baseline strata i；hm^2
i	=	1,2,3……number of strata
t	=	1,2,3……the number of years since the project began；a

8.1.4 Variation of baseline vine biomass carbon stocks

The change of carbon stocks of dead wood in each strata under the baseline scenario is estimated by method "carbon stocks change" and "default value"：

$\Delta C_{DW\_BSL,t} = \sum_{i=1} \Delta C_{DW\_BSL,i,t}$		Equation(19)
$\Delta C_{DW\_BSL,i,t} = \sum_{i=1} \left(\frac{C_{DW\_BSL,i,t_2} - C_{DW\_BSL,i,t_1}}{t_2 - t_1} \right)$		Equation(20)
$C_{DW\_BSL,i,t} = C_{TREE\_BSL,i,t} * DF_{DW}$		Equation(21)
Where：		

$\Delta C_{DW\_BSL,t}$	=	annual variation of baseline dead wood biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{DW\_BSL,i,t}$	=	annual variation of baseline strata i of dead wood biomass carbon stocks in year t；tCO_2-e·a^{-1}
$C_{DW\_BSL,i,t}$	=	Dead wood biomass carbon stocks of baseline strata i in year t；tCO_2-e
$C_{TREE\_BSL,i,t}$	=	Biomass of dead wood in baseline strata i in year t；tCO_2-e
DF_{DW}	=	The conservative default factor, is the ratio of dead wood carbon stocks to living wood biomass carbon stocks within the project boundary；%
t_1, t_2	=	Year t1 and t2 under baseline scenario,$t_1 \leq t \leq t_2$
i	=	1,2,3……baseline strata

8.1.5 Variation of baseline mangrove biomass carbon stocks

Project participants may estimate the annual change in baseline mangrove biomass carbon stocks within the project boundary in year t on the basis of the following best to worst method：

Method Ⅰ：

Changes in mangrove biomass carbon stocks under baseline scenario($\Delta C_{BIO\_BSL,t}$)equals to sum of variations of mangrove tree biomass carbon stocks ($\Delta C_{TREE\_BSL,t}$), ($\Delta C_{SHRUB\_BSL,t}$)、variations of vine tree biomass carbon stocks($\Delta C_{VINE\_BSL,t}$)、variations of dead wood biomass carbon stocks($\Delta C_{DW\_BSL,t}$), which results of using methods mentioned in section 8.1.1-8.1.4 above、variations of shrub biomass carbon stocks

Method Ⅱ：

Project participants can also choose one of the following two methods“default value " according to the actual situation of the project to estimate the annual variations of the baseline mangrove biomass carbon stocks within the project boundary in the year t. The calculation method is as follows：

Default value method 1：

$\Delta C_{BIO\_BSL,t} = \frac{44}{12} * DV_{BI} * A_{BSL}$		Equation(22)
Where：		
$\Delta C_{BIO\_BSL,t}$	=	annual variation of baseline mangrove biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
DV_{BI}	=	Conservative default factor, annual increment of mangrove biomass carbon stocks per unit area；tC·hm^{-2}·a^{-1}

A_{BSL}	=	Total area within the baseline project boundary；hm^2
t	=	1,2,3……number of years since the project began；a
44/12	=	Molecular weight ratio of CO_2 to C；non-dimensional

Default value method2：

$\Delta C_{BIO\_BSL,t} = \sum_{i=1} \left(\frac{C_{BIO\_BSL,t_2} - C_{BIO\_BSL,t_1}}{t_2 - t_1} \right)$	Equation(23)
$C_{BIO\_BSL,t} = \frac{44}{12} * DV_{Bio} * A_{BSL}$	Equation(24)

Where：		
$\Delta C_{BIO\_BSL,t}$	=	annual variation of baseline mangrove biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$C_{BIO\_BSL,t}$	=	In year t, baseline mangrove biomass carbon stocks within the project boundary；tCO_2-e·a^{-1}
DV_{Bio}	=	Conservative default factor, mangrove biomass carbon stocks per unit area；tC·hm^{-2}
A_{BSL}	=	Total area within the baseline project boundary；hm^2
t	=	1,2,3……number of years since the project began；a
44/12	=	Molecular weight ratio of CO_2 to C；non-dimensional

8.1.6 Increase in GHG emissions within the project boundary under the baseline scenario

In the baseline scenario, there are two sources of increase in GHG emissions within the project boundary. One is the increase in GHG emissions within the project boundary caused by land use change，see Equation(25)for the calculation method. The second is the methane emission of mangrove ecosystem itself，see Equation(26)for the calculation method：

$GHG_{BSL,t} = GHG_{CL\_BSL,t} + GHG_{ME\_BSL,t}$	Equation(25)
$GHG_{CL\_BSL,t} = \sum_{x=1} \frac{44}{12} * A_{LUC,t,x} * \beta_{LUC,x}$	Equation(26)

Where：		
$GHG_{BSL,t}$		Increase in GHG emissions within the project boundary under the baseline scenario in year t；tCO_2-e·a^{-1}
$GHG_{CL\_BSL,t}$	=	Increase in GHG emissions from land use changes in the baseline scenario in year t；tCO_2-e·a^{-1}
$GHG_{ME\_BSL,t}$	=	Methane emissions from mangrove ecosystems within project boundary under baseline scenarios in year t；tCO_2-e·a^{-1}
$A_{LUC,t,x}$	=	Area of mangrove tree land converted to land use x under the baseline scenario in year t；hm^2
$\beta_{LUC,x}$	=	Carbon emission coefficient of mangrove tree land conversion to land use x；tC ·hm^{-2}

44/12	=	Molecular weight ratio of CO_2 to C；non-dimensional
t	=	1,2,3……number of years since the project began；a

$GHG_{ME\_BSL,t} = \sum_{x=1} A_{MA,BSL,t} * \beta_{MA,t} * GWP_{CH_4}$	Equation(27)

Where：		
$GHG_{ME\_BSL,t}$	=	Methane emissions from mangrove ecosystems within project boundary under the baseline scenario in year t；tCO_2-e·a^{-1}
$A_{MA,BSL,t}$	=	Area of mangrove ecosystem under baseline scenario in year t；hm^2
$\beta_{MA,t}$	=	Methane emission coefficient of mangrove ecosystem；default value=0.157t·hm^{-2}·a^{-1}
GWP_{CH_4}	=	The global warming potential of CH_4, which is used to convert CH_4 to CO_2 equivalent；default value=25
t	=	1,2,3……number of years since the project began；a

8.2 Annex2 Method for calculating carbon stocks in the project scenario

This annex corresponds to section 5.7.1 of the main text.

The project carbon stock is equal to the sum of the changes in carbon stocks in each carbon pool within the project boundary, minus the increase in GHG emissions generated within the project boundary, namely：

$\Delta C_{ACTURSL,t} = \Delta C_{p,t} - GHG_{ME\_PROJ,t}$	Equation(28)

Where：		
$\Delta C_{ACTURSL,t}$	=	Project carbon stocks in year t；tCO_2-e·a^{-1}
$\Delta C_{p,t}$	=	The annual variation in the carbon stock of the selected carbon pool within the project boundary in year t；tCO_2-e·a^{-1}
$GHG_{ME\_PROJ,t}$	=	Methane emissions from mangrove ecosystems within the project boundary under project scenario in year t；tCO_2-e·a^{-1}

The annual variation in the carbon stock of the selected carbon pool within the project boundary is calculated as follows in year t：

$\Delta C_{P,t} = \Delta C_{BIO\_PROJ,t}$	Equation(29)
$\Delta C_{BIO\_PROJ,t} = \Delta C_{TREE\_PROJ,t} + \Delta C_{SHRUB\_PROJ,t} + \Delta C_{VINE\_PRO,t} + \Delta C_{DW\_PROJ,t}$	Equation(30)

Where：		
$\Delta C_{P,t}$	=	Annual variation of carbon stocks in selected carbon pool in year t；tCO_2-e·a^{-1}
$\Delta C_{BIO\_PROJ,t}$	=	Annual variation of project mangrove biomass carbon stocks within project boundaries in year t；tCO_2-e·a^{-1}

$\Delta C_{TREE\_PROJ,t}$	=	Annual variation of project tree biomass carbon stocks within project boundaries in year t；tCO_2-e·a^{-1}
ΔC_{SHRUB_PROJ}	=	Annual variation of project shrub biomass carbon stocks within project boundaries in year t；tCO_2-e·a^{-1}
$\Delta C_{VINE\_PRO,t}$	=	Annual variation of project vine biomass carbon stocks within project boundaries in year t；tCO_2-e·a^{-1}
$\Delta C_{DW\_PROJ,t}$	=	Annual variation of project dead wood biomass carbon stocks within project boundaries in year t；tCO_2-e·a^{-1}

8.2.1 Variation of project tree biomass carbon stocks within the project boundary

The calculation method of carbon stocks change of mangrove tree biomass within the project boundary is as follows：

$\Delta C_{TREE\_PROJ,t} = \sum_{i=1} \Delta C_{TREE\_PROJ,i,t}$	Equation(31)
$\Delta C_{TREE\_PROJ,i,t} = \sum_{i=1} \left(\frac{C_{TREE\_PROJ,i,t_2} - C_{TREE\_PROJ,i,t_1}}{t_2 - t_1}\right)$	Equation(32)
$C_{TREE\_PROJ,i,t} = \frac{44}{12} * \sum_{j=1} (B_{TREE\_PROJ,i,j,t} * CF_j)$	Equation(33)

Where：		
$\Delta C_{TREE\_PROJ,t}$	=	Annual variation of project tree biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{TREE\_PROJ,i,t}$	=	Annual variation of baseline tree biomass carbon stocks in strata i within the project boundary in year t；tCO_2-e·a^{-1}
$C_{TREE\_PROJ,i,t}$	=	Tree biomass carbon stocks of project strata i in year t；tCO_2-e
$B_{TREE\_PROJ,i,j,t}$	=	Biomass of tree species j in baseline strata i in year t；td.m.
CF_j	=	Carbon content rate of species j biomass；tC·(td.m.)$^{-1}$
t_1, t_2	=	Project scenario year t_1 and year t_2，$t_1 \le t \le t_2$
i	=	1,2,3……the number of project strata
j	=	1,2,3……tree species j in project strata i
t	=	1,2,3……the number of years since the project began；a
44/12	=	Molecular weight ratio of CO_2 to C; non-dimensional

For estimation of tree biomass within project boundaries($B_{TREE\_PROJ,i,j,t}$),the calculation can be made using the method in 8.1.1, only if it is consistent with the calculation method chosen under the baseline scenario

8.2.2 Variation of project shrub biomass carbon stocks within the project boundary

The calculation method of carbon stock changes of mangrove shrubs under the project scenario is consistent with the baseline scenario as follows：

$\Delta C_{SHRUB\_PROJ,t}=\sum_{i=1}\Delta C_{SHRUB\_PROJ,i,t}$	Equation(34)
$\Delta C_{SHRUB\_PROJ,i,t}=\sum_{i=1}\left(\frac{C_{SHRUB\_PROJ,i,t_2}-C_{SHRUB\_PROJ,i,t_1}}{t_2-t_1}\right)$	Equation(35)
$C_{SHRUB\_PROJ,i,t}=\frac{44}{12}*CF_S*(1+R_S)*B_{SHRUB\_PROJ_{i,t}}*A_{PROJ_i}$	Equation(36)

Where：		
$\Delta C_{SHRUB\_PROJ,t}$	=	Annual variation of project shrub biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{SHRUB\_PROJ,i,t}$	=	Annual variation of baseline shrub biomass carbon stocks in strata i within the project boundary in year t；tCO_2-e·a^{-1}
$C_{SHRUB\_PROJ,i,t}$	=	Shrub biomass carbon stocks of project strata i in year t；tCO_2-e
CF_S	=	Carbon content rate of shrub biomass；tC·(td.m.)$^{-1}$or gC·(td.m.)$^{-1}$
R_S	=	Ratio of below-ground biomass to above-ground biomass of shrub；non-dimensional
$B_{SHRUB\_PROJ,i,t}$	=	Shrub average biomass per hectare in project strata i om year t；td.m.·hm^{-2}
A_{PROJ_i}	=	Area of project strata i；hm^2
t_1,t_2	=	Project scenario year t_1 and year t_2，$t_1 \le t \le t_2$
i	=	1,2,3……the number of project strata
j	=	1,2,3……tree species j in project strata i
t	=	1,2,3……the number of years since the project began；a
44/12	=	Molecular weight ratio of CO_2 to C; non-dimensional

For estimation of Shrub biomass within the project boundary($B_{SHRUB\_PROJ,i,t}$),the calculation can be made using the method in 8.1.2.

8.2.3 Variation of project vine biomass carbon stocks within the project boundary

The calculation method of carbon stock changes of mangrove vines under the project scenario is consistent with the baseline scenario as follows：

$\Delta C_{VINE\_PROJ,t}=\sum_{i=1}\Delta C_{VINE\_PROJ,i,t}$	Equation(37)
$\Delta C_{Vine\_PROJ,i,t}=\sum_{i=1}\left(\frac{C_{Vine\_PROJ,i,t_2}-C_{Vine\_PROJ,i,t_1}}{t_2-t_1}\right)$	Equation(38)
$C_{VINE\_PROJ,i,t}=\frac{44}{12}*\sum_{j=1}\left(B_{VINE\_PRO,i,j,t}*CF_{V,j}\right)$	Equation(39)

Where：		
$\Delta C_{VINE\_PROJ,t}$	=	Annual variation of project vine biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{Vine\_PROJ,i,t}$	=	Annual variation of baseline vine biomass carbon stocks in strata i within the project boundary in year t；tCO_2-e·a^{-1}
$C_{Vine\_PROJ,i,t}$	=	Vine biomass carbon stocks of project strata i in year t；tCO_2-e
$B_{VINE\_PRO,i,j,t}$	=	Biomass of vine species j in baseline strata i in year t；td.m.

$CF_{V,j}$	=	Carbon content rate of vine species j；tC·(td.m.)$^{-1}$or gC·(td.m.)$^{-1}$
t_1, t_2	=	Project scenario year t_1 and year t_2，$t_1 \leq t \leq t_2$
i	=	1,2,3……the number of project strata
t	=	1,2,3……the number of years since the project began；a
44/12	=	Molecular weight ratio of CO_2 to C; non-dimensional

Calculation of project biomass of shrub carbon stock is the same as it is in the baseline calculation, please refer to section 8.1.3.

8.2.4 Variation of project dead wood biomass carbon stocks within the project boundary

The calculation method of carbon stock change of dead wood in each strata within the project boundary is consistent with the baseline scenario, hence the estimation method in section 8.1.4 is applied:

$\Delta C_{DW\_PROJ,t} = \sum_{i=1}^{t} \Delta C_{DW\_PROJ,i,,t}$	Equation(40)
$\Delta C_{DW\_PROJ,i,t} = \sum_{i=1} \left(\frac{C_{DW\_PROJ,i,t_2} - C_{DW\_PROJ,i,t_1}}{t_2 - t_1} \right)$	Equation(41)
$C_{DW\_PROJ,i,t} = C_{TREE\_PROJ,i,t} * DF_{DW}$	Equation(42)

Where：		
$\Delta C_{DW\_PROJ,t}$	=	Annual variation of project dead wood biomass carbon stocks within the project boundary in year t；tCO_2-e·a^{-1}
$\Delta C_{DW\_PROJ,t}$	=	Annual variation of baseline dead wood biomass carbon stocks in strata i within the project boundary in year t；tCO_2-e·a^{-1}
$C_{DW\_PROJ,i,t}$	=	Dead wood biomass carbon stocks of project strata i in year t；tCO_2-e
$C_{DW\_PROJ,i,t}$	=	Dead wood biomass carbon stocks of project strata i in year t；tCO_2-e
DF_{DW}	=	The conservative default factor is the ratio of dead wood carbon stock to living wood biomass carbon stock within the project boundary；%
t_1, t_2	=	Project scenario year t_1 and year t_2，$t_1 \leq t \leq t_2$
i	=	1,2,3……the number of project strata
t	=	1,2,3……the number of years since the project began；a

8.2.5 Variations in mangrove biomass carbon stocks within project boundaries

The calculation method of mangrove biomass carbon stock changes within the project boundary is the same as it is in the baseline scenario, hence the method in section 8.1.5 is used to estimate the variations.

8.2.6 Increase in GHG emissions within the project boundary under the project scenario

In the project scenario, the increase of GHG emissions within the project boundary is derived from the methane emissions of mangrove ecosystem itself, and the calculation method is the same as it is in the baseline scenario, which is calculated using Equation (27) in 8.1.6.

8.3 Annex3 Calculation of project emission reduction

This annex corresponds to Section 5.6.3 of the main text

$\Delta C_{NET,t} = \Delta C_{ACTURAL,t} - \Delta C_{BSL,t} - LK_t$		Equation(43)
Where：		
$\Delta C_{NET,t}$	=	Project emission reductions in year t；$tCO_2\text{-e}\cdot a^{-1}$
$\Delta C_{ACTURAL,t}$	=	Project carbon removals in year t；$tCO_2\text{-e}\cdot a^{-1}$
$\Delta C_{BSL,t}$	=	Baseline carbon removals in year t；$tCO_2\text{-e}\cdot a^{-1}$
LK_t	=	Leakage produced by the project in year t；$tCO_2\text{-e}\cdot a^{-1}$
t	=	1,2,3……the number of years since the project began；a

8.4 Annex4 Sampling design

This annex corresponds to section 6.1.4 of the main text. The method requires 90% accuracy at 90% reliability level. If the accuracy of the measurement is lower than this value, the project participant can increase the number of samples to make the measurement result meet the accuracy requirements. The number of sample plots required for project monitoring can be calculated using the following methods:

1) According to Equation (44), if n≥30 is obtained, the ultimate number of plots is the value n; If n< 30, then the value when the degree of freedom is n-1 should be adopted. Equation (44) should be used for the second iteration calculation, and the obtained value is the ultimate number of sample plots.

$n = \frac{N * t_{VAL}{}^2 * (\sum_i w_i * s_i)^2}{N * E^2 + t_{VAL}{}^2 * \sum_i w_i * s_i^2}$		Equation(44)
Where：		
n	=	The number of monitoring plots required to estimate biomass carbon stocks within project boundary; non-dimensional
N	=	Sample population of monitored plots within the project boundary，$N = \frac{A}{A_P}$， where:A=total area(hm^2)， A_P =area of sample plot；non-dimensional

t_{VAL}	=	Reliability specifications. At a certain level of reliability, when the degrees of freedom are infinite (∞), the values of the bilateral quantile table of the distribution；non-dimensional
w_i	=	The area weight of the project carbon layer within the project boundary，$w_i = A_i/A$，where A=project total area(hm^2)，A_i=area of strata i(hm^2)；non-dimensional
s_i	=	Standard deviation of estimated biomass carbon stocks in the project strata within the project boundary；tC/hm^2
E	=	Allowable margin of error for project biomass carbon stock estimates (i.e. half of the confidence interval))，represented by s_i in each strata；tC/hm^2
i	=	1, 2, 3…number of strata

(2)When the sampling area is large (sampling area is greater than 5% of the project area), calculate according to Equation (44) to obtain value n (the number of plots), adjust the value n according to Equation (45), so as to determine the ultimate number of plots (n_a).：

$n_a = n * \frac{1}{1+n/N}$		Equation(45)
Where：		
n_a	=	The number of monitored plots required to estimate biomass carbon stocks within adjusted project boundaries；non-dimensional
n	=	The number of monitored plots required to estimate biomass carbon stocks within the project boundary；non-dimensional
N	=	Sample population of monitored plots within the project boundary；non-dimensional

(3)When the sample area is small (the sample area is less than 5% of the project area), the simplified Equation (46) can be used：

$n = \left(\frac{t_{VAL}}{E}\right)^2 * (\sum_i w_i * s_i)^2$		Equation(46)
Where：		
n	=	The number of monitored plots required to estimate biomass carbon stocks within project boundaries；non-dimensional
t_{VAL}	=	Reliability specifications. At a certain level of reliability, when the degrees of freedom are infinite (∞), the values of the bilateral quantile table of the distribution；non-dimensional
w_i	=	The area weight of the project carbon layer within the project boundary，$w_i = A_i/A$，where A=project total area(hm^2)，A_i=area of strata i(hm^2)；non-dimensional
s_i	=	Standard deviation of estimated biomass carbon stocks in the project strata within the project boundary；tC/hm^2

E	=	Allowable margin of error for project biomass carbon stock estimates (i.e. half of the confidence interval)), represented by s_i in each strata; tC/hm^2
i	=	1, 2, 3…number of strata

(4)The number of monitoring plots allocated to each mangrove type is calculated using the optimal allocation method according to Equation (47):

$n = n_i = n * \frac{w_i * s_i}{\sum_i w_i * s_i}$		Equation(47)
Where:		
n_i	=	The number of monitoring plots required to estimate biomass carbon stocks in the project strata within the project boundary; non-dimensional
n	=	The number of monitored plots required to estimate biomass carbon stocks within the project boundary; non-dimensional
w_i	=	The area weight of the project carbon layer within the project boundary, $w_i = A_i / A$, where A=project total area(hm^2), A_i=area of strata i(hm^2); non-dimensional
s_i	=	Standard deviation of estimated biomass carbon stocks in the project strata within the project boundary; tC/hm^2
i	=	Standard deviation of estimated biomass carbon stocks in the project strata within the project boundary; tC/hm2

8.5 Annex5 Method for determination of tree biomass carbon stocks

This annex corresponds to section 6.1.7 of the main text.

Step 1: Measure the diameter (DBH), height (H) and/or wood density (D) of all living trees in the sample plot, with minimum DBH at 3cm. Whether to measure the height of respiratory roots (h) in the sample plot should be determined according to the biomass equation used in the actual calculation. If the measurement of respiratory root biomass is included in the measurement of the biomass of respiratory roots, the height of respiratory roots (h) in the sample plot can be not measured; otherwise, the height of all respiratory roots in the sample plot (h) should be measured. Based on the measured data, the allometric growth equation of respiratory root height and respiratory root biomass is to be established;

Step 2: biomass equation method is used to calculate the biomass of tree species in the plot. The biomass of tree species in the plot is accumulated to obtain the horizontal biomass of the plot. The forest biomass carbon stocks at the plot level and the average unit area of each carbon layer are calculated according to the forest biomass of the plot；

Step 3：Equation (48) and Equation (49) are used to calculate the mean of the strata sample (the estimation of the average carbon stocks of forest biomass per unit area) and its variance：

$c_{TREE,i,t} = \frac{\sum_{p=1}^{n_i} c_{TREE,i,p,t}}{n_i}$			Equation(48)
Where：			
$c_{TREE,i,t}$	=	Estimated values of the average unit area of forest biomass carbon stocks in strata i of the project in year t；tCO_2-e·hm^{-2}	
$c_{TREE,i,p,t}$	=	The carbon stocks of tree biomass per unit area of sample plot p in strata i of the project；tCO_2-e·hm^{-2}	
n_i	=	Number of sample plot in project strata i	
i	=	1,2,3……number of project strata	
p	=	1,2,3……sample plot in project strata i	
t	=	1,2,3……number of years since the project began；a	

$S^2_{c_{TREE,i,t}} = \frac{\sum_{p=1}^{n_i} (c_{TREE,i,p,t} - c_{TREE,i,t})^2}{n_i * (n_i - 1)}$			Equation(49)
Where：			
$S^2_{c_{TREE,i,t}}$	=	The variance of the estimated average unit area of forest biomass carbon stocks in strata i of the project in year t；$(tCO_2$-e·$hm^{-2})^2$	
$c_{TREE,i,p,t}$	=	Carbon stocks of forest biomass per unit area of sample plot p in strata i of the project in year t；tCO_2-e·hm^{-2}	
$c_{TREE,i,t}$	=	Estimated value of the average unit area of forest biomass carbon stocks in strata i of the project in year t；tCO_2-e·hm^{-2}	
i	=	1,2,3……number of project strata	
p	=	1,2,3……sample plot in project strata i	
t	=	1,2,3……number of years since the project began; a	

Step 4： Equation (50) and Equation (51) are used to calculate the estimate of the overall mean value of the project (the estimate of the carbon stock of forest biomass per unit area) and its variance：

$c_{TREE,t} = \sum_{i=1}^{M} (w_i * c_{TREE,i,t})$			Equation(50)
Where：			
$c_{TREE,t}$	=	Estimates of carbon stocks of forest biomass per unit area within the project boundary in year t；tCO_2-e·hm^{-2}	

w_i	=	The ratio of the carbon layer area to the total area of the project, $wi = Ai/A$; non-dimensional
$c_{TREE,i,t}$	=	Estimate of the average unit area of forest biomass carbon stocks in strata i of the project in year t; tCO_2-e·hm^{-2}

$S_{c_{TREE,t}}^2 = \sum_{i=1}^{M} (w_i{}^2 * \frac{S_{c_{TREE,i,t}}^2}{n_i})$		Equation(51)
Where:		
$S_{c_{TREE,t}}^2$	=	Variance of the estimate of the project population mean (average forest biomass carbon stock per unit area) in year t; $(tCO_2\text{-e}\cdot hm^{-2})^2$
w_i	=	The ratio of strata i areas to the total area of the project, $w_i = Ai/A$; non-dimensional
$S_{c_{TREE,i,t}}^2$	=	Variance of the estimated average unit area of forest biomass carbon stocks in strata i of the project in year t; $(tCO_2\text{-e}\cdot hm^{-2})^2$
n_i	=	Number of sample plots in strata i
M	=	Number of total stratified strata of estimated forest biomass carbon stocks within the project boundary
i	=	1,2,3……number of project strata
t	=	1,2,3……number of years since the project began

Step 5: Equation (52) is used to calculate the uncertainty of carbon stocks of forest biomass per unit area within the project boundary:

$u_{c_{TREE,t}} = \frac{t_{VAL} * S_{c_{TREE,t}}}{c_{TREE,t}}$		Equation(52)
Where:		
$u_{c_{TREE,t}}$	=	Uncertainty in estimates of average unit area forest biomass carbon stocks within the project boundary (relative error limit) in year t; %.The relative error is required to be no more than 10%, that is, the sampling accuracy is not less than 90%.
t_{VAL}	=	Reliability index. The degree of freedom is equal to n-M (where n is the total number of sample plots within the project boundary, M is the total number of stratified strata), the confidence level is 90%, and t_{val} is obtained by consulting the bilateral quantile table of distribution. For example, if the confidence level is 90% and the degree of freedom is 45, the value of the bilateral distribution can be calculated as 1.6794 by entering "=TINV(0.10,45)" in the Excel spreadsheet
$S_{c_{TREE,t}}$	=	The square root of the variance of the estimated average unit area forest biomass carbon stock within the project boundary (i.e., standard error) in year t; tCO_2-e·hm^{-2}
$c_{TREE,t}$	=	Estimates of carbon stocks of forest biomass per unit area within the project boundary in year t; tCO_2-e·hm^{-2}

Step 6: **E**quation (53) is used to calculate the total carbon stocks of forest biomass within the project boundaries in year t:

	Equation(53)

Where：		
$C_{TREE,t}$	=	Estimates of forest biomass carbon stocks within project boundaries in year t；tCO_2-e
A	=	Total area of each strata within the project boundary；hm^2
$c_{TREE,t}$	=	Estimates of carbon stocks of forest biomass per unit area within the project boundary in year t；tCO_2-e·hm^{-2}
t		1,2,3……number of years since the project began；a

Step 7： Equation (54) is used to calculate the annual change of forest biomass carbon stocks within the project boundaries. It is assumed that the change of forest biomass is linear over a period of time：

$dC_{TREE(t_1,t_2)} = \frac{C_{TREE,t_2} - C_{TREE,t_1}}{T}$		Equation(54)
Where：		
$dC_{TREE(t_1,t_2)}$	=	Annual change in tree biomass carbon stocks within project boundaries between year t_1 and year t_2；tCO_2-e·a^{-1}
$C_{TREE,t}$	=	Estimates of forest biomass carbon stocks within project boundaries in year t；tCO_2-e
T	=	The interval between two consecutive measurements($T = t_2 - t_1$)；a
t_1, t_2	=	Year t_1 and t_2 since the beginning of project activities，$t_1 \leq t \leq t_2$

For the first verification, the carbon stock of forest biomass at the start of the project activity is assigned to a variable in the Equation (48) $c_{TREE,i,t}$,namely：in the first verification $c_{TREE,i,t_1} = c_{TREE\_BSL}$，in which，$t_1$=0，$t_2$=the year when the first verification is carried out

Step 8： The change of forest biomass carbon stocks within the project boundary in year t ($t_1 \leq t \leq t_2$) of the verification period is calculated using Equation (55)：

$\Delta C_{TREE,t} = dC_{TREE(t_1,t_2)} * 1$		Equation(55)
Where：		
$\Delta C_{TREE,t}$	=	Annual variations in forest biomass carbon stocks within project boundary in year t；tCO_2-e·a^{-1}
$dC_{TREE(t_1,t_2)}$	=	Annual variations in forest biomass carbon stocks within project boundary between year t_1 and t_2；tCO_2-e·a^{-1}
1	=	1 year；a

8.6 Annex6 Method for determination of shrub biomass carbon stocks

This annex corresponds to section 6.1.8 of the main text.

The biomass of shrub is usually related to the ground diameter, branch number, irrigation height and crown diameter, so the method of biomass equation can be used to monitor the carbon stocks of shrub biomass carbon pool.

Step 1：Set quadrate k in sample plot p in project strata i(Area≥2m^2,10m^2 [i] recommended). Measure the ground diameter, height, crown width and number of branches of shrubs in the quadrate, and the biomass per unit area of shrubs in the quadrate can be calculated using the one-dimensional or multivariate biomass Equation (56) :

$c_{Shrub,i,p,t} = \frac{\sum_{k=1}\sum_{j=1}[f_{Shrub,j}(x_1,x_2,x_3 \ldots) * N_{i,p,k,j,t} * CF_{S,j} * (1+R_{S,j})]}{\sum_{k=1} A_{Shrub,i,p,k,t}} * \frac{1}{100} * \frac{44}{12}$	Equation(56)

Where：		
$c_{Shrub,i,p,t}$	=	Average shrub biomass carbon stocks per unit area in sample sit p in strata i within the project boundary in year t；tCO_2-e ·hm^{-2}
$f_{Shrub,j}(x_1,x_2,x_3 \ldots)$	=	Single shoot biomass equation, considering the above-ground biomass of shrubs and shrub measurement factors of species j(x_1,x_2,x_3 ...)(base diameter, irrigation height, crown width, crown diameter, etc); gd.m·per branch
$N_{i,p,k,j,t}$	=	Number of branches of species j in quadrate k, samples site p, strata i of the project; branches
CF_S, j	=	Carbon content rate of species j shrub biomass；tC·(td.m.)$^{-1}$or gC·(gd.m.)$^{-1}$
R_S, j	=	Ratio of below-ground biomass to above-ground biomass of shrub species j；non-dimensional
$A_{Shrub,i,p,k,t}$	=	Area of qudrate k of sample plot p in strata i in year t；m^2
i	=	1,2,3……number of project strata
p	=	1,2,3……number of sample plot in strata i
k	=	1,2,3……number of quadrate in sample plot p
j	=	1,2,3……shrub species j
t	=	1,2,3……number of years since the project began；a
$\frac{1}{100}$	=	Coefficient for converting g·m^{-2} into t·hm^{-2}
44/12	=	Molecular weight ratio of CO_2 to C；the number of years since the project began；non-dimensional

Step 2：To calculate the estimated carbon stocks of shrub biomass per unit area of the strata of the project and its variance, refer to Equation (48), Equation (49). Replace $c_{TREE,i,t}$ with $c_{Shrub,i,t}$， replace $c_{TREE,i,p,t}$ with $c_{Shrub,i,p,t}$， replace $S_{c_{TREE,i,t}}$ with $S_{c_{Shrub,i,t}}$ ；

Step 3：Calculate the estimate of the overall mean value of the project within the project boundary (the estimate of the carbon stock of average shrub biomass per unit area) and its variance, referring to Equation (50), Equation (51). Replace $c_{TREE,t}$ with $c_{Shrub,t}$,replace $c_{TREE,i,t}$ with $c_{Shrub,i,t}$, replace with $S_{C_{Shrub,t}}$, replace $S_{C_{TREE,i,t}}$ with $S_{C_{Shrub,i,t}}$;

Step 4：Calculate the uncertainty of the estimated carbon stock of average shrub biomass per unit area within the project boundary, referring to Equation (52). Replace $u_{c_{TREE,t}}$ with$u_{c_{Shrub,t}}$, replace$S_{C_{TREE,t}}$ with $S_{C_{Shrub,t}}$, replace $c_{TREE,t}$ with $c_{Shrub,t}$;

Step 5：Calculate estimates of total shrub biomass carbon stocks within the project boundary in year t, referring to Equation (53)，replace $C_{TREE,t}$ with $C_{Shrub,t}$, replace $c_{TREE,t}$ with $c_{Shrub,t}$;

Step 6：Calculate the annual variation of shrub biomass carbon stocks within project boundaries. It is assumed that the change of shrub biomass increases linearly over a period of time. Equation (54). Replace $C_{TREE,t}$ with $C_{Shrub,t}$, replace $dC_{TREE(t_1,t_2)}$ with $dC_{Shrub(t_1,t_2)}$;

Step 7：Calculate the variation of shrub biomass carbon stocks within the project boundary in year y ($t_1 \leq t \leq t_2$)of the verification, referring to Equation(55). Replace $dC_{TREE(t_1,t_2)}$ with $dC_{Shrub(t_1,t_2)}$, replace $\Delta C_{TREE,t}$ with $\Delta C_{Shrub,t}$

8.7 Annex7 Method for determination of vine biomass carbon stocks

This annex corresponds to section 6.1.9 of the main text.

The biomass of vines is usually related to the diameter at 1.3m above the ground, so the biomass equation method can be used to monitor the carbon stocks in the biomass carbon pool of vines

Step 1：Set quadrate k in sample plot p in project strata i(Area≥2m^2,10m^2 is recommended).Biomass equation is used to measure the diameter of vinces at 1.3m from the ground, referring to equation (57). Calculate the biomass per unit area of vines in the sample plot p:

$c_{Vine,i,p,t} = \frac{\sum_{k=1}\sum_{j=}[f_{Vine,j}(\Phi) * N_{i,p,k,j,t} * CF_{V,j}]}{\sum_{k=1} A_{Vine,i,p,k,t}} * \frac{1}{100} * \frac{44}{12}$		Equation(57)
Where：		

$c_{Vine,i,p,t}$	=	The average carbon stocks per unit area of vine plants in sample plot p in strata i within the project boundary；tCO_2-e ·hm^{-2}
$f_{Vine,j}(\Phi)$	=	The correlation equation between the biomass of vine species j and the diameter of vines at 1.3m from the ground；gd.m·per branch
$N_{i,p,k,j,t}$	=	Number of branches of species j in quadrate k, samples site p, strata i of the project; branches
$CF_{V,j}$	=	Carbon content rate of biomass of vines species j；tC·$(td.m.)^{-1}$or gC·$(gd.m.)^{-1}$
$A_{Vine,i,p,k,t}$	=	Area of quadrate k of sample plot p in project strata iin year t；m^2
i	=	1,2,3……number of project strata
p	=	1,2,3……sample plot of strata i
k	=	1,2,3……quadrate of sample plot p
j	=	1,2,3……vine species j
t	=	1,2,3……number of years since the project began；a
$\frac{1}{100}$	=	Correlation for converting g·m^{-2} to t·hm^{-2}
44/12	=	Molecular weight ratio of CO2 to C；the number of years since the project began；non-dimensional

Step 2：Calculate the estimated carbon stocks of the average unit area of vine biomass in each strata of the project and its variance, refer to Equation (48), Equation (49). Replace $c_{TREE,i,t}$ with $c_{Vine,i,t}$ ，replace $c_{TREE,i,p,t}$ with $c_{Vine,i,p,t}$ ，replace $S_{C_{TREE,i,t}}$ with $S_{C_{Vine,i,t}}$ ；

Step 3：Calculate the estimate of the overall mean value of the project within the project boundary (the estimate of the average carbon stocks of vine biomass per unit area) and its variance by referring to Equation (50), Equation (51). Replace $c_{TREE,t}$ with $c_{Vine,t}$，replace $c_{TREE,i,t}$ with $c_{Vine,i,t}$，replace $S_{C_{TREE,t}}$ with $S_{C_{Vine,t}}$， replace $S_{C_{TREE,i,t}}$ with $S_{C_{Vine,i,t}}$ ；

Step 4：Calculate the uncertainty of the estimated average unit area of vine biomass carbon stocks within the project boundary, referring to Equation (52).Replace $u_{C_{TREE,t}}$ with $u_{C_{Vine,t}}$， replace$S_{C_{TREE,t}}$ with $S_{C_{Vine,t}}$， replace $c_{TREE,t}$ with $c_{Vine,t}$；

Step 5：Calculate estimates of total biomass carbon stocks of vines within the project boundaries in year t, referring to Equation (53. Replace $C_{TREE,t}$ with $C_{Vine,t}$ ，replace $c_{TREE,t}$ with $c_{Vine,t}$ ；

Step 6：Calculate the annual variations of carbon stocks of vine biomass within project boundaries. It is assumed that the change of vine biomass is linear over a period of time. Equation (54).Replace $C_{TREE,t}$ with $C_{Vine,t}$替， replace $\mathrm{dC_{TREE(t_1,t_2)}}$ with $dC_{Vine(t_1,t_2)}$；

Step 7：Calculate the variations of carbon stocks of vine biomass within the project boundary at year t ($t_1 \leq t \leq t_2$) of the verification period, referring to Equation (55).Replace $dC_{TREE(t_1,t_2)}$ with $dC_{Vine(t_1,t_2)}$， replace $\Delta C_{TREE,t}$ with$\Delta C_{Vine,t}$。

8.8 Annex8 Method for determination of dead wood biomoass carbon stocks

This annex corresponds to section 6.1.10 of the main text.

8.8.1 Determination of dead standing wood carbon stocks

$c_{DWS,i,p,t} = c_{DWS\_TREE_{i,p,t}} + c_{DWS\_STUMP_{i,p,t}}$		Equation(58)
Where：		
$c_{DWS,i,p,t}$	=	Carbon stocks of dead standing woods of sample plot p in strata i in year t；tCO_2-e
$c_{DWS\_TREE_{i,p,t}}$	=	Carbon stocks of dead standing woods of sample plot p in strata i in year t；tCO_2-e
$c_{DWS\_STUMP_{i,p,t}}$	=	Carbon stocks of standing stumps of sample plot p in strata i in year t；tCO_2-e
i	=	1,2,3……number of project strata
p	=	1,2,3……sample sits in strata i
t	=	1,2,3……number of years since the project began；a

The dead wood means (a) dead standing wood that have lost only leaves and minor twigs; (b) dead standing wood that have lost leaves, minor twigs and twigs. For the two types of dead standing wood above, the DBH and height of each dead are measured firstly, and the carbon stocks of each tree is calculated using the method of estimating carbon stocks of living standing wood, and then multiplied by the discount factor. The carbon stocks of each dead standing wood is estimated based on the corresponding carbon stock of dead standing wood, and the carbon stocks of dead standing woods are added to the plot level($C_{DWS\_TREE_{i,p,t}}$)：

(a)dead standing woods lost only leaves and twigs: the carbon stocks of dead standing woods is the carbon stocks of the whole dead standing woods multiplied by the discount factor 0.975；

(b)dead standing wood that have lost leaves, minor twigs and twigs：the carbon stocks of dead wood is the carbon stocks of the whole living wood multiplied by the discount factor 0.80

For dead standing woods or dead standing stumps that do not meet the above two categories, the following method can be used to obtain the carbon stocks of dead stumps at the plot level $C_{DWS\_STUMP_{i,p,t}}$。 Use the scimitar test method (hit the fallen wood with the scimitar, if the blade bounces back, it is not rotten wood; If the blade enters a little, it is semi-rotten wood; The stumps are divided into three density levels, i.e. (i) un-rotten wood; (ii) semi-rotting wood; And (iii) rotten wood. Each density level is assigned a density discount factor (β), which is multiplied by the basic wood density to obtain the density of dead-standing stumps。

If the height of the standing stump is less than 4 m, determine the diameter of the middle point of each stump (D_{MID_STUMP}). If the height of the standing stump is equal to or greater than 4 meters, the chest height diameter of each stump is determined. When the height of the standing stump exceeds 4 meters, the diameter of the middle point is calculated using the following formula:

$D_{MID\_STUMP} = 0.57 * DBH_{STUMP} * (\frac{H_{STUMP}}{H_{STUMP} - 1.3})^{0.80}$		Equation(59)
Where：		
D_{MID_STUMP}	=	Diameter of the middle point of the standing stump；m
DBH_{STUMP}	=	DBH (1.3m) of the standing stump；m
H_{STUMP}	=	The height of the standing stump；m
1.3	=	Measured DBH at the height；m

The calculation method of carbon stocks of standing stump is as follows：

$c_{DWS\_STUMP,i,p,t} = \frac{44}{12} * \sum_{j=1}[CF_j * \rho_j * (1 + R_j) * \frac{\Pi}{4} * \sum_{q=1} D^2_{MID\_STUMP,j,q} * H_{STUMP,j,q} * \beta_{j,q})]$		Equation(60)
Where：		
$c_{DWS\_STUMP,i,p,t}$	=	Carbon stocks of standing stumps in strata i in year t；tCO_2-e
CF_j	=	Carbon content rate of tree species j biomass；$tC(t.d.m.)^{-1}$
ρ_j	=	Wood density of tree species j；g/cm^3
R_j	=	Ratio of below-ground biomass to above-ground biomass of species j；non-dimensional
$D_{MID\_STUMP,j,q}$	=	Intermediate point diameter of standing stumps q of species j in strata i in year t；m
$H_{STUMP,j,q}$	=	Height of standing stumps q of species j in strata i in year t；m
$\beta_{j,q}$	=	Density discount coefficient corresponding to dead stump q of species j in strata i in year t.Unless project participants have more detailed data, the following default values for density discount

		factors are used:(i)Unrotted wood=1.00；(ii)Semi-rotted wood=0.80；(iii)Rotted wood= 0.45；non-dimensional
i	=	1,2,3……number of project strata
j	=	1,2,3……species j in strata i
p	=	1,2,3……sample plot in strata i
q	=	1,2,3……standing stumps q of species j in strata i
t	=	1,2,3……number of years since the project began；a

8.8.2 Determination of dead downed wood carbon stocks

It is necessary to measure and estimate the carbon stocks of dead downed wood by using line transect method. Two transect lines with a total length of less than 100 m are arranged in the sample plot so that they intersected vertically in the center of the sample plot. The diameters of all downed wood (≥5cm) crossed with the transect lines are measured.

The downed wood are divided into three density levels according to the degree of decay, and each density level is assigned a discount factor according to the method of dead stumps. Carbon stocks of downed wood in the site is:

$c_{DWL,i,p,t} = \frac{44}{12} * \sum_{j=1} CF_j * \rho_j * \frac{\Pi^2}{8L} * \sum_{q=1} D_{j,q}^2 * \beta_{j,q}$	Equation(61)

Where：		
$c_{DWL,i,p,t}$	=	Carbon stocks of dead downed wood of sample plot p in strata i in year t；tCO_2-e
CF_j	=	Carbon content rate of tree species j biomass；$tC(t.d.m.)^{-1}$
ρ_j	=	Wood density of tree species j；g/cm^3
L	=	Total length of the transect；m
$D_{j,q}$	=	The diameter of the downed wood intersecting with the transect；cm
$\beta_{j,q}$	=	The density discount coefficient of the first decaying tree of the tree intersecting with the transline is referred to the coefficient of the standing stump；non-dimensional
i	=	1,2,3……number of project strata
j	=	1,2,3……species j in strata i
p	=	1,2,3……sample plot in strata i
q	=	1,2,3……standing stumps q of species j in strata i
t	=	1,2,3……number of years since the project began；a

8.8.3 Calculation of carbon stocks of dead wood

Step 1：Based on the measurement results of 8.8.1 and 8.8.2, the biomass carbon stocks of dead standing wood and downed wood in sample plots are accumulated to obtain the biomass carbon stocks of dead wood at the sample plot level($c_{DW,i,p,t}$)；

Step 2：Calculate the estimated carbon stocks value of the average unit area of dead wood biomass in the carbon layer of the project and its variance, refer to Equation (48), Equation (49). Replace $c_{TREE,i,t}$ with $c_{DW,i,t}$ ，replace $c_{TREE,i,p,t}$ with $c_{DW,i,p,t}$ ，replace $S_{c_{TREE,i,t}}$ with $S_{c_{DW,i,t}}$ ；

Step 3：Calculate the estimate of the total mean value of the project within the project boundary (the estimate of carbon stocks of average unit area of dead wood biomass) and its variance, referring to Equation (50), Equation (51). Replace $c_{TREE,t}$ with $c_{DW,t}$, replace $c_{TREE,i,t}$ with $c_{DW,i,t}$， replace $S_{c_{TREE,t}}$ with $S_{c_{DW,t}}$， replace $S_{c_{TREE,i,t}}$ with $S_{c_{DW,i,t}}$ ；

Step 4：Calculate the uncertainty of the estimated carbon stock of average unit area of dead wood biomass within the project boundary, referring to Equation (52).Replace $u_{c_{TREE,t}}$ with $u_{c_{DW,t}}$， replace $S_{c_{TREE,t}}$ with$S_{c_{DW,t}}$， replace $c_{TREE,t}$ with$c_{DW,t}$；

Step 5：Calculate the estimate of total biomass carbon stocks of dead wood within the project boundary in year 1, referring to Equation (53). Replace $C_{TREE,t}$ with $C_{DW,t}$ ，replace $c_{TREE,t}$ with $c_{DW,t}$ ；

Step 6：Calculate the annual change of carbon stocks of dead wood biomass within the project boundary. It is assumed that the change of dead wood biomass increases linearly over a period of time. Referring to Equation (54). Replace $C_{TREE,t}$ with $C_{DW,t}$，replace $dC_{TREE(t_1,t_2)}$ with $dC_{DW(t_1,t_2)}$；

Step 7：Calculate the variations of carbon stocks of vine biomass within the project boundary at year t ($t_1 \le t \le t_2$) of the verification period, referring to Equation(55). Replace $dC_{TREE(t_1,t_2)}$ with$dC_{DW(t_1,t_2)}$， replace $\Delta C_{TREE,t}$ with$\Delta C_{DW,t}$.

8.9 Annex9 Data and parameter need not to monitor

This annex corresponds to section 6.4 of the main text.

Data / Parameter	CF_j
Data unit：	tC(td.m.)$^{-1}$
Equation No. applied：	Equation(5)、(33)、(60)(61)

Description：	Carbon content rate of species j biomass
Source of data：	Priority selection sequence of source of data： (a) Parameters of relevant local species as determined by project participants (to be supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present; (c) Data on provincial mangrove tree species or tree groups (e.g. provincial greenhouse gas inventories); (d) Data on national mangrove tree species or tree groups (e.g., national greenhouse gas inventories); (e) Default value: 0.50. *Source: IPCC LULUCF Good Practice Guide*
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	$f_{AB,j}(DBH_j\,, H_j\,, \rho_j\,)$
Data unit：	td.m·per plant[1]
Equation No. applied：	Equation(6)
Description：	Correlation equation between aboveground biomass and DBH, tree height and wood density of species j
Source of data：	Priority selection sequence of source of data： (a) Parameters of relevant local tree species as determined by project participants (to be supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present; (c) Select from annex 11
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	ρ_j
Data unit：	g/cm^3
Equation No. applied：	Equation(6)、(8)、(9)、(60)、(61)
Description：	Wood density of species j
Source of data：	Priority selection sequence of source of data：

<table>
<tr>
<td></td>
<td>
(a) Parameters of relevant local species as determined by project participants (to be supported by transparent and verifiable information);
(b) Available, published, local or similar ecological survey data at present;
(c) Data on provincial mangrove tree species or tree groups (e.g. provincial greenhouse gas inventories);
(d) Data on national mangrove tree species or tree groups (e.g., national greenhouse gas inventories);
(e) Select default values from the following table:
<table>
<tr><th>树种</th><th>ρ_j</th><th>树种</th><th>ρ_j</th></tr>
<tr><td>白骨壤 Avicennia marina</td><td>0.62</td><td>拉关木 Laguncularia C. F. Gaertn.</td><td>0.60</td></tr>
<tr><td>木榄 Bruguiera gymnorrhiza</td><td>0.81</td><td>红树 Sharpleaf mangrove</td><td>0.87</td></tr>
<tr><td>角果木 Ceriops tagal</td><td>0.85</td><td>红茄苳 Rhizophora mucronata</td><td>0.83</td></tr>
<tr><td>海漆 Excoecaria agallocha</td><td>0.41</td><td>杯萼海桑 Sonneratia alba J.Smith.</td><td>0.47</td></tr>
<tr><td>小叶银叶树 Heritiera parvifolia Merr.</td><td>0.86</td><td>无瓣海桑 Sonneratia apetala</td><td>0.50</td></tr>
<tr><td>银叶树 Acacia leucophloca</td><td>0.84</td><td>木果楝 Xylocarpus Granatum</td><td>0.61</td></tr>
</table>
Data source：Coastal blue carbon: methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrasses
</td>
</tr>
<tr><td>Measurement procedure：</td><td>Not applicable</td></tr>
<tr><td>Other comments：</td><td></td></tr>
</table>

Data / Parameter	R_j
Data unit：	non-dimensional
Equation No. applied：	Equation(6)、(9)、(10)、(60)
Description：	Ratio of below-ground biomass to above-ground biomass of species j

Source of data：	Priority selection sequence of source of data： (a) Parameters of relevant local tree species as determined by project participants (to be supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present; (c) Data on provincial mangrove tree species or tree groups (e.g. provincial greenhouse gas inventories); (d) National data on mangrove tree species or tree groups (e.g., national greenhouse gas inventories).
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	$f_{AR,j}(h)$
Data unit：	td.m.
Equation No. applied：	Equation(7)
Description：	Allometric equation of respiration root biomass and respiration root height of species j
Source of data：	Priority selection sequence of source of data： (a) Parameters of relevant local tree species as determined by project participants (to be supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present; (c) Data on provincial mangrove tree species or tree groups (e.g. provincial greenhouse gas inventories); (d) National data on mangrove tree species or tree groups (e.g., national greenhouse gas inventories).
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	$f_{TB,j}(DBH_j, H_j, \rho_j)$
Data unit：	td.m·per plant
Equation No. applied：	Equation(8)

Description：	Correlation equations of whole plant biomass and DBH, tree height and wood density pf species j
Source of data：	Priority selection sequence of source of data： (a) Parameters of relevant local tree species as determined by project participants (to be supported by transparent and verifiable information); (b) available, published, local or similar ecological survey data; (c) Select from annex 11.
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	BEF_j
Data unit：	non-dimensional
Equation No. applied：	Equation(9)
Description：	Biomass expansion factor of species j
Source of data：	Priority selection sequence of source of data： (a) Parameters of relevant local tree species as determined by project participants (to be supported by transparent and verifiable information); (b) available, published, local or similar ecological survey data; (c) Data on provincial mangrove tree species or tree groups (e.g. provincial greenhouse gas inventories); (d) Data on national mangrove tree species or tree groups (e.g., national greenhouse gas inventories); (e) Default value: 3.4. *Source: IPCC LULUCF Good Practice Guide*
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	CF_S
Data unit：	$tC{\cdot}(td.m.)^{-1}$or $gC{\cdot}(gd.m.)^{-1}$
Equation No. applied：	Equation(13)(36)
Description：	Carbon content rate of shrub
Source of data：	Priority selection sequence of source of data： (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present; (c) Data on provincial shrub species (groups) (e.g., provincial GHG inventories);

	(d) Data on shrub species (groups) at the national level (e.g. national greenhouse gas inventories); (e) Default value: 0.47 *Data source：Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities(V04.2,EB 85)*
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	R_S
Data unit：	non-dimensional
Equation No. applied：	Equation(13)、(36)
Description：	Ratio of below-ground biomass to above-ground biomass of shrubs
Source of data：	Priority selection sequence of source of data： (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present; (c) Data on provincial shrub species (groups) (e.g., provincial GHG inventories); (d) Data on shrub species (groups) at the national level (e.g. national greenhouse gas inventories); (e) Default value: 0.40. *Data source：Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities(V04.2,EB 85)*
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	BDR_{SF}
Data unit：	non-dimensional
Equation No. applied：	Equation(14)
Description：	The ratio of average above-ground shrub biomass per hectare with shrub cover of 1.0 to average above-ground forest biomass per hectare in the project implementation area
Source of data：	Priority selection sequence of source of data： (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present;

	(c) Data on provincial shrub species (groups) (e.g., provincial GHG inventories); (d) Data on shrub species (groups) at the national level (e.g. national greenhouse gas inventories); (e) Default value: 0.10 *Data source：Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities(V04.2,EB 85)*
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	$CF_{v,j}$
Data unit：	tC·(td.m.)$^{-1}$ 或 gC·(td.m.)$^{-1}$
Equation No. applied：	Equation(17)、(39)
Description：	Carbon content rate of vine species j biomass
Source of data：	Priority selection sequence of source of data： (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) available, published, local or similar ecological survey data; (c) Default value: 0.46. *Data source：Coastal blue carbon: methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrasses*
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	f_{VINE}（Φ）
Data unit：	td.m·per plant
Equation No. applied：	Equation(18)
Description：	The allometric growth equation established based on the correlation between diameter and biomass at 1.3m above ground
Source of data：	Priority selection sequence of source of data： (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) available, published, local or similar ecological survey data; (c) The following default equation is used: Biomass of vine= $（\text{diameter 1.3 meter above the ground}）^{2.657} * e^{0.968*ln（\text{diameter 1.3 meter above the ground}）}$

	Data source：Coastal blue carbon: methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrasses
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	DF_{DW}
Data unit：	%
Equation No. applied：	Equation(21)、(42)
Description：	Ratio of biomass carbon stock of dead wood and living wood within the project boundary
Source of data：	Priority selection sequence of source of data： (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present; (c) Default value: 2.55. *Data source: IPCC LULUCF Good Practice Guide*
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	DV_{BI}
Data unit：	$tC{\cdot}hm^{-2}{\cdot}a^{-1}$
Equation No. applied：	Equation(22)
Description：	Conservative default factor, annual increase of mangrove biomass carbon stocks per unit area
Source of data：	Priority selection sequence of source of data： (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present.
Measurement procedure：	Not applicable
Other comments：	

Data / Parameter	DV_{BIO}
Data unit：	$tC{\cdot}hm^{-2}$
Equation No. applied：	Equation(24)

Description:	Conservative default factor, mangrove biomass carbon stocks per unit area
Source of data:	Priority selection sequence of source of data: (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) available, published, local or similar ecological survey data; (c) Select default values from IPCC relevant documents:
Measurement procedure:	Not applicable
Other comments:	

Data / Parameter	$\beta_{LUC,x}$
Data unit:	tC ·hm^{-2}
Equation No. applied:	Equation(26)
Description:	Carbon emission coefficient of mangrove forest land conversion to the land use x
Source of data:	Priority selection sequence of source of data: (a) Locally relevant data measured by project participants (supported by transparent and verifiable information); (b) Available, published, local or similar ecological survey data at present; (c) Provincial or national level data applicable to the project implementation area. (d) Default value: (see table below) *Data source: 赖力.中国土地利用的碳排放效应研究[D].南京大学,2010.*
Measurement procedure:	Not applicable
Other comments:	

Land use type	**Carbon emission coefficient(tC·hm^{-2})**
Cultivated land	3.732
Grazed grassland	4.011
Construction land	59.957
Water	-0.360
Unutilized land	7.215

8.10 Annex10 Data and parameters to be monitored

This annex corresponds to section 6.5 of the main text.

Data / Parameter	A_{BSL_i}
Data unit：	hm^2
Equation No. applied：	Equation(6)、(7)、(8)、(9)、(10)、(13)、(18)、(36)
Description：	Area of baseline strata i
Data source：	Field work measurement
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5/10 years
QA/QC：	The quality assurance and quality control (QA/QC) procedures used in the national forest resources survey should be adopted, and the area measurement error should be less than 5%
Other comments：	Presented as A_{PROJ_i} under project scenario

Data / Parameter	DBH_j , H_j
Data unit：	cm
Equation No. applied：	Equation(6)、(8)
Description：	DBH/eyebrow diameter/ground diameter, tree height
Data source：	Field work measurement
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	The height of the tree can be the height of the whole tree, or other heights, depending on the definition used in the equation

Data / Parameter	h
Data unit：	cm
Equation No. applied：	Equation(7)
Description：	Height of respiratory root of species j
Data source：	Field work measurement
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	

Data / Parameter	$CC_{SHRUB\_BSL_{i,t}}$
Data unit：	non-dimensional
Equation No. applied：	Equation(14)
Description：	Shrub cover of the project strata i inyear t
Data source：	Field work measurement
Measurement procedure：	The visual method, line transect method, tachyscopic method and so on are usually used to estimate shrub cover.
Monitoring frequency：	Monitor every 5 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	Represented as $CC_{SHRUB\_PROJ,i,t}$ under the project scenario

Data / Parameter	Φ
Data unit：	cm
Equation No. applied：	Equation(18)
Description：	The diameter of the vine at 1.3 above the ground
Data source：	Field work measurement
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys，
Monitoring frequency：	Monitor every 5 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.If there is not such resources, the procedures described in the relevant publicly published technical manuals or IPCC GPG LULUCF 2003 can be used.
Other comments：	

Data / Parameter	A_{BSL}
Data unit：	hm^2
Equation No. applied：	Equation(22)、(24)
Description：	Total area within the project boundary under baseline scenario
Data source：	Field work measurement
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5/10 years

QA/QC：	The quality assurance and quality control (QA/QC) procedures used in the national forest resources survey are adopted, and the area measurement error is less than 5%
Other comments：	Presented as A_{PROJ} under the project scenario

Data / Parameter	A_p
Data unit：	hm^2
Equation No. applied：	Equation(44)
Description：	Fixed plot area
Data source：	Field work measurement、verified
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5/10 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	

Data / Parameter	A_k
Data unit：	hm^2
Equation No. applied：	Equation(56)、(57)
Description：	Qudrate area od the fixed sample plot
Data source：	Field work measurement、verified
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5/10 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	

Data / Parameter	$DBH_{STUMP,j,q}$
Data unit：	m
Equation No. applied：	Equation(59)
Description：	DBH of standing stumps of species j in sample plot p in strata i in year t
Data source：	Field work measurement
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys

Monitoring frequency：	Monitor every 5 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	

Data / Parameter	$H_{STUMP,j,q}$
Data unit：	m
Equation No. applied：	Equation(59)、(60)
Description：	Height of standing stumps of species j in sample plot p in strata i in year t
Data source：	Field work measurement
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	

Data / Parameter	$D_{j,q}$
Data unit：	cm
Equation No. applied：	Equation(61)
Description：	Diameter of downed wood q of species j crossed with sample line
Data source：	Field work measurement
Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	

Data / Parameter	L
Data unit：	m
Equation No. applied：	Equation(62)
Description：	Total length of the sample line
Data source：	Field work measurement

Measurement procedure：	Adopt standard operating procedures used for national forest resource inventory or forest planning and design surveys
Monitoring frequency：	Monitor every 5 years
QA/QC：	Adopt quality assurance and quality control (QA/QC) procedures used in national forest resource surveys.
Other comments：	The height of the tree can be the height of the whole tree, or other heights; Depends on the definition used in the equation