

## GOVERNMENT NOTICES • GOEWERMENTSKENNISGEWINGS

## DEPARTMENT OF ENVIRONMENT, FORESTRY AND FISHERIES

NO. 1283

04 DECEMBER 2020

NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT, 2004  
(ACT NO. 39 OF 2004)**DRAFT METHODOLOGICAL GUIDELINES FOR QUANTIFICATION OF GREENHOUSE GAS EMISSIONS - CARBON SEQUESTRATION IN THE FORESTRY INDUSTRY TO SUPPORT THE IMPLEMENTATION OF THE GREENHOUSE GAS EMISSION REPORTING REGULATIONS, 2016 FOR PUBLIC COMMENT**

I, Barbara Dallas Creecy, Minister of Forestry, Fisheries and the Environment, under section 56 and section 57 of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) hereby publish for public comment, the Methodological Guidelines for Quantification of Greenhouse Gas Emissions - Carbon Sequestration in The Forestry Industry - Guidelines for Validation and Verification of Greenhouse Gas Emissions. The Guidelines can be accessed at: [https://www.environment.gov.za/legislation/gazetted\\_notices](https://www.environment.gov.za/legislation/gazetted_notices)

Regulation 10 of the National Greenhouse Gas Reporting Regulations published under General Notice No. 275 in Government Gazette No. 40762 of 3 April 2017 (the Regulations) requires data providers to report using methods set out in the methodological guidelines for quantification of greenhouse gas emissions. To this end, the Department of Environment, Forestry and Fisheries has developed methodological guidelines for quantification of greenhouse gas emissions - carbon sequestration in the forestry industry, to serve as a companion to the Regulations for data providers with forestry plantations. Members of the public are invited to submit written representations or comments, within 30 days from the date of the publication of this notice in the Gazette, to any of the following addresses:

By post: The Director-General: Department of Environment, Forestry and Fisheries  
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Any inquiries in connection with the draft guidelines can be directed to Mr Jongikhaya Witi at 012 399 9048 or 083 991 9913.

Comments received after the closing date may not be considered.



**BARBARA DALLAS CREECY**  
MINISTER OF FORESTRY, FISHERIES AND THE ENVIRONMENT



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## **SCHEDULE**

### **Methodological Guidelines for Quantification of Greenhouse Gas Emissions – Carbon Sequestration in the Forestry Industry**

A companion to the South African National Greenhouse  
Gas Emission Reporting Regulations



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### Acronyms

$\Delta C_B$	Annual change in carbon stocks in biomass
BEF	Biomass Expansion Factor
BCEF	Biomass Conversion and Expansion Factor
C	Carbon
CAI	Current Annual Increment
CF	Combustion factor
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon dioxide
CO <sub>2</sub> eq	Carbon dioxide equivalents
COC	Chain of custody
D	Density
DEFF	Department of Environment, Forestry and Fisheries
DOM	Dead organic matter (composed of dead wood and litter)
d.m.	dry matter
DW	Dead wood (sub-pool of DOM)
FES	Forest Economic Services
FSC	Forest Stewardship Council
GC	Growth curve
GHG	Greenhouse gas
GS	Gold Standard
ha	hectares
HWP	Harvest wood products
IPCC	Inter-governmental Panel on Climate Change
ISO	International Organisation for Standardisation
KP	Kyoto Protocol
LCA	Life cycle analysis
LT	Litter (sub-pool of DOM)
LULUCF	Land use, land use change and forestry
MAI	Mean Annual Increment
MRV	Monitoring, reporting and verification
N <sub>2</sub> O	Nitrous oxide
NAEIS	National Atmospheric Emissions Inventory System
NFA	National Forest Act
NGER	National GHG Emissions Regulation
NGHGIS	National GHG Information System
PAMSA	Paper Manufacturers Association of South Africa
PEFC	Programme for the Endorsement of Forest Certification
QA/QC	Quality Assurance and Quality Control
R	Ratio of below-ground biomass to above-ground biomass
S <sub>B</sub>	CO <sub>2</sub> component of biogenic fuel emissions from the combustion of biogenic fuels from plantations
S <sub>fert</sub>	Emissions from fertilisers
S <sub>fire</sub>	Emissions from fires
S <sub>HWP</sub>	Emissions/removals from HWP

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SAGERS	South Africa's GHG Emissions Reporting System
SOC	Soil organic matter
TAR	Third Assessment Report
TUP	Temporary Unplanted Areas
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard
WBP	Wood-based panels
wwt	wet white tonnes





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### Definitions

**“3rd party forests”** is defined a forest land area or ownership that is not eligible under the C Tax Act. Wood supplier for HWP production having between 1000 and 10000 ha of forest which is not-eligible in the scheme. Its participation in the scheme is only possible through eligible entities which report emissions from fossil fuels “E” under the C tax.

**“accounting”** is a method to calculate the amount of emission reduction or sequestration, following the rules defined in this rulebook, by an eligible company.

**“accounting period”** is the period over which for which emissions reduction or removals by forestry activities are reported and accounted, which is annually from 1st of January to December the 31st, submissions are due at the end of each fiscal year.

**“accounting rulebook”** refers to the Forestry Accounting Rulebook provided in Chapter B.

**“afforestation”** is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.

**“deforestation”** is the direct human-induced conversion of forested land to non-forested land (consistent with IPCC, 2014). This includes all areas that meet the forest definition (including invasive species such as wattle).

**“facility”** is a plantation management unit or manufacturing facility

**“forest”** definition from the National Forest Act (Act 84 of 1998) (NFA) states that:

- i. “forest” includes a natural forest, a woodland and a plantation (Section 1(2)(x) of NFA);
- ii. “natural forest” means a group of trees whose crowns are largely contiguous, or which have been declared by the Minister to be a natural forest (Section 1(2)(xx) of NFA);
- iii. “plantation” means a group of trees cultivated for exploitation of the wood, bark, leaves or essential oils (Section 1(2)(xxii) of NFA); and
- iv. “woodland” means a group of indigenous trees which are not a natural forest, but whose crowns cover more than five percent of the area bounded by the trees forming the perimeter of the group (Section 1(2)(xxxix) of NFA).

However, in order to facilitate a robust reporting and accounting system for forestry under the GHG Reporting Regulations, using the Marrakech Accord (2011) as a guide, a forest is defined as follows:

**“Forest”** is defined as having a minimum area of land of 1.0 hectare with tree crown cover (or equivalent stocking level) of more than 30 per cent with trees with the potential to reach a minimum height of 5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 30 per cent or tree height of 5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest.”

**“forest activity”** refers to the activities forest management, afforestation and deforestation.

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**“forest management”** is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner. **Note:** The broad definition of management shall be applied, which means including planned management of silvicultural intervention even if the forest is not currently managed.

**“gross-net accounting”** is an accounting method to calculate the accounting amount which does not consider a reference period, so it is equal to the reported gross removal/emission for a forest category over the accounting period.

**“net-net accounting”** is an accounting method to calculate the accounting amount as the reported emissions/removals over the accounting period minus the annual emissions/removals for the selected reference period.

**“liable entity”** is a Forest and forest products Company with processing facilities such as sawmills, board mills and pulp and paper mills within South Africa and that are required to report under the South African Carbon Tax Act.

**“mass-balance”** is a rule where amount entering the system is equal to amounts exiting the system.

**“methodological guidelines”** refers to the Methodological Guidelines for Land Activities in Forest Plantations provided in Chapter C.

**“MRV tool”** refers to the Carbon Tax Sequestration MRV Tool for Forest Plantations and Timber Processing Industry.

**“not a source”** is a rule that allows to exclude from accounting a carbon pool in which the C stock change is neutral or a sink (acts as removal) rather than a source (emission).

**“reference period”** is the period which is selected as representing the baseline circumstances for emission or removals level, it can be one to several successive years. It is used for net-net accounting to estimate the mean annual net emission/removal for forest over the selected period.

**“registered taxpayer”** is a person or company that is registered to account and report under the C Tax Act.

**“reporting”** is the provision of data by a taxpayer in a comparable, transparent, consistent, accurate and complete manner to DEFF for estimation of accountable CO<sub>2</sub>eq emissions/removals

**“taxpayer”** means a person or company liable for the carbon tax in terms of section 3 of the Carbon Tax Act 2019.

**“verification”** refers to the collection of activities and procedures that can be followed during the planning and development, or after completion of an inventory report that can help to establish its reliability for the intended applications of that inventory. Typically, methods external to the inventory are used to check the truth of the inventory or input parameters (Guidelines for Validation and Verification of Emissions).



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## **Chapter A: Introduction and background**

### **A.1. Introduction**

The Carbon Tax Act (Act No. 15) of 2019 (referred to as “C Tax Act” in this document) attempts to incentivise reduction of fossil fuel emissions and to increase sequestration associated with the land use and forestry sectors. This means that permanent carbon dioxide (CO<sub>2</sub>) removals from atmosphere are used to offset against emissions from the use of fossil fuels and other fugitive emission for companies reporting and accounting under the C tax scheme. In the C tax scheme sequestration represents the number in respect of greenhouse gas emissions, expressed in terms of carbon dioxide equivalent, that were sequestered in respect of that tax period as verified and certified by the Department of Environment, Forestry and Fisheries (DEFF).

Sequestration in the forestry sector can broadly be split into 3 major activities, namely a) removals in the forest C cycle (including land use change related management), b) storage of C in harvested wood products (HWP) and c) substitution of energy intensive materials or fossil fuels with timber products (Figure A.1).

Forestry activity related carbon (C) sequestration can be achieved through:

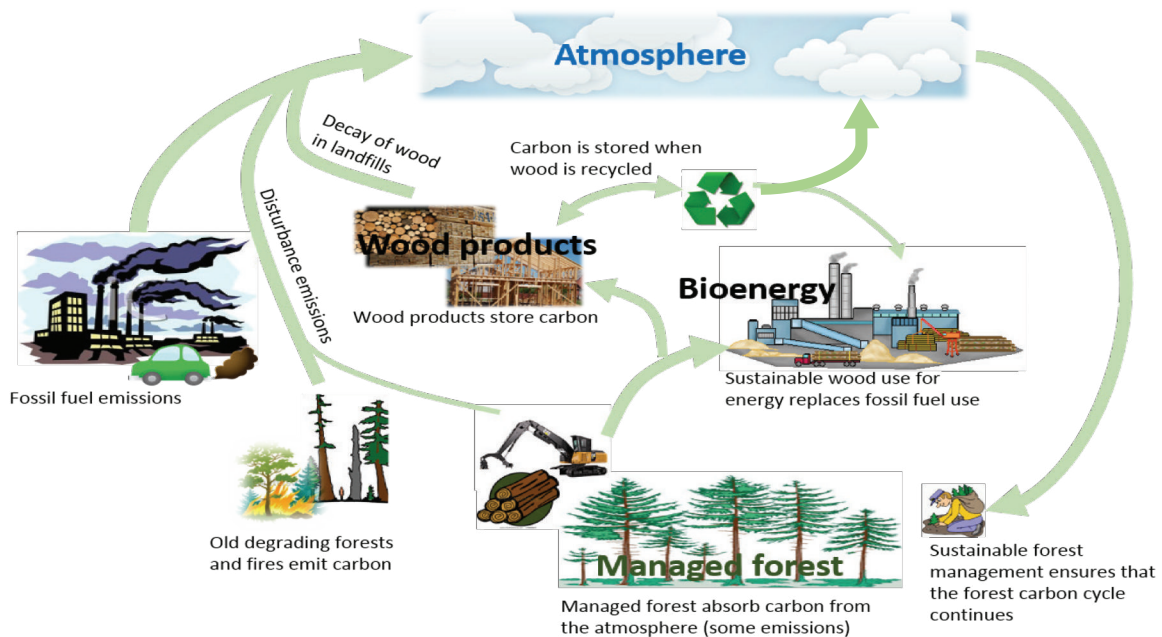
- Afforestation and reduction of deforestation;
- Extension of the rotation ages in current plantations or reduced harvest, integral harvesting and use of wood parts of the trees;
- Substitution with tree species with higher capacity of carbon uptake and storage over a rotation (e.g. faster growth, wood with higher density or increase productivity through genetic improvement);
- Manufacture of harvested wood products (HWP) from domestically produced timber;
- Production of harvested wood products with a longer lifetime or increased recycling of products in order to further delay emissions from HWP;
- Substitution of energy intensive products such as steel or cement with wood products (i.e. product substitution);
- Increase of the carbon permanently stored in the soils, deadwood and litter pools;
- Reduction of controlled biomass burning such as burning of harvest residues;
- Reduction of greenhouse gas emissions from fertiliser application.

Sequestration in the forest ecosystem is a result of the net uptake of C during photosynthesis, accumulation in the deadwood and soil pools, decomposition losses associated with turnover of C in deadwood and emission of greenhouse gasses due to disturbances (e.g. harvest, fires) and application of fertilisers. Disturbance due to management intervention has the largest impact on the C balance resulting in either net removals or net emissions of CO<sub>2</sub> into the atmosphere. One of the largest impacts on managed forest plantation C balance is the level of harvest relative to growth increment (Grassi et al., 2018). It is generally accepted that afforestation results in a net removal of CO<sub>2</sub> from the atmosphere for the first rotation, but deforestation causes emissions of similar magnitude. It is important that accounting CO<sub>2</sub> removals from atmosphere under financial mechanisms or emissions reduction mitigation action are permanent.

HWP removals are a function of manufacture of long-life timber products, which are stored in the HWP pool, and emissions from the existing (historical) HWP pool back to the atmosphere due to



product end life and cascading into other products or uses (e.g. bioenergy). HWP sequestration does not take place just by production of HWP but by adding more HWP to the pool than what is being released back to the atmosphere.



**Figure A.1: A schematic representation of GHG flows between the atmosphere and forestry related activities including forest management, disturbances, wood processing emissions, net HWP storage and product substitution.**

Product substitution is based on the concept of avoidance of emissions by replacement of processes or products using wood as a substitute (Stare and O Connor, 2010). Life cycle analysis (LCA) of wood products provides a way of measuring the CO<sub>2</sub> savings that can be made by use of wood products and replacement of high CO<sub>2</sub> emission potential products such as energy, cement etc. (Oliver, 2014). However, the accounting of product substitution is not included in C offsetting mechanisms, emission trading and C tax schemes due to methodological complexities and detailed data required to determine the extent of substitution. Potential sequestration can vary considerably depending on assumptions used and the system boundary used in the LCA (Stare and O Connor, 2010).

In order for emissions and removals to be accounted under International Climate Change Targets (e.g. Kyoto Protocol), C trading platforms or C tax schemes, certain well adopted principles should be adhered to such as permanence, additionality, leakage, robustness and avoidance of double accounting. Permanence of accounted removals is a particularly complex issue to address in the context of forest activities. All accounted forest and HWP removals should in principle be permanent to reflect real removals from the atmosphere. In this context, the relationship between emissions associated from harvest from forestland, the production of HWP and the decomposition of the HWP pool needs to be taken into account (i.e. accounting must ensure mass balance of relevant C flows).

Additionality is another principle which is difficult to deal with in the land use sector, in particular, accounted removals should be directly human induced and additional to historical trends to ensure



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that effective emission reduction to the atmosphere are real and fully attributable to the concerned activity. This requires consideration of base line, and reference level accounting frameworks, such as gross net or net-net accounting (Grassi et al., 2018; 16CMP/1<sup>1</sup>, 2CMP/7 and 8).

This chapter outlines the concepts, accounting principles, specific forest industry considerations and concerns and the justification of proposed accounting rules for accounting forest and HWP emissions/removals under the South African Carbon Tax Act of 2019.

## **A.2. System boundary**

The scope of this guideline is to only consider an accounting framework for forest and HWP related emissions and removals in the South African plantations and timber processing sector. The accounting of emissions associated with wood processing and use of fossil fuels (defined as “E” in the C Tax Act) have already been developed under the C Tax Act and are not considered.

In order to account for sequestration activities accounting for plantation management and wood processing (i.e. “S”), all C pools (biomass, deadwood, litter, soils and HWP) and non-CO<sub>2</sub> emissions such as those from fires, management of soils, fertiliser and lime application in activities are considered based on internationally established methods (IPCC, 2006). Specific novel approaches are, however, explored to facilitate company-based accounting under the C Tax Act.

Ownership and liability of emissions and removals is a key system boundary consideration. Although the C Tax Act lays out the criteria for eligibility, careful consideration on how timber flows from small and non-eligible plantation owners are included in the accounting framework without creating a reporting burden on owners with limited resources. This aspect has not been extensively explored in the C Tax Act, we propose new criteria for eligibility under the C Tax Act to address these issues. Rules defined here also observe avoiding double-accounting or leakage.

## **A.3. Legislative Framework**

### **A.3.1. National Greenhouse Gas Emissions Reporting Regulations**

The National Greenhouse Gas Emission Reporting Regulations (NGER) published under the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) were gazetted on 3 April 2017. Amendments to the regulations were issued for public comment on 6 September 2019 but have not yet been promulgated. Annexure 1 of the amended regulations list the activities and thresholds for which GHG emissions must be reported. The NGER serves as a reporting framework under international obligations.

Plantations meeting the area threshold specified in the NGER are required to register in the South African GHG Emissions Reporting System (SAGERS) (which is part of the National Atmospheric Emissions Inventory System (NAEIS)). Plantation activity data and emission factors will be reported through the reporting templates and this data will be utilized to improve the National GHG Inventory for carbon tax reporting and for international reporting.

<sup>1</sup> <https://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf>



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### A.3.2. The Carbon Tax Act 2019

The C Tax Act serves as an accounting framework at the company scale. The legal basis for this is the Carbon Tax Act (Act No. 15 of 2019) which came into effect from 1 June 2019. Amendments to the Act were gazetted on 31 October 2019.

Section 6 (1) sets out the formula for calculation of the tax payable by a taxpayer in respect of a tax period.

$$X = < \{[(E - S) \times (1 - C)] - [D \times (1 - M)]\} + \{P \times (1 - J)\} + \{F \times (1 - K)\} > \times R$$

**Equation A.1**

The variables in the above formula are:

- (a) "X" represents the amount to be determined that must not be less than zero (i.e. No tax credits are issued if X is a net removal of CO<sub>2</sub> from the atmosphere);
- (b) "E" represents the number in respect of the total fuel combustion related greenhouse gas emissions of the taxpayer in respect of that tax period expressed as a carbon dioxide equivalent;
- (c) "S" represents the number in respect of greenhouse gas emissions, expressed in terms of carbon dioxide equivalent, that were sequestered in respect of that tax period as verified and certified by the Department of Environment, Forestry and Fisheries (DEFF);
- (d) "C" represents a number equal to the sum of the percentages of allowances determined under sections 7, 10, 11, 12, and 13 of the C Tax Act in respect of that tax period, subject to section 14 of the act;
- (e) "D" represents the number in respect of the petrol and diesel related greenhouse gas emissions of that taxpayer in respect of that tax period expressed as a carbon dioxide equivalent, determined in terms of section 4(1) of the act.
- (f) "M" represents a number equal to the sum of the percentages of the allowances determined under sections 7, 12 and 13 in respect of that tax period, subject to section 14 of the tax act;
- (g) "P" represents the number in respect of the total industrial process related greenhouse gas emissions of the taxpayer in respect of that tax period expressed as a carbon dioxide equivalent determined in terms of section 4(1) or (2)(c) of the tax act;
- (h) "J" represents a number equal to the sum of the percentages of the allowances determined under sections 7, 8, 10, 11, 12 and 13 in respect of that tax period, subject to section 14 of the tax act;
- (i) "F" represents the number in respect of the total fugitive greenhouse gas emissions of the taxpayer in respect of that tax period expressed as a carbon dioxide equivalent determined in terms of section 4(1) or (2)(b) of the act;
- (j) "K" represents the sum of the percentages of the allowances determined in terms of sections 7, 9, 10, 11, 12 and 13 in respect of that tax period, subject to section 14 of the tax act; and
- (k) "R" represents the rate of tax prescribed under section 5 of the tax act.

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GHG emissions represented by the variable “E” in the formula are calculated in accordance with the methodology set out in the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry (DEA, 2017).

The applicable allowances for listed activities that are summed to calculate variable “C” are set out in Schedule 2 of the Carbon Tax amendments.

Key points included in the C Tax amendments that are relevant to the forestry sector are:

- a) Schedule 1: Biogenic fuels that include wood/wood waste, sulphite lyes (black liquor), other primary solid biomass, charcoal, bio-gasoline, biodiesels, other liquid biofuels, landfill gas, sludge gas, other biogas and municipal waste (biomass fraction) report CO<sub>2</sub> emissions separately **and are not included** in the CO<sub>2</sub> emission totals (namely in “E”). The calculated values for N<sub>2</sub>O and CH<sub>4</sub> are included in the calculation for the variable “E”.
- b) Schedule 2: All activities listed under IPCC Code 3 (Agriculture, Forestry and other land use) and Code 4 (Waste) are discounted with a 100% allowance.
- c) The threshold for reporting by plantations is set out as >100 ha in the NGER and the Carbon Tax Act.

Although the variable “S” is included in the formula, the calculation method is not defined. The guidelines to be developed within this project will develop the methodology for measurement and verification.

Although the calculation of “S” is not explicitly outlined in the C Tax Act, there are a number of elements in the Act that pertain to eligibility of forest plantations and sector owners/companies and which define the system boundary of a forest accounting system (Table A.1). These elements can be directly used to define some accounting rules since they are already defined in law.

**Table A.1: Elements extracted from the 2019 C Tax Act, amendments to the act (B18-2019) and proposed further amendments (appendix 1) which have relevance to accounting rules**

Element	Rule relevant to forestry rules [relating to]	Reference in C tax act 2019	Rule clarification required
Adjustment to (E-S). The current act caps the term (E-S) in the case where $S > E$ . However, the basic emission tax free allowances in schedule 2 relating to forestry indicate that net emission for forestry categories are discounted at 100%	No, but relevant to overall accounting.	Item 6 (k) pg 14 of the Act and schedule 2 of the Act	Proposed amendment to the act (see Annex A) "If the sum of subcategories 3B1a, 3B1b, 3C1a, 3C4, and 3D1 is an accountable net emission then "(E-S)"=E."
CO <sub>2</sub> emissions from combustion of wood, wood waste and biogenic liquids is zero	No, N <sub>2</sub> O and CH <sub>4</sub> emissions from combustion of wood and wood waste are included in "E" in eq.1 [applicability, relevance]	Schedule 1, Table 1 pg 45 in amendments to the Act (B18-2019)	Yes, black liquor (sulphite lyes) CO <sub>2</sub> emissions are excluded.
Fossil fuel emissions from manufacture of wood and wood products has a 60% allowance	No, this refers to fossil fuel emissions included in "E" so does not relate to biogenic emissions [applicability, relevance]	Schedule 2 pg 48 of the Act 2019 (May 2019)	No
Exclusion of processing emissions from production of harvested wood products (HWP)	Emissions from production of HWP (P in eq. 1) are excluded from taxation due to a 100% allowance for CO <sub>2</sub> (U). Note CH <sub>4</sub> and N <sub>2</sub> O emissions are reported under "E" [applicability, relevance]	Schedule 2, Table 3 pg 60 of the Act	Yes, are CO <sub>2</sub> emissions for biogenic fuel sources to be reported, but not accounted under the C Tax Act

Owners with forest of areas greater than 1000 ha and less than 10 000 ha are required to register, and owners with areas equal or greater than 10 000 ha of plantation and required to register and report	Yes, provided a threshold for participation in, the use of "S" only if lands owned or leased by a company are equal to or greater than 10 000 ha [eligibility]	Schedule 2 pg 58 of the Act	Yes, need to create rules regarding eligibility, permanence, leakage avoidance and additionality (direct human induced in relation to natural unmanaged forests) using the threshold defined in the C Tax Act or re-define provide for enhanced? eligibility criteria (see System Boundary section)
The threshold for HWP category 3D1 is N/A	Yes, the current act excludes HWP, but proposed amendments to the threshold will include HWP	Schedule 2 pg 60 of the Act	Yes, need to create rules to include HWP but potential sequestration must be linked to harvest emissions in related forest areas. Rules to differentiate between company own and third party wood sources.
The thresholds for biomass burning, direct and indirect emission from managed soils categories 3C1a, 3C4 and 3 C5 are N/A	Yes, but these emissions are excluded, proposed amendments to the threshold will include reporting of these emissions (appendix 1)	Schedule 2 pg 60 and 63 of the Act	Yes, the 100% tax free emission allowance means that these emissions are reported but not accounted
Thresholds for waste treatment in processing	Yes	Schedule 2 IPCC code 4	Excluding the reporting of emission below waste thresholds. However, emissions from the waste sector only include CH <sub>4</sub> and N <sub>2</sub> O. C waste emissions need to be reported under HWP but not accounted (the tax free emission allowance is set at 100%)



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### A.4. Existing forest industry frameworks

A number of existing forest data resources and certification schemes have been suggested to be suitable for inclusion and/or adaption for reporting and accounting requirements under the C Tax Act:

- a) The Forestry Economics Services (on behalf of DEFF) collects all plantation and timber production data as legally required in terms of Regulation 19 made by the Minister of Agriculture, Forestry and Fisheries under the provisions of Section 6(1) and Section 6(3) of the National Forest Act, 1998 (Government Gazette No 32185, dated 29 April 2009). This data is submitted by all company and state owned plantations in electronic format on a form referred to as the “Green Mamba” form. This is the primary data source on forestry statistics, such as the Forestry South Africa Handbook. The project has considered the inclusion of data in the reporting format outlined in the Green Mamba forms. Forest products chain of custody standards (COC) and certification (PEFC and FSC) demonstrates that registered company produces source timber from controlled, well managed forest resources. The forestry industry suggests that COC or certification should be used as a proxy for sustainable timber production, preservation of forest C stocks and that these mechanisms could be incorporated in an accounting framework. However, this approach has drawbacks:
  - Since COC or certification uses sustainability indicators to assess adherence to the schemes, this is often misinterpreted that timber is sustainably produced, while at best it could be described as responsible management with no causative link with carbon sequestration as an ecosystem service. For example, FSC criteria<sup>2</sup>, under the S.A. standard, does not assess harvest relative to volume increment, a core sustainability indicator linked to forest C budgets (Grassi et al, 2018). Moreover, C sequestration is not listed as one of the ecosystem criteria under the FSC standard.
  - The assumption that certified plantations would not be a net emission for any reporting period does not hold. In fact, nearly 60% of the worlds certified forests and plantations are in Europe. Some member state GHG inventories report that net emissions or a decline in forest C stocks since 1990 (UNFCCC<sup>3</sup>). The same can be seen in the emission/removal trends for the South African, which shows that annual forest stock changes are a net emission and that C stocks have generally declined despite participation on COC and certification schemes.
  - Not all timber suppliers to the processing facilities are certified<sup>4</sup>. In South Africa approximately 76% of the plantations areas are owned or managed by large companies, 95% of which are certified. Another 20 % of the plantation area is owned by commercial farmers or family companies (typically between 100 and 5,000 ha). Only 30% of these areas are covered by one of the four certification schemes and nearly no small growers are covered by a scheme. This means that even if certification was used as a proxy to ensure harvested 3<sup>rd</sup> party and non-registered forest areas

<sup>2</sup> <https://fsc.org/en/document-centre/documents/resource/319>

<sup>3</sup> <https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019>

<sup>4</sup> Source SA Forestry Online [http://saforestryonline.co.za/articles/environment/how\\_effective\\_is\\_forest\\_certification/](http://saforestryonline.co.za/articles/environment/how_effective_is_forest_certification/)



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(under the C Tax Act) are replanted and “responsibly” managed, most on the 3<sup>rd</sup> party timber sources supplied to manufacturing facilities may still not be certified.

- Participation in COC or a certification scheme does not guarantee permanence of accounted removals because certification may not be renewed following subsequent audits.

Despite the above-mentioned difficulties, it is acknowledged that COC and certification could be used in cases where the risk of non-permanent accounting of removals is low, such as in the case of 3<sup>rd</sup> party forest emissions and removals and inflows into HWP storage (see Accounting Rules in Chapter B). However, 3<sup>rd</sup> parties can only be included if proof of certification is provided and that the burden of reporting and accounting is put on the company accounting for “S” under the C tax scheme.

### A.5. Defining the Variable “S” and system boundaries

The previous “Technical guidance for the reporting of GHG emissions from plantation forests, biogenic fuels and harvested wood products within the South African plantation forest and forest products sector” (Knowles and Christie, 2018) defines the net sequestration by forest and forest products (“S”), as:

$$S = S_B + S_{HWP} - \Delta C - S_{fire} - S_{fert} \quad \text{Equation A.2}$$

Where:

- $S_B$  = CO<sub>2</sub> component of biogenic fuel emissions from the combustion of biogenic fuels sourced from South African plantations (e.g. wood, bark, black liquor) expressed in t CO<sub>2</sub>eq. Note that this excludes non-CO<sub>2</sub> emissions but these are reported and accounted under ‘E’;
- $S_{HWP}$  = CO<sub>2</sub> emissions or removals by harvested wood products (expressed in t CO<sub>2</sub>eq);
- $\Delta C$  = Annual change in plantation carbon stocks (expressed in t CO<sub>2</sub>eq);
- $S_{fire}$  = Emissions from controlled burning and wildfires (N<sub>2</sub>O and CH<sub>4</sub> expressed in t CO<sub>2</sub> eq);
- $S_{fert}$  = The fraction of emissions from applied fertiliser (N<sub>2</sub>O expressed in t CO<sub>2</sub>eq).

Subsequent to the compilation of the Knowles and Christie guideline document, the amendments to the C Tax Act define biogenic fuels as a net zero CO<sub>2</sub> emission assuming that sources are renewable. In addition, through the implementation of a mass balance methodology of  $S_{HWP}$ , biogenic fuel use and CO<sub>2</sub> emissions are included in this calculation. Since the conventions for net removals of CO<sub>2</sub>eq under the UNFCCC that emissions are denoted as a positive value and sequestration as a negative value, both  $S_{HWP}$  and  $\Delta C$  should have negative values in equation A.3, to denote net removals of CO<sub>2</sub>eq. Equation A.2, therefore, becomes:

$$S = -S_{HWP} - \Delta C - S_{fire} - S_{fert} \quad \text{Equation A.3}$$





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Emissions from fires and fertilisation are to be reported under the C Tax Act, but these emissions are not included in the final tax account as the C Tax Act fully discounts these emissions (see equation A.4). The rationale for reporting (under the C Tax Act) but not accounting for these emissions is that baseline data is required to develop more suitable accounting procedures in the future. Fertiliser emissions may be excluded from reporting (under C Tax Act) in future if they are found to be insignificant, but the initial reporting is required to determine if these emissions are below the significance threshold. Fire is to be reported so that a background level can be determined in order to exclude wildfire emissions in future (see section A.12.4 for method suggestions for excluding wildfire). On the other hand, fire and fertilisation emissions may also be included for accounting if determined to be significant and if the C Tax Act is reviewed. Equation A.3 is therefore rewritten as:

$$S = -S_{HWP} - \Delta C - \left[ S_{fire} - \left( S_{fire} \times \frac{D}{100} \right) \right] - \left[ S_{fert} - \left( S_{fert} \times \frac{D}{100} \right) \right] \quad \text{Equation A.4}$$

D is the current discount defined in the act (Schedule 2, C Tax Act of 2019), which is 100% for emissions from fires and fertiliser application. Equation 4 excludes emissions associated with forest lands in the IPCC guidelines, which are considered to be negligible in South Africa. These include:

***Nitrogen mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils ( $F_{SOM}$ ) (du Toit et al, 2016). However,  $F_{SOM}$  can directly calculated from soil C stock changes under  $\Delta C$  (equation A.4) and included in the future if considered to be significant (see***



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- a) Table A.2).
- b) CO<sub>2</sub> emissions associated with lime application is not a practice of SA plantations.

#### **A.6. Principles of a Robust GHG Accounting System**

The Intergovernmental Panel on Climate Change (IPCC), the International Organisation for Standardisation (ISO), the Verified Carbon Standard (VCS), the Gold Standard (GS) as well as South Africa's National Atmospheric Emission Inventory System (NAEIS) and National GHG Inventory Management System (NGHGIS), among others, have adopted the common principles of relevance, significance, completeness, consistency, accuracy, transparency and comparability. These principles should be applied to entities accounting for "S" under the C Tax Act.



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**Table A.2: Common principles informing the scope and structure of organization GHG inventories.**

Common Reporting Principles*	Description (as defined in ISO 14064-1)
Relevance	Select the GHG sources, GHG sinks, GHG reservoirs, data and methodologies appropriate to the needs of the intended user.
Completeness	Include all relevant GHG emissions and removals. Include all relevant information to support criteria and procedures.
Consistency	Estimations of GHG stocks, emissions and removals should be done consistently across time and space
Comparability	Enable meaningful comparisons in GHG-related information over time and across different data providers
Accuracy	Reduce bias and uncertainties of parameters used and accounted amounts as far as is practical
Transparency	Disclose sufficient and appropriate GHG-related information to allow intended verifiers to make decisions with reasonable confidence and reporting and accounting rules have been adhered to.
Significance	An emission for a pool or source may only be excluded from reporting and accounting if it is smaller than a significance threshold which is a fraction of the total emission and removals. Following the UNFCCC guidelines (art 37(b) of decision 24/cp19), the significance threshold is <0.05% of the total emissions for both "E" and "S" (i.e. sum of absolute emissions from "E" and "S").
Adherence to the IPCC Guidance (AFOLU 2006 and KP-supplement 2013)	The IPCC guidance provides the reporting methodology which is broadly adopted under the forestry reporting rulebook (Annex B). This is important in cases where models may be used or where company specific factors are used in calculation emissions and removals. Note: some IPCC guidance is not followed in detail, such as HWP (see section A.8.3)

\*These common principles are shared by IPCC, ISO, VCS, CDM, GS, GHG Protocol as well as South Africa's National Atmospheric Emissions Inventory System (NAEIS) and National GHG Inventory Management System (NGHGIS).

***Additional considerations on overriding principles should be adhered to when a framework for robust accounting of GHG emissions and removals is developed (***

Table A.3). These principles are based on international agreements, such as the Paris Agreement, agreements from other UNFCCC Conference of the Parties (particularly 16CMP/1<sup>5</sup>, 2CMP/7 and 8), the voluntary market principles and climate change policy drivers behind the C Tax Act.

<sup>5</sup> <https://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf>



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**Table A.3: Common principles adopted when developing a robust carbon accounting system and considerations specific to accounting of forest land under the C Tax Act.**

Accounting principles	Considerations
Eligibility	<p><b>Forest definition:</b> The forest definition should be consistent with the National forest definition but with additional criteria to ensure robust reporting of areas.</p> <p><b>Ownership and liability:</b> Tax act thresholds stipulate that plantation forests eligible for registration and define liability for removals or emissions.</p> <p>Eligibility should ensure that the mass flow of C between HWPs and forest land C budgets are maintained.</p>
Permanence	<p><b>Once in, always in principle:</b> Once emissions and removals are accounted for in a unit of forest land these areas and pools should be continued to be reported and accounted throughout the accounting period and for subsequent accounting periods.</p> <p>Permanence has important implications on the treatment of deforestation and decay of accounted HWP removals</p>
Accounting periods and intervals	Reporting Periods and intervals pursuant to the Carbon Tax Act
Robustness	The treatment of any accounted activities be based on sound science, that mass balance is conserved and accounting should ensure emissions or removals are verifiable.
Additionality	<p>That the mere presence of carbon stocks be excluded from accounting.</p> <p>That accounting excludes removals resulting from indirect human activities: (i) elevated carbon dioxide concentrations above their pre-industrial level; (ii) indirect nitrogen deposition; and (iii) the dynamic effects of age structure resulting from activities and practices before the accounting year.</p> <p>This is an important consideration when deciding on appropriate accounting rules, such as gross-net or net-net accounting and the rules for HWP accounting.</p>
Incentives and policy alignment:	Accounting framework should consider other policies such as those set out under the national framework, UNFCCC and the Paris Agreement (e.g. action plans) but also incentivise companies to enhance forest sinks and reduce emissions without being unfairly penalized for current and historical management practice.
Leakage	Increased emissions of GHGs or decreased removals should not result outside the accounting framework boundary. For example: use of timber sources from outside the geographical of South Africa for production of HWPs or timber from non-reporting or unregistered entities could result



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	in increased emission or deforestation in other regions or from forest lands non-certified for sustainable management.
Double accounting avoidance	Emissions or removals shall not be accounted twice. For example, already produced pulp, recycled pulp or paper from another production facility cannot be used as a carbon inflow into the HWP pool for the reporting entity.

## A.7. Challenges faced when implementing carbon accounting system at the company level

### A.7.1. Eligibility and liability

The use of an area threshold as a criterion for accounting forest and HWP emissions/removals (C Tax Act October 2019) has implications regarding inclusion of timber to HWP from non-eligible, 3<sup>rd</sup> party, forest owners. The major forest companies who will account for HWP removals can only include timber produced by eligible companies under the Act (from own wood land and leased land), estimated to be ca. 80% or less of the annual harvest. This is because the emissions associated with harvest have to be linked to removals associated with HWPs to ensure balanced and robust accounting.

Another issue is that the area-based criteria also does not consider related eligibility to account for "E" under the act. It is possible in the future that a wood product manufacturer has to account for emissions from "E" but cannot account for potential forest removals if the forest areas they own falls below the area threshold.

It is therefore, proposed that the area threshold currently used in the C Tax Act should be removed and eligibility to account should be solely based on the threshold related to processing and fossil fuel emissions "E" (Figure A.2, option A).

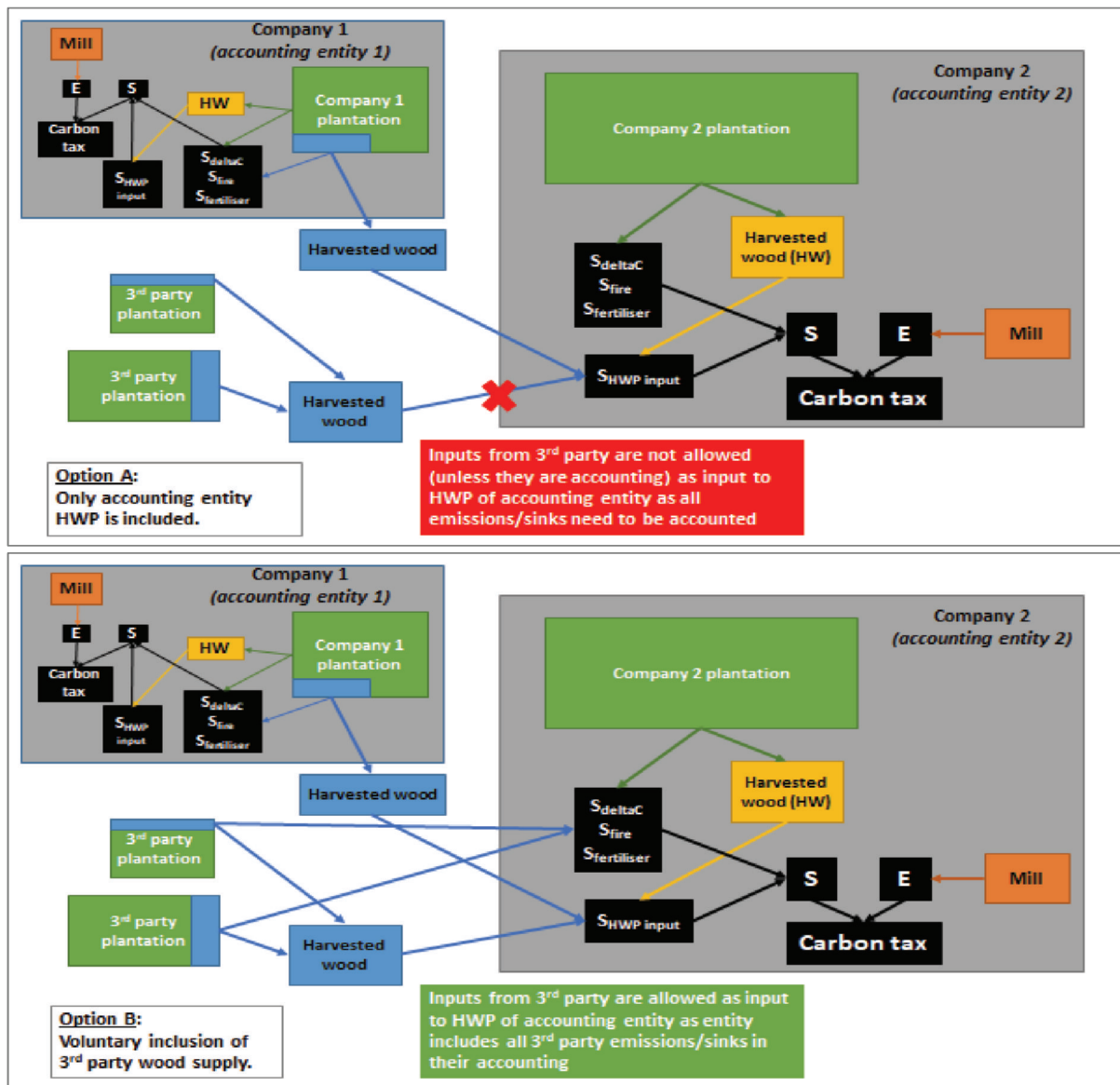
During the consultation, the forestry industry indicated that it would be important to include all wood flows into the HWP pool as there were concerns that the market would be biased as companies would lean towards purchasing wood from accounting companies. This may cause smaller plantations to be disadvantaged. As discussed, emissions associated with such harvest would need to be included to ensure permanence. In order to try to accommodate this an additional voluntary clause in proposed framework where non-eligible 3<sup>rd</sup> party timber inflows can be included in the HWP accounting by eligible companies (Figure A.2, option B) provided that the following conditions are met:

- Ownership of HWP removals and emissions is assigned to the wood processing company;
- 3<sup>rd</sup> party forest emissions associated with the harvest timber inflows into the HWP pool are accounted;
- There is no double accounting if timber is supplied to two or more registered companies accounting for HWP;
- All timber from 3<sup>rd</sup> parties must be registered with COC or certified from sustainability perspective (i.e. replanting to occur after harvesting within the legal 5-year period). This is a departure from the NGER but ensures harmonisation between land ownership and industry related emissions.



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**Figure A.2: Illustration of the process for accounting excluding (Option A) and including (Option B) voluntary 3<sup>rd</sup> party HWP inputs.**

The proposed accounting options for eligible HWP inflows is presented in Figure A.2. Option A only considered eligible companies under the C Tax Act. Option B includes a voluntary inclusion of 3<sup>rd</sup> party HWP inflows as long as 3<sup>rd</sup> party forest emissions/removals are also reported and accounted.



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### A.7.2. Reporting of 3<sup>rd</sup> party emissions/removals by accounting entity

The forestry industry expressed concern around the reporting of 3<sup>rd</sup> party emissions/removals by an accounting entity, since the NGER stipulates that an entity reports for emissions/sequestration on activities over which they have operational control. Their view is that an entity cannot therefore report on behalf of a plantation ownership that will be required to register and report independently. The forestry industry suggests using the chain of custody (COC) be used for inclusion of 3<sup>rd</sup> party HWP by the accounting entity instead of having the accounting entities report the 3<sup>rd</sup> party emissions/removals.

In response, operational control is stipulated in the NGER, however, these rules are for accounting under the C Tax Act and are guided by the text in the Act. In the C Tax Act, it is only those companies that have “E” that will be accounting for the “S”, so companies with plantations only will not be reporting and accounting independently under the C Tax Act. As indicated in the section A.8.1. above it is proposed that the area threshold be removed from the C Tax Act and replaced with entities with “E” so as not to cause confusion between the two legislations. Further to this, the reasons that COC cannot be used instead of reporting is discussed in section A.A.4. . Therefore the only two options for accounting are presented in Figure A.2.

### A.7.3. HWP accounting

The HWP first order decay approach for semi-finished HWP (IPCC, 2006) proposed by Knowles and Christie, (2018) for use under the C Tax Act, has numerous drawbacks when implemented at company scale:

- a) Application of the first order decay approach means that emissions from previously historically produced HWP must be accounted in subsequent years. If there is change of ownership or where a company may exceed the eligibility threshold to the account for “E” for the first time, then newly registered companies (persons) are being debited for emissions created by previous owners or historical HWP inflows that were not accounted. Ownership is a key eligibility criterion under the C Tax Act. Therefore, annual accounting requires the accounting of removals and all emissions associated with production and use of the HWP in the year when HWPs are manufactured so to ensure that permanence principles are adhered to. The IPCC approach can be applied at the company level for annual accounting but this would require the reporting and accounting of emissions from HWP produced in previous years (for many decades or since establishment).
- b) The IPCC semi-finished product approach to allocate timber harvest to wood product does not consider company level processing efficiencies in conversion or raw timber to products. A recent South African study (Adu Poku, 2015) provides process specific mass flow approaches and conversion factors for the paper industry and similar approaches can be applied to the sawlog processing industry. Previous studies show that more detailed timber allocation models to finished products provide more accurate removal estimates when compared to the IPCC semi-finished product approach based on FAO data (Aleinikovas et al., 2018). The mass flow approach, proposed by Adu Poku (2015) appears to be the best option for the South African industry.
- c) The IPCC methodology (2006) does not clearly outline the assumptions used when determining the life time (half-life) of wood and wood products. The methodology assumes a time constant (half-life) and that the product life goes to recycling or waste or burning etc.





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In South Africa, it is estimated that ca. 68% of paper is recycled<sup>6</sup>, but recycled paper should not be considered as an emission (Vácha, 2011). To account for recycling, a large proportion of paper should be reallocated to the recycled inflow pool every year or the half-life decay should be applied to 32% only. The same would apply to solid wood cascading and recycling, but there are no known national studies on detailed life cycle analysis in wood products.

Consequently, the **proposed accounting rules advocate to use the mass flow approach** (Adu Poku, 2015) with product efficiencies and flow factors derived from South African studies (Adu Poku, 2015; Christie and Sholes, 1995) supplemented by international data where data is not available (UNECE/FAO, 2010). Mass flow approach means that the total amount of C entering the system (e.g. round wood and recycled paper) equals the sum of C outputs from the system (e.g. in sawn-wood, gaseous emissions from burning wood). The application of method for accounting for emissions from HWP emissions is discussed in section A.8.3.

### A.7.3.1. C stock and Emissions from HWPs

*HWPs are included in "S" as a potential sequestration because removals are deemed to be permanent and that credits cannot be accounted simply do to the creation of C stocks (*

Table A.3:). **HWP sequestration does not take place just by production of HWP but by adding more HWP to the pool that what is being released back to the atmosphere, so accounting should be based on removals and emissions or a stock change from year to year (IPCC, 2006).**

The industry claims that ownership is the key liability for accounting of emissions for corporate/company, so the consumer should be responsible for all related emissions. However, there are numerous drawbacks and risks associated with this proposal:

- a) **Equal treatment of all sectors:** Long term retention of C in manufactured products are considered viable for annual accounting if the product life cycle is more than 1 year. Therefore, sequestration from production of charcoal, firewood, matches and other biogenic compounds in the food sector (for example) are excluded from the C Tax Act because they are considered as short-term products due to the relatively fast decay of the products after production and sale to the consumer. **Emissions from these products are, therefore, implicitly accounted.** Although paper and other HWP have long lifecycles, the decay of the created HWP pool should be accounted to ensure permanence and **so that accounting rules are applied equally across all sectors.**
- b) **Removals must be permanent (so there is an actual benefit for the atmosphere, i.e. less CO<sub>2</sub>).** For HWP removals to be permanent, emissions from the HWP pool must be considered. If the ownership principle is applied, then all future emissions from HWP should be accounted under the waste sector. However, waste emissions are not included in the C Tax Act due the methodological complexity. Therefore, if emissions cannot be accounted under the forest sector then all removals and emissions should be excluded from the act due to methodological complexity and to ensure that removals are permanent. This, again, is consistent application of rules to all sectors.

<sup>6</sup> <https://www.thepaperstory.co.za/south-africas-paper-recycling-rate-rises-to-68-4/>



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- c) **Robust accounting.** If no emissions are applied to all HWP, then the accounting framework does not acknowledge extensive scientific evidence<sup>7</sup> that solid wood products have longer life-cycles than paper. The discount under the act already excludes biogenic and waste emissions for HWP manufacturing. Therefore, the paper industry will be able to claim the same amount of credits per t C of product as the sawn wood and wood-based panel manufacturing facilities. This is contrary to the scientific literature.
- d) **Baseline approach.** Fact that various industrial entities produce various HWP with different climate or C storage impact is considered part of the baseline, resulted from historical contribution to the national economy.

### A.7.3.2. How should HWP decay be accounted?

The forest industry does not accept that the IPCC approach is suitable for accounting HWP removal and emissions. Use of the mass flow approach provides a partial solution for the C allocation aspect of the method. However, alternative methods to account for emissions on an annual basis are still required. A review of the literature concluded the use of one of the three options discussed below could be considered.

#### A.7.3.2.1. *The land fill approach*

The default half-life factors applied to the paper and other timber products is suggested to be over conservative and the half-life value for paper products is too generalised to capture the range of products produced by the paper industry (see section A.8.3.a)). Alternative approach may be that to use the **share of wood products converted to C emissions in landfills** (Skog and Nicholson 1998). Some studies suggest that C emissions from paper in landfill varies from 3- 38 % over 96 years (Skog & Nicholson, 1998; **Error! Reference source not found.**), magnitudes lower than the expected C lost based on the first order decay approach. The comparable half-life of paper using the landfill approach is 220 years, compared to 1 to 6 years for paper (IPCC, 2006, Skog & Nicholson, 1998). Land fill approach by Skog and Nicholson does not consider paper recycling, product life in use and combustion of paper, so could be considered as an underestimation of emissions.

**Table A.4: Estimated maximum proportions of wood and paper converted to CO<sub>2</sub> or CH<sub>4</sub> in landfills (Skog & Nicholson, 1998) with associated life-cycle retention values (fLC<sub>96</sub>).**

Product type (i)	Maximum % carbon converted	fLC <sub>96</sub>
<b>Solid wood</b>	<b>3</b>	<b>0.97</b>
Newsprint	16	0.84
Coated paper	18	0.82
Boxboard	32	0.68
Office paper	38	0.62
<b>Mean for paper and pulp</b>		<b>0.74</b>

#### A.7.3.2.2. *The 100-year approach*

A proposed alternative is the use of the 100-year approach (Miner, 2006), which is designed for application to corporate accounting, considering **future decay of today products of the company** in

<sup>7</sup> Skog and Nicholson, 1998; Profft et al., 2009; Winjum et al., 1998; Brown et al., 1999; Marland et al., 2010; Miner and Perez-Garcia, 2007; Broadmeadow and Matthews, 2003; O'Connor, 2010; Lippke et al., 2011; Henschel et al., 2008; Pingoud et al., 2006; Skog, 2008; Ellison et al., 2011; UNECE, 2010; etc



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contrast to the national reporting by the IPCC approach (that applies decay to historical inflows). This approach proposes three important modifications:

- a) It recognised that the decay is not a first order function, i.e. the decay constant varies over time (see Kurtz et al., 1992; Row & Phelps, 1996). This acknowledges that decay constant declines over time due to the slower breakdown of more recalcitrant C (such as lignin) remaining in product after end of use and during decay. These functions also attempt to construct decay curves by considering time-in-use, an improvement on the IPCC assumptions (see section A.8.3).
- b) The 100-year time frame is based on the general IPCC approach used to defining radiative forcing potentials and this 100-year period is used in many climate change projection scenarios.
- c) The approach facilitates annual accounting where all future emissions and current removals are accounted in one year.
- d) Removals and emissions are all attributed to current business options of the company.

The 100-year method involves five steps:

- 1) Identify the types and amounts of biomass-based products (e.g. Pine or Eucalyptus) that are made in the year of interest and end up in a final product (e.g. sawlog, pallet, mining poles, paper, long life paper etc.)
- 2) Express this annual production in terms of the amount of biomass carbon per year for each product.
- 3) Divide the products into categories based on function and allocate the carbon to the functional categories. Some of the functions may be single use products. Alternatively, products can be divided into the categories used for national and international harvested wood products.
- 4) Use 2<sup>nd</sup> or 3<sup>rd</sup> order decay curves or other time-in-use information to estimate the fraction of the carbon in each functional category, expected to remain in use for 100 years.
- 5) Multiply the amount of carbon in annual production in products in each functional category by the fraction remaining at 100 years. The result is the amount of sequestered carbon in the products in each functional category attributable to this year's production.

### A.7.3.2.3. The CCAR approach

All C trading platforms, besides the Californian Carbon Action Registry (CCAR), do not account for HWP because of methodological and system boundary complications. The CCAR solution is to **use the IPCC approach but to exclude historical HWP C stock in the first year of reporting** because it is not often possible to derive this data at a corporate level. At the end of the first year, the net emission/removal of HWPs is equal to the amount of carbon in products-in-use associated with the company's production for that year. In each subsequent year, the company estimates additions to, and losses from, the pool of carbon attributable to its products. Additions are equal to the carbon in products-in-use attributable to new production. Losses are determined by decay curves that describe the amounts of products-in-use removed from service each year.

Under a scenario where the annual production of new products remains constant, the approach results in large annual increases in the pool of carbon in products-in-use in early years, and smaller annual increases over time. This is because the annual losses from the pool of products-in-use are small at first but increase over time as the pool gets larger and the products get older. This results in what might be termed a "start-up effect", which may be an undesirable feature in a corporate accounting context (Miner, 2006).



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The disadvantage of this approach is that the use of first order decay models tend to overestimate emissions, but the multiple time decay constant approach (e.g. Row and Phelps, 1996) can be used. Another disadvantage is that the accounting of emissions of manufactured product is done in years subsequent to production and these emissions increase as the HWP pool increases. Another disadvantage is related to when company has a new owner (which should continue the account for previous owner emissions) or start new accounting (when “start-up effect” is strong).

### A.7.3.2.4. *Comparisons and conclusions*

In conclusion, all of the outlined methods have problems from an accounting perspective and do not accurately reflect emission reductions perspective and true atmospheric effect. If future emissions are accounted in advance (e.g. the landfill and 100-year approach), the company is in effect paying a C tax in advance. On the other hand, if emissions are accounted when they occur in subsequent years then all emissions and removals are not accounted in the year and the company may be prone to legacy risks in the future.

Comparison of the potential outcomes on implementing a HWP accounting method for the three HWP is summarised in Table A.5.

**Table A.5: A comparison between the landfill carbon remaining approach (LCA), CCAR and 100 year approaches for accounting emissions and removals for paper production in a hypothetical mill (assuming production of 200 000tC/year based on the mass flow principle). The effect of using different half-lives and life-cycle retention values (FLC96 or FR). Retention fraction (FR) values are calculated using corresponding half-life values in the same row. The 2 year half-life (highlighted in red) is the current IPCC default for paper, and the FLC96 of 0.74 (highlighted in green) is the suggested value for paper based on an average of the data from Skog and Nicholson (1998) (see Table A.4).**

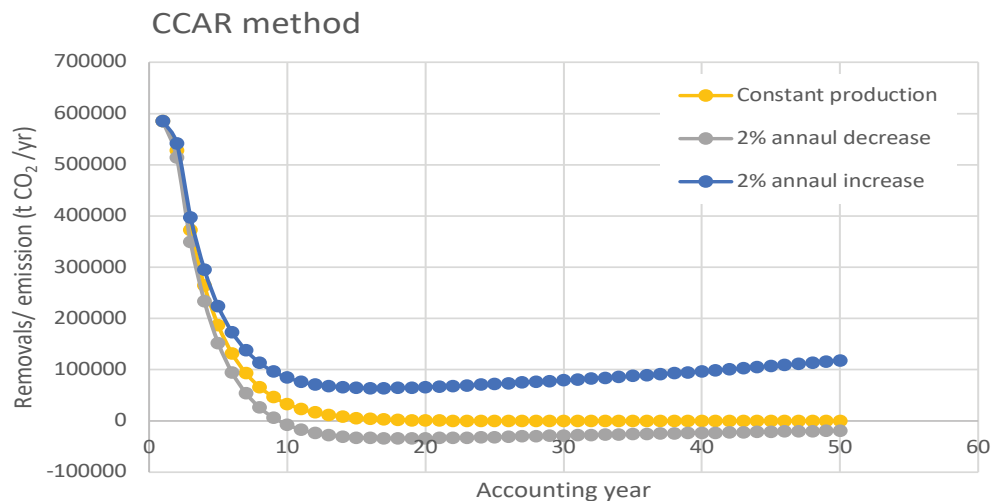
S <sub>HWP</sub> with landfill factor 96 year		S <sub>HWP</sub> CCAR approach (using IPCC half-life) Year 1 of accounting		S <sub>HWP</sub> 100 year approach Row and Phelps decay curve (FR are calculated at half-lives of 1 -10)	
FLC96	t CO <sub>2</sub> /yr	Half life (yr)	t CO <sub>2</sub> /yr	FR	t CO <sub>2</sub> /yr
<b>0.74</b>	<b>542 667</b>	1	366 667	0.05	35 911
0.8	586 667	<b>2</b>	<b>518 548</b>	0.06	41 553
0.85	623 333	3	582 050	0.06	45 758
0.9	660 000	4	616 661	0.07	49 298
0.95	696 667	5	638 407	0.07	52 445
1	733 333	10	684 228	0.09	65 416

As seen in Table A.5, the application of the landfill carbon remaining approach (LCA) approach, compared to the CCAR and 100-year method, offers a large advantage to the paper industry. It should be noted that the CCAR approach has a high “start-up value” but this will decline sharply regardless of future production outputs (Figure A.3).



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**Figure A.3: A projected estimate of accountable HWP removals/emissions under the CCAR scheme using a hypothetical mill with a pulp production of 225 000 tC/yr as an example assuming a constant or 2% annual increase of decrease in production output.**

The 100-year approach appears to be the most robust from a scientific point of view, but this is still sensitive to assumptions on the time products are in use. The 100-year approach would be the preferred option, but only if data can be provided on product time in use for the industry.

The LCA approach clearly overestimates C retention in wood products. The corresponding half-life of paper using a FLC96 of 0.74 (Skog & Nicholas, 1998) is 220 years. This is greater than the half-life of lignin (150 years) in natural ecosystems (Dittmar, 2001), which is theoretically unlikely. Although it is acknowledged that the 1<sup>st</sup> order half lived are overly conservative, the 100-year approach and multiple time decay models show that differences are quite small (Miner (2006). Uncertainty analysis by Pingoud et al (2011) show that the level of uncertainty for first order decay short life products (2-4 year half-lives) is only 9-20% and most published half- life values for paper do not exceed 6 years (Miner, 2006).

Although the life-cycle retention value (FLC96) for different products (Skog and Nicholson, 1998), may largely overestimate HWP removals, the risk of claiming excessive credits due to removals is limited due to the cap applied under the C Tax Act (Table A.1). Moreover, since the annual accounting of future emissions might be argued as a payment of tax in advance, this downside may be seen to be compensated by the over estimation of removals. The LCA approach covers more HWP categories (see Skog and Nicholson 1998, Christie and Scholes, 1995) and will not have a large influence in differences in claimed credits if emissions are not accounted (Table A.6).

**Table A.6: The proposed impact of using the LCA approach for annual accounting HWP removals and emissions for mills with various pulp production using the average paper FLC96 factor of 0.74.**



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	Annual production (Adu Poku, 2015)	S <sub>HWP</sub> with FLC96	S <sub>HWP</sub> without FLC96	Difference
Mill	pulp (t C/yr)	t CO <sub>2</sub> /yr		
Mill A	400 000	1 085 333	1 466 667	381 333
Mill B	300 000	814 000	1 100 000	286 000
Mill C	200 000	542 667	733 333	190 667
Mill D	100 000	271 333	366 667	95 333
Mill E	50 000	135 667	183 333	47 667
Mill F	20 000	54 267	73 333	19 067
Mill G	10 000	27 133	36 667	9 533
Mill H	2 000	5 427	7 333	1 907

The proposed interim accounting approach is to adopt the mass flow approach with the land fill approach to account emissions. However, it is strongly recommended that the 100-year approach should be implemented in future C tax periods as soon as industry specific studies are completed to derive suitable half-life, and product use period assumptions.

### A.8. Reporting of fertilisers and fires

Emissions from fertilisers and fires have been included in "S" as all emissions/removals from plantation activities need to be accounted for. However, the C Tax Act fully discounts emissions from biomass burning and fertilisation, therefore during this first tax phase these activities are only reported but not included in the accounting (i.e. not included in the calculated tax liability). The reason for continued reporting of these emissions is to collect company level baseline data so that these emissions can be excluded or included in the accounting in future. This reporting was also initially agreed by the forestry industry during a stakeholder meeting.

#### A.8.1. Fertilisers

*The forestry industry indicated that fertiliser emissions are insignificant and should not be included in the reporting. The rulebook states that emissions can be excluded from reporting and accounting if it is smaller than a significance threshold. The UNFCCC significance level is described as either an absolute size (500 kt CO<sub>2</sub>eq) or a fraction (<0.05%) of the absolute total emissions/removals. The absolute value of 500 kt CO<sub>2</sub>eq is only applicable at the national level, and C Tax is at the company level, therefore this absolute significance level was removed from the significance definition*

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Table A.2). For emissions to be insignificant they must be less than 0.05% of the total emissions for both “E” and “S”.

A theoretical exercise was conducted by SAPPI to calculate the worst-case scenario of non-CO<sub>2</sub> emissions from the application of fertiliser at planting for national level plantations to show its insignificance. It was estimated that if the 1.2 million plantation hectares were all planted to eucalypts on a 10-year rotation, the 120 000 ha of replanted area will have an annual emission of 18.6 kt CO<sub>2</sub>eq as a result of nitrogen fertiliser application. This is an estimate for national level plantations. The difficulty is that insignificance is a fraction of total emissions/removals of the company, i.e. the net of “E” and “S”, and determining the net emissions/removals for the plantation and timber processing industry is complex. It requires data which will be obtained through the C Tax reporting, hence the recommendation to complete this reporting as part of the C Tax accounting until it can be shown that fertiliser emissions are less than 0.05% of the net emissions/removals of a company.

#### **A.8.2. Fires**

The reporting of emissions from fires is recommended so that data can be obtained to determine a threshold for exclusion of natural disturbance and fires (see section A.12.4 on natural disturbance provision). The natural disturbance provision will require company level emissions and these emissions also need to be divided into controlled and wildfire emissions. Where data is lacking for the calculation of these emissions, IPCC default values are provided in the accounting tool.

There are different approaches for accounting for natural disturbance and a suggested methodology for the future is provided in section A.12.4. This approach would, however, be reviewed and discussed further when a natural disturbance provision is being considered for inclusion and once data has been obtained.

### **A.9. Accounting frameworks**

There are various proposed accounting frameworks designed to deal with different forestry activities.

**Gross-net accounting:** is generally applied to afforestation and deforestation activities, where actual reported emissions or removals are accounted for each year.

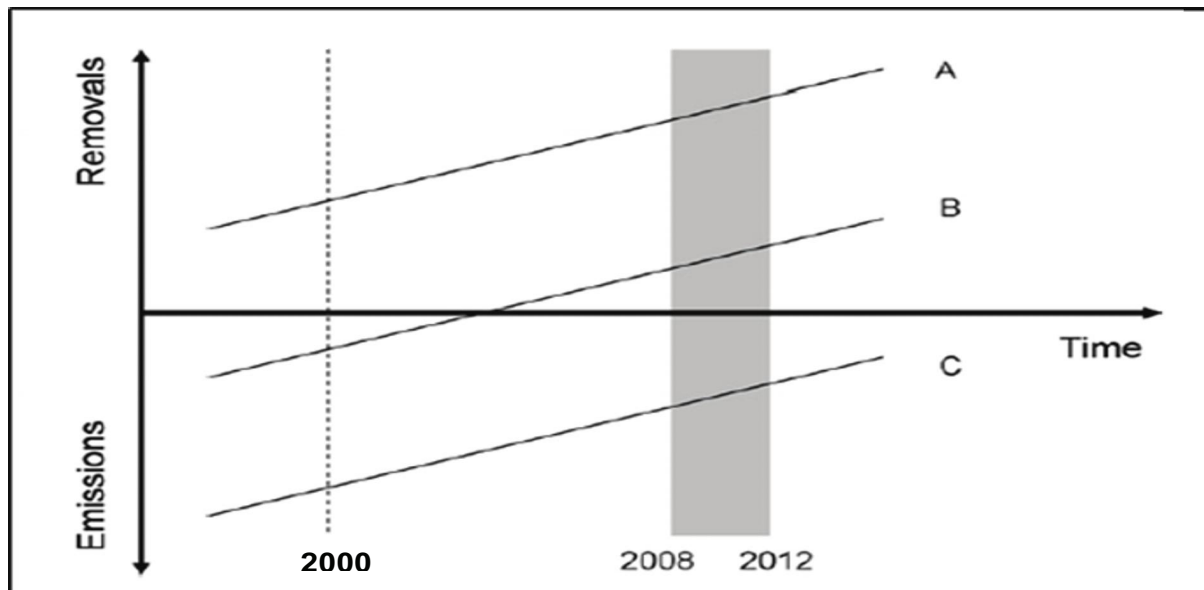
**Net-net accounting:** is applied to managed forests, where removals or emissions need to factor out indirect human induced removals/emissions (see additionality principle) or incentives are provided to account where there are net emissions. Notably, there is a reduction in the accounted amounts of net emissions in managed areas over time. The net-net accounted value is calculated using the reported emissions/removals in an accounting period (grey zone in Figure A.4: (2008-2012) relative to a reference year (example 2000 in Figure A.4). In all of the scenarios provided in Figure A.4, credits will be accounted, even in the case where net emissions are reported in the accounting period (Scenario C). Debits will only be accounted if the slope between the reference year and accounting year is negative.





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*Figure A.4: Examples of net-net accounting of reported emissions and removals.*

**Net-net with a reference level:** This is an adopted net-net approach which accounts for dynamic shifts in age class structure and historic management legacy. However, the approach requires the use of complex models (to simulate at least biomass growth under management interventions). This is dealt with in more detail in section A.12.3.

**An accounting cap:** The C Tax Act applies a cap where credits from “S” cannot exceed debits from “E”, i.e. there is no tax rebate if the sum of “E” and “S” is a net removal (see Table A.1:). In order to provide a fair and balanced cap and in accordance with the discounts applied to the Land sector in schedule 2 of the C Tax Act, we proposed the same should apply to a situation where the sum of emissions and removals from forests and HWP is a net emission (i.e. additional emissions from “S” cannot be added to “E” (see Table A.1). The advantage of the cap is that it limits the amount of credits that can be claimed through forest activities whilst at the same time incentivising participation of the forestry industry in the C Tax Act where net forest and HWP activities may be a net emission, particularly under a gross net accounting framework. This may function as compensation across time given the intensity of commercial activity.

### A.9.1. Justification for the Use of Annual Gross-net Accounting

Gross-net reporting has been recommended to apply to all eligible forest activities because of the following:

- To provide incentives for accounting of removals through allocation of timber for long term wood products and creation of new forest sinks through continued afforestation. Application of a net-net framework would provide no incentive for these.
- Although a gross-net approach or the only net-net options available at present (i.e. net-net with a reference period) does not factor out any dynamic age class legacy

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effect on forest growth increment, particularly due to historical afforestation legacy there is no modelling capacity to develop an alternative approach at present.

- c) Application of a gross-net accounting to both the forest and HWP category ensures that the accounting system is robust and balanced. Applying different accounting framework to HWP and forest land would result in unbalanced and inconsistent accounting”
- d) Application of one accounting procedure to all forest categories facilitates a simpler reporting task. Ideally the cost and effort of reporting under the C Tax Act should be minimised and simplified as much as possible.
- e) Although a gross-net approach does not factor out any indirect human influences on emissions and removals, it is assumed that any windfalls are offset by debits associated with management legacy which is not factored out.
- f) Liability for very large debits due to natural disturbances are excluded because emissions from fires are not accounted under the current framework.
- g) “Implicit cap” from C Tax Act ensures that accounted credits are limited by the size of the “E” debit and debits cannot be incurred for “S”.
- h) Encourages participation and collecting data for future when enhanced accounting can be applied.

## **A.10. Reporting and verification**

### **A.10.1. Sequestration submission process**

For C Tax reporting of sequestration, taxpayers are required to register on NAEIS. Here the MRV tool will be provided for completion. Once completed the tool can be uploaded to NAEIS where it will go to DEFF for review (Figure A.5). A taxpayer may be selected to undergo an independent review (see further details in the Verification Guidelines in Chapter D). Once reviewed and verified, DEFF will approve the “S” amount and submit it to SARS where it will be combined with the other emission components in the carbon tax equation to determine the overall tax liability.



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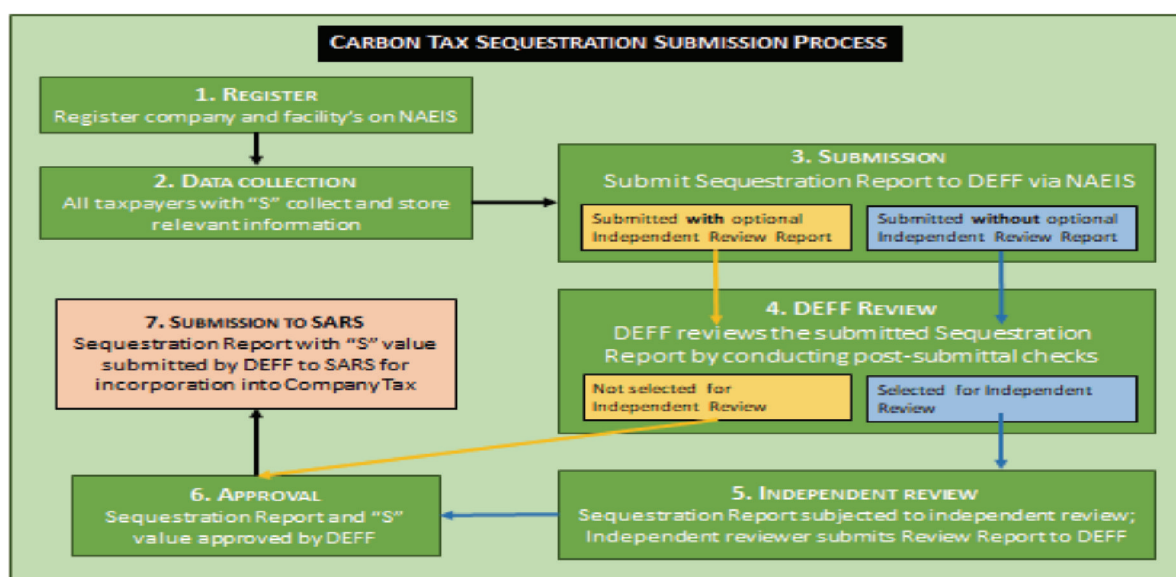


Figure A.5: Carbon Tax sequestration submission process.

### A.10.2. Reporting

The NGER specifies **reporting requirements, not accounting rules** to be applied under the C Tax Act. The accounting requirements are therefore much stricter than NGER requirements as accounting rules (such as permanence, inclusion of deforestation and new HWP methodologies) need to be included and adhered to. There was, therefore, a need to develop a separate accounting tool (Carbon Tax Sequestration MRV tool for Forest Plantations and Timber Processing Industry (referred to as "MRV Tool" in this document)) for company sequestration accounting purposes (Figure A.6). Although all efforts were made to harmonize reporting requirements under the C Tax Act and those required under the NGER, the **overriding framework for developing accounting rules must be derived from text in the 2019 Carbon Tax Act**.

The MRV tool is provided as an excel spreadsheet and is attached with this document. The MRV tool provides an option for using a default methodology (tier 1) with provided emission factors and conversion factors. Tier 1 approaches can be used in the absence of available methodologies (e.g. soils and dead organic matter). If companies have their own emission or conversion factors, these can be used (tier 2 reporting). Where models are used (tier 3), the description of the calculations, methods input data and output data should be transparently documented and verified by DEFF. Methodological guidelines detailing the use of the tool are provided in Annex C.

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**A.10.3. Verification**

Reporting under the NGER cannot be directly be linked to accounting under the C Tax Act as the former is documented at the plantation level and the latter at a company level (Figure A.6). As a consequence, there is no required verification of accounted emissions removals by eligible companies against GHG reported emissions or removals. All accounting related verification are based on nationally available forestry statistics (e.g. Green Mamba reports discussed in section A.5) and additional verification processes (see verification guidelines in Chapter D).

Recently the process for submitting Green Mamba forms was investigated. The forms are sent out by Forestry Economic Services (FES) to the various plantations, who then complete the forms. SAPPI provided us with an excel version of the form. It is not clear yet if all companies have the excel sheets or if some just have pdf forms. This still needs to be clarified. The forest plantations then complete the form and send it in hard copy to FES. FES converts the information into a database, aggregates the data for the whole plantation industry and produces the Timber Statistics Report. It is this report which gets submitted to DEFF<sup>8</sup>.

The problem with this is that it means FES has the actual raw data, not DEFF, making it difficult for DEFF to do verification with Green Mamba forms. The Green Mamba forms would therefore need to be requested from FES or from the individual companies. Alternatively, an external verifier could be tasked with doing verification on site. The other alternative is that the Green Mamba form be modified or additional items added so as to report all data required for NGER and then this could be submitted under the NGER reporting. It should, however, note that these Green Mamba forms provide long term historical data for plantations, therefore any modifications or additions to the forms should be able to allow for aggregation to ensure consistency with historical records. FES indicated that their contract was up for renewal shortly and so additional reporting requirements could possibly be incorporated into the current Green Mamba forms.

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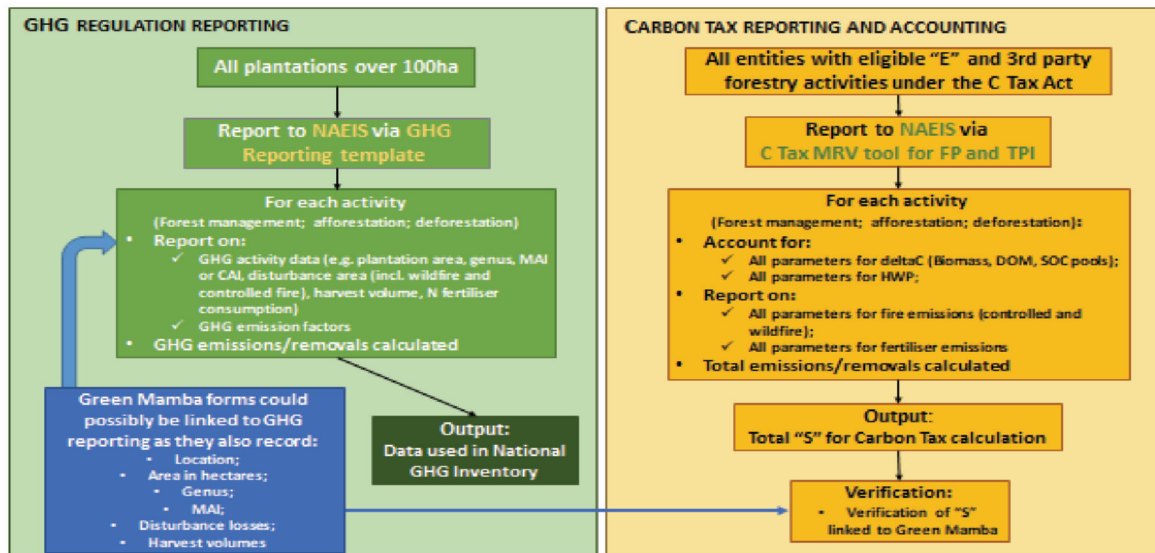


Figure A.6: Illustration showing the two different reporting processes.

### A.10.4. Reducing the reporting burden

Reporting can become a burden on companies and the aim is to try to minimise reporting where possible. The forestry industry already reports data to DEFF via the Green Mamba forms (see section A.5), therefore there was a request by the forestry industry to try to harmonise the current Green Mamba reporting with the C Tax accounting and reporting. This was considered, however, as discussed above, the accounting requires quite specific data and not all the required data is recorded in the Green Mamba forms (the data by activity, for example). It is recommended that the Green Mamba data rather be used in the verification process for verifying various activity data included in the C Tax accounting and reporting.

## A.11. Future considerations

### A.11.1. Net-net Accounting Frameworks

The UNFCCC COP (2/CMP7) and the EU LULUCF regulation 841/EU(2018) implemented the use of a forward-looking baseline approach to define the reference level for managed forests based on dynamic forest models. This approach factors out age-class legacy and other indirect human factors whilst still providing an incentive for potential C credits, but also allowing the continuation of sustainable management practice without potential debits associated with management legacy. This legacy has been shown to be associated with age-class shifts in forest areas due to either fluctuation in afforestation or practices that result in non-uniformly distributed ages classes in forest ecosystems (Black et al., 2012; Botcher et al., 2008). The same trends are evident based on our analysis of the plantation on forestry industry carbon stock changes. The forward-looking baseline approach is generally accepted as credible science-based carbon accounting approach based on the projected

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continuation of documented historical forest management practice (Grassi et al., 2018). Meanwhile the gross-net approach is retained for afforestation and deforestation.

The advantage of this approach, in a South African forest industry perspective, is that implementation of improved management practice or deployment of genetically improved nursery stock can potentially increase any removals and hence companies can account removal credits for these activities. The suggested framework allows for the continuation of sustainable management practice and utilisation of HWP without unfairly debiting accountable emissions due to age class legacy effects (see Box A. 1).

The development of forward-looking baselines requires the implementation of modelling frameworks that simulate changes in forest age class structure based on silvicultural rules defined for different species and existing stands over the defined reference period.

#### **A.11.2. Current Forest Carbon Modelling Capacity**

The development of a forward-looking baseline requires the ability to dynamically model forest C stocks based on silvicultural practice and shifts in the state of the forest (i.e. age class shifts as a result of management etc.). Based on a review of the forestry industry's capacity to develop and use complex tier 3 models for reporting or development baselines (this project and Knowles and Christie, 2018), it is suggested that the capacity is not sufficiently developed to implement such an approach.

A phased approach to the implementing of reporting should be implemented that allows entities to report using Tier 1 methodology unless the information is available for an entity to submit information using higher tier calculation.

A study by Ndalowa (2014) highlighted the potential use of internationally available models, such as CBM\_CFSv3 (Kurz et al., 2009) or CASMOFOR (Somogyi, 2019), for reporting and modelling future GHG profiles from South African plantations. However, it was also suggested that considerable time and resources are required to implement this at a company or national scale (Knowles and Christie, 2018). Other national platforms such as the carbon calculator are being developed to calculate carbon stocks in above- and below ground biomass pools (du Toit et al 2016, 2019). We are also aware that some companies such as Sappi have produced carbon stock change forecasts based on Mean Annual Increment (MAI) growth curves and inventory information.

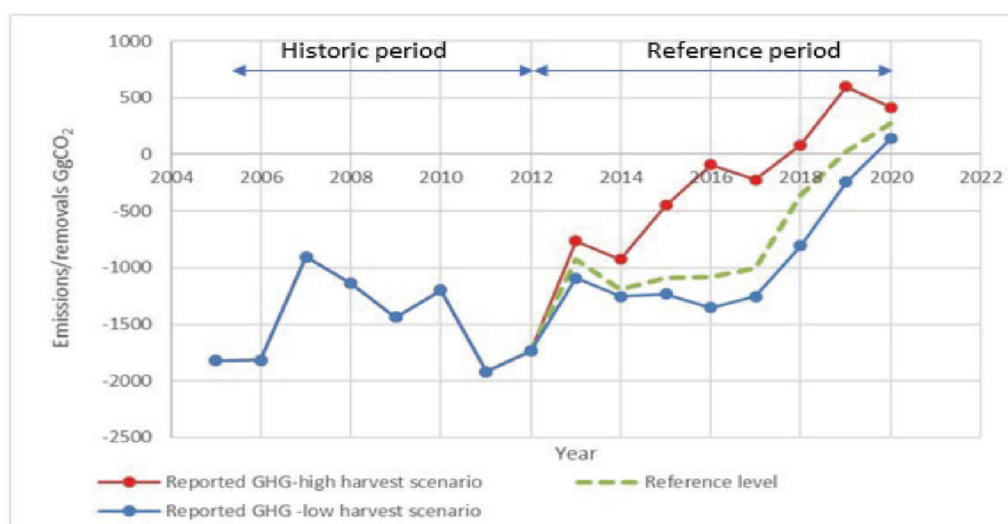
It is noted, however, that the basic information and allometric equations for the calculation of above ground biomass changes are available (du Toit et al., 2016) and these together with growth curves can be used to develop integrated modelling frameworks, which can simulate forest stock changes using different silvicultural assumptions but not for different climatic conditions.



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### Box A. 1: Net-net accounting using a projected reference level (example)



The figure shows hypothetical reported GHG emission and removals for managed forest land and HWP, where the sink is declining due to age class legacy effects under two scenarios. The high level of harvest (red line) scenario is due to increase demand for timber of timber products. The low harvest scenario represents a case where forest sinks are enhanced through deployment of improved genetic material and a reduction in the level of harvest.

The projected forest reference level (FRL, green line) was constructed using historical management practices based on the historic period using a dynamic model.

The accountable emissions/removals under a gross-net accounting framework in the reference period would be equivalent to the absolute values for each year over the reference period (solid symbols). Note that there would be an accountable net emission of 413 and 137 GgCO<sub>2</sub>eq. in 2020 for both the high and low scenarios, respectively.

Under a net-net forward-looking base line approach the annual accountable amount is the equal to the reported amount minus the FRL in any given year in the reference period. Under the high harvest scenarios, an annual net debit of 134 to 994 Gg of CO<sub>2</sub>eq. will be incurred. However, a net credit of -60 to -420 Gg CO<sub>2</sub>eq. will be accounted under the low harvest scenario. In the year 2020, the low harvest scenario reports a net emission of 137 Gg CO<sub>2</sub>, but the FRL emission is higher (275 Gg CO<sub>2</sub>eq.), which means an accounted credit of -138 GgCO<sub>2</sub> is incurred.

### A.11.3. Forward looking baseline (net-net) rules

It is recommended that the proposed accounting framework applied to managed forests should be reviewed in the next 3-5 years to determine if a forward looking base-line [reference level] approach can be adopted for managed forest lands based on the proposal by Grassi et al. (2018). Assuming that the modelling capacity has been developed by that time, the following accounting rules and criteria should be considered in constructing a reference level:





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- a) The projected reference level should be based on historical management practice (silvicultural practices they were *actually* applied) used for a defined historic reference period, for which period data needs to be available. Accordingly, the following information should be considered:
  - i) historic thinning practice such as thinning intensity and frequency for specified species
  - ii) historic rotation ages and fallow periods for specific species/management cohorts;
  - iii) historic proportional inflows of timber products into HWPs;
  - iv) historic levels of deforestation and afforestation.
  - v) The projected reference level should not include the following factors (after the initial year of the simulation):
    - envisaged increased levels of harvest due to increased demand or future policy
    - the harvest to volume increment ratios observed for the reference period should not be exceeded in the projected reference level
    - planned changes in forest structure, management or composition of tree species.

Guidance on construction of reference levels are outlined by Grassi et al. (2018):

- b) Models must be able to simulate age-class dynamics as a result of management and simulations should replicate historical carbon inventory estimates.
- c) The generated reference level must be reviewed and verified by an independent third party based on defined rules before a new accounting cycle is implemented. This can be verified by a technical board set up by the Forestry industry and DEFF.
- d) The South African Forestry Industry advocated the implementation of a Technical Advisory Board to guide the development of revised reporting and accounting rules. Such a body could be involved with the definition of reference periods, implementation of a 100year HWP approach (see section 8.3.1), review processes or even model capacity building.
- e) The reference level should be able to simulate all C pools, unless a pool is explicitly ruled out in the legislation revision.
- f) There must be a capacity to adjust for changes in methodology over time by implementation of a technical correction when accounting for forest and HWP emissions and removals.
- g) Net-net accounting with a baseline should be applied to both HWP and managed forest to ensure robust and balance accounting.

### A.11.4. Accounting of natural disturbances

***The following section outlines possible accounting approaches for natural disturbance if future amendment of the Carbon Tax Act no longer discounts fire and natural disturbance emissions from accounting. This cannot be implemented at present because there is no baseline data at the company level. However, baseline data can be collected over the next 5 years. Industry has agreed to report these emissions at a company level so that sufficient baseline data can be collected to develop threshold for exclusion of natural disturbance and fire emissions. Controlled burning may be reported, but only accounted if emissions exceed a defined threshold (***



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Table A.2), and if the effort of collection of data is disproportionate (e.g. high costs) with respect to overall benefit (e.g. emissions are negligible).

In order to minimise the impact of “force majeure” disturbance effects, such as wildfires, a natural disturbance provision, similar to that used for Kyoto Protocol<sup>9</sup> accounting and the EU LULUCF regulation<sup>10</sup>, can be applied. This eliminates the liability of non-anthropogenic GHG emissions and emissions that are beyond the control of the taxpayer.

The forest industry could consider the use of a background level to correct for non-controlled GHG emissions (Box A.2). Due to climate change the incidence of natural disturbance events will increase (more droughts, hail, heat, etc.). Furthermore, the occurrence of natural disturbance is not similar from year to year. History shows that there are large peaks in certain years when disasters strike, such as the 2007/2008 fires (Figure A.7). Industry will not be penalised for such events that are outside their control if a natural disturbance baseline rule is defined and used.

Carbon stock changes due to natural disturbances and effects beyond human control (e.g. droughts, pests and diseases, fire, frost, snow, etc.) should be excluded from accounting. An attempt has been made to develop a method to partition between the effects (Krug, 2018). Kurz (2018) provided a conceptual framework that can be used as a starting point.

- a) The natural disturbance provision allows areas effected by wildfires to be excluded from accounting if the annual emissions from wildfires in company owned forest exceeds a background level. The burnt area is removed from the accounting until biomass C stocks are equivalent to those before the disturbance event took place.
  - i) The background threshold could be based on historical wildfire data for each eligible company;
  - ii) If the threshold is exceeded in an accounting year then emissions and removals for these areas are excluded from accounting until such time that the C stocks in these areas are equivalent to the biomass stock before the wildfire event;
  - iii) Companies should still report C annual stock changes for the areas excluded, which must be geospatially explicitly identified (i.e. a GIS boundary, GIS co-ordinates or maps showing boundaries and describing the elements which define the boundary), as a separate item in their annual reporting.
  - iv) Emission associated with salvage logging shall continue to be reported and accounted;
  - v) If the excluded areas are deforested after the natural disturbance provision was applied, then emissions shall be accounted for in the current reporting year when deforestation is identified.
  - vi) Emission from controlled burning, i.e. burning of harvest residues or fire breaks, should be excluded from the natural disturbance provision.
- b) The natural disturbance background must be calculated for afforested and managed forest land activities separately if different accounting frameworks are used.
- c) The background level cannot be adjusted after submission and verification and it will be applied for all accounting periods (one off submission).

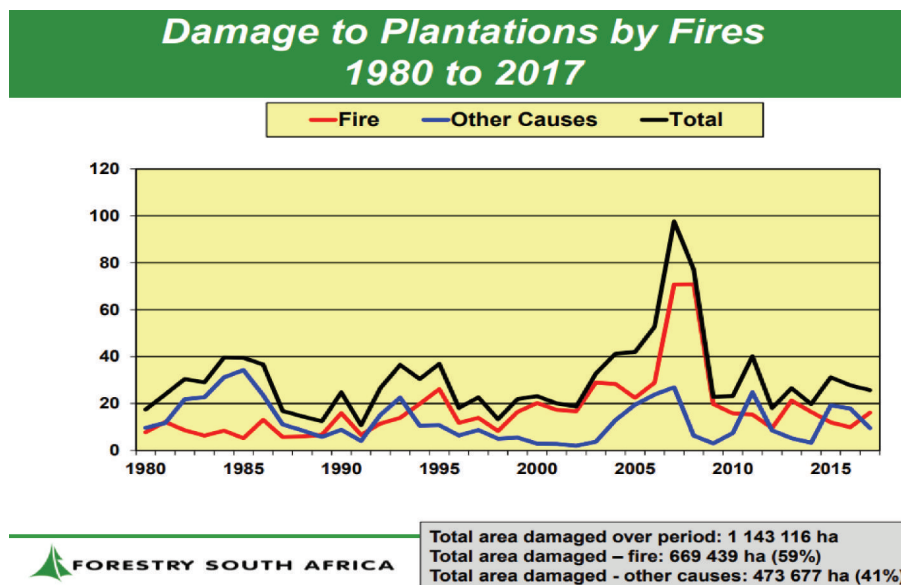
<sup>9</sup> <https://unfccc.int/resource/docs/2012/cmp8/eng/13a01.pdf#page=2>

<sup>10</sup> [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L\\_.2018.156.01.0001.01.ENG&toc=OJ:L:2018:156:TOC](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0001.01.ENG&toc=OJ:L:2018:156:TOC)



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*Figure A.7: Plantation area damaged between 1980 and 2017.*

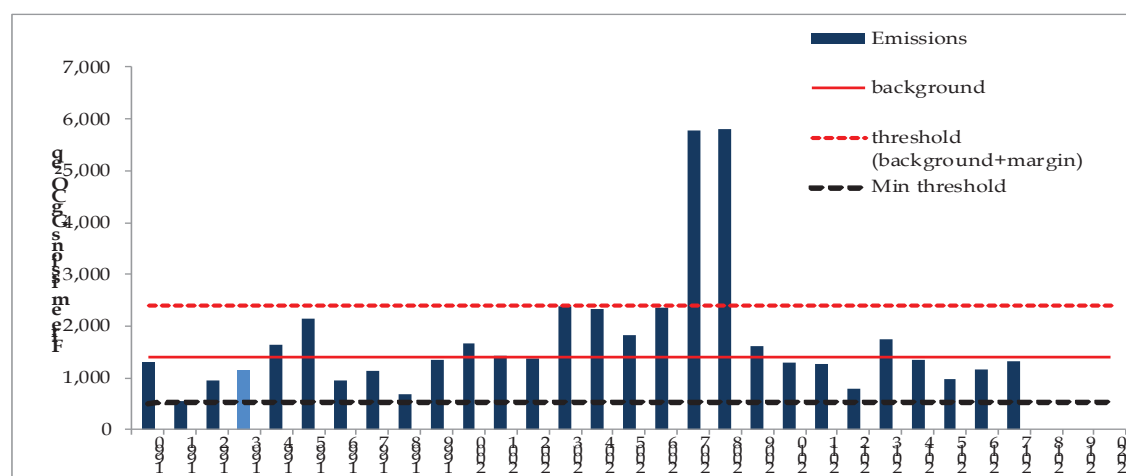


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### Box A.2: The natural disturbance example

The forest areas subject to fire (**Error! Reference source not found.**) were used to calculate CO<sub>2</sub>eq. emissions for the period 1990-2017 using IPCC tier 1 methods and emission factors. The background level is calculated as the mean and the margin is the standard deviation. Outliers are removed from the data set for any given year if the annual emission is greater than the background plus 2 times the margin value (IPCC, 2014). The background and margin values are then recalculated until all outliers are removed. The reference threshold is then determined as the background plus 2 times the margin, when there are no outliers in the calibration dataset (see figure below).



In this figure 2007 and 2008 are outliers and these were removed before the final threshold (margin plus background were estimated). When emissions from fire are greater than the threshold (ca. 2513 Gg CO<sub>2</sub>eq) emissions will be excluded from accounting under the natural disturbance provision.

An alternative approach, and one better suited for situations where calibration data is limited, is the minimum background threshold (IPCC, 2104). The threshold is determined as the minimum emission value observed over the time series. In this example the threshold will be 575 Gg CO<sub>2</sub>eq (black line in the figure).

It is proposed that the minimum threshold may be more suitable under the C Tax Act if calibration data for each registered company is to be collected and reported over the next 5 years. In this case, the threshold can be defined as the minimum emission from natural disturbances over the period 2020-2024.



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## Chapter B: Accounting Rulebook

### B.1. Introduction

The aim of the rulebook is to provide an instrument for inclusion of carbon (C) sequestration as a component of the C Tax Act accounting framework under the relevant legislation applicable in South Africa.

Although C sequestration and emissions from the South African Forestry Industry have been reported in the National Greenhouse Gas (GHG) inventory, values have been calculated at a national level using information available to Government and application of the default values set out in the IPCC guidelines. The implementation of the Carbon Tax, liability for emissions will be calculated at a company level. The IPCC has acknowledged that there are challenges associated with the application of the guidelines to areas other than national inventories, such as carbon accounting, and has held expert meetings to review these (e.g. Sofia, 1-3 July 2014). Some major challenges include: difference in boundary-setting, availability, detail and quality of data, questions of appropriateness of emission factors and activity data, insufficient level of detail for specific applications and the non-prescriptive nature of guidance on some issues.

The accounting rules outlined in this document are based on, criteria set out in the C Tax Act, proposed modifications to the Act (see discussion in section A.8), international guidelines (e.g. Conference of Parties under UNFCCC) and consideration of country specific factors based on consultation with Forestry South Africa and PAMSA. In this context, it is important to distinguish between accounting of emissions/removals under the C Tax Act and reporting by companies of sequestration and emissions associated with forestry plantations to the National Greenhouse Gas Emissions Reporting Regulations (NGER). Although many of the reporting considerations in the act are taken directly from the NGER, some of the reporting requirements under the NGER are not adaptable to inclusion as the basis for an accounting framework under the C Tax Act, particularly those related to forestry and other land use activities. The justification of the forestry and harvested wood product (HWP) accounting rules is provided in Chapter A.



### B.1.1. Definition of S

The term “S” in the C Tax Act, as discussed in section A.6. above, is defined as:

$$S = -S_{HWP} - \Delta C - \left[ S_{fire} - \left( S_{fire} \times \frac{D}{100} \right) \right] - \left[ S_{fert} - \left( S_{fert} \times \frac{D}{100} \right) \right] \quad \text{Equation B.1}$$

### B.1.2. HWP accounting

HWP are accounted by applying the mass flow approach with the land fill approach to account for emissions, therefore  $S_{HWP}$  is calculated as:

$$mC_{HWP} = mC_{RM} - mC_E - mC_{SW} - mC_{LW} \quad \text{Equation B.2}$$

Where:

- $mC_{HWP}$  = mass of biogenic carbon in HWP leaving the mill. This should include pulp, paper, solid wood products, saw milling waste sold for pulping if applicable, fines or lignin by products (t C);
- $mC_{RM}$  = mass of biogenic carbon entering the mill in the timber raw materials (t C);
- $mC_E$  = mass of biogenic carbon leaving the mill as gaseous emissions (t C);
- $mC_{SW}$  = mass of biogenic carbon exiting the mill as solid waste (t C);
- $mC_{LW}$  = mass of biogenic carbon exiting the mill as liquid waste (effluent) (t C).

Note: waste discharge threshold applies to  $mC_{SW}$  and  $mC_{LW}$  and emissions are only accounted if these thresholds are exceeded (see IPCC code 4 schedule 2 of the 2019 Carbon Tax Act).

Since biogenic and waste emissions are discounted (D) under the 2019 Carbon Tax Act Equation B.2 can be rewritten as equation B.3.

$$mC_{HWP} = mC_{RM} - \left( mC_E \times \frac{D}{100} \right) - \left( mC_{SW} \times \frac{D}{100} \right) - \left( mC_{LW} \times \frac{D}{100} \right) \quad \text{Equation B.3}$$

The discount is currently set at 100 % in the 2019 Carbon Tax Act, but these emissions will still be reported.

The land fill approach shall be used to account for HWP emissions:

$$S_{HWP(i)} = mC_{HWP(i)} \times fLC_{96(i)} \quad \text{Equation B.4}$$

Where:

- $S_{HWP(i)}$  = sequestered carbon as HWP of product (i);
- $fLC_{96(i)}$  = fraction of C decayed over 96 years (Skog & Nicholson, 1998).



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### B.2. Emission pools or sources included under the various forest activities

Forest plantations can accumulate carbon in three different pools, i.e. living biomass, dead organic matter (DOM, that includes dead wood and litter) and soil organic carbon (SOC). Conversely, if forest plantation is change to a non-forest used, this can result in GHG emissions. Management practices (e.g. application of fertiliser and controlled burning) and wildfires also results in GHG emissions. Table B.1 indicates which pools or emission sources are mandatory.

Table B.1: Sources included or excluded in the reporting and accounting of “S” for the C Tax Act.

Component in Eq B.1	C Pools or non-CO <sub>2</sub> emissions	Gases	Forest activity
$S_{HWP}$	Sawnwood, wood-based products, pulp and paper	CO <sub>2</sub>	All but excluding deforestation
$\Delta C$	Aboveground biomass (AGB)	CO <sub>2</sub>	All
	Belowground biomass (BGB)	CO <sub>2</sub>	All
	Deadwood and litter (DOM)	CO <sub>2</sub>	All*
	Mineral soils (SOC)	CO <sub>2</sub>	All <sup>#</sup> except deforestation
$S_{fire}$	Wildfires	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O	Reported but not accounted
	Controlled burning	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O	Reported but not accounted
$S_{fert}$	Emissions associated with application of fertilisers	N <sub>2</sub> O	Reported but not accounted
$F_{SOM}$	Mineralisation losses associated with SOC loss (related to soil management)	N <sub>2</sub> O	Not reported until baseline data is available for a significance test

\* Carbon stock changes for DOM should only be reported for afforestation (1st rotation forests up to 20-years old) and deforestation if tier 1 or tier 2 methods are used as under these circumstances changes in DOM in forest management will not occur. If an entity uses advanced tier 3 models, then carbon stock changes can also be reported for managed forest land remaining forest land.

<sup>#</sup> Carbon stock changes for SOC should only be reported for afforestation (1st rotation forests up to 20-years old) if tier 1 or tier 2 methods are used as under these circumstances changes in SOC in forest management will not occur.

### B.3. Accounting Rules

The following accounting rules will apply to entities when accounting carbon tax liabilities. These rules are primarily based on proposed amendments to the C Tax Act (see Annex A) but also in line with international agreements, such as the Paris Agreement, agreements from other UNFCCC Conference of the Parties (particularly 16CMP/1<sup>11</sup>, 2CMP/7 and 8), the voluntary market principles and climate change policy drivers behind the C Tax Act 2019.

<sup>11</sup> <https://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf>



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### B.3.1. Eligibility

The current eligibility criteria under the NGER and the C Tax Act is an area threshold of 100ha. These eligibility criteria are redefined to facilitate accounting HWP removals from 3<sup>rd</sup> party timber harvests, where owned forest areas are less than 100 ha. The rationale is that eligibility to register and account should be based on the criteria to report “E” and not on the area threshold.

#### B.3.1.1. Ownership and liability

- a) Only taxpayers that are eligible to report and account for “E”, as stipulated under the C Tax Act, can account for forest and HWP emissions and removals (S).
- b) Once an area of forest owned by an eligible taxpayer (B.3.1.1.a) is included and registered for accounting, then it shall continue to be reported and accounted for subsequent tax periods.
- c) To avoid double accounting, ownership of the removals by HWP resides with the processing company and not the plantation from which it is sourced.
- d) Inflows of harvest from other registered taxpaying companies into HWP may be accounted by the eligible taxpayer, provided that the source and amount HWP inflows are transparently identified.
- e) Eligible taxpayers may voluntarily elect to account for forest emissions/removals and inflows into HWP from 3<sup>rd</sup> party forest plantations areas subjected to, lease, harvest rights or supply contract agreements with the eligible manufacturing company. In this case:
  - i. It is the eligible taxpayer’s responsibility to report and account for 3<sup>rd</sup> party forestry emissions/removals associated with harvests included in HWP inflows.
  - ii. All 3<sup>rd</sup> party forest emissions and removals shall be reported and accounted only in the year that harvests from the 3<sup>rd</sup> party forest area is used as inflows to HWPs.
  - iii. 3<sup>rd</sup> party HWP inflows may only be accounted if proof of chain of custody certification is provided in the year relevant HWP inflows are accounted.
  - iv. The 3<sup>rd</sup> party area of forest associated with harvest must be the unit (e.g. sub-compartment) that was harvested (not the total forest area owned by the 3<sup>rd</sup> Party) and this area must be identifiable and traceable (using GIS or maps).
  - v. If the harvested timber from a unit of 3<sup>rd</sup> party land is sold to more than one registered taxpaying company, then the individual taxpayer shall transparently account for the equivalent proportion amount of emissions from harvest and inflow into the HWP pool.
- f) If there is a change in ownership, lease or harvest rights, all emissions and removals are the liability of the new land owner.
- g) Only domestically sourced wood from forest land registered by the taxpayer, other registered taxpayers under the act, or accounted 3<sup>rd</sup> party area are eligible to be accounted as HWP inflows (see section B.3.1.1 a and e).

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**B.3.2. Accounting categories and activities****B.3.2.1. Afforestation and deforestation activities**

- a) Afforestation (A), deforestation (D) and associated harvested wood products (HWPs) shall be identified and reported as separate activities and accounted for annually on a gross-net basis<sup>12</sup>.
- b) Afforestation areas shall include all established 1<sup>st</sup> rotation forests for the first 20 years of the rotation. After 20-years, these areas shall be transition to the managed forest land category.

**B.3.2.2. Forest management activities**

- a) Managed forest areas include all managed forest activities which do not fall under the A and D activities.
- b) Forest management and associated HWPs should be reported as a separate activity.
- c) Accounting of managed forest areas shall be accounted for on a gross-net basis<sup>13</sup>.

**B.3.2.3. 3<sup>rd</sup> Party forest activities**

- a) Election of accounting emissions and removals in forest and HWP for 3<sup>rd</sup> party areas (see B.3.1.1 e) is voluntary.
- b) To avoid double accounting, emissions and removals associated with the areas (i.e. see B.3.1.1 d and e) of forests owned by 3<sup>rd</sup> parties shall be reported as a separate category and transparently accounted in the year associated harvests are accounted as HWP inflows.

**B.3.2.4. Harvested wood products**

- a) Harvested wood product emissions and removals from afforested activities may be reported and accounted under forest management activities if taxpayers cannot distinguish the amount of harvest coming from afforestation or forest management activities. However, deforestation, other registered taxpayers and 3<sup>rd</sup> party HWP removals should be reported as separate categories.
- b) Harvested wood products shall be estimated based on the mass balance approach (see section A.8.3.2 of Chapter A).
- c) Estimation of mass flow components shall be based on mass flow fractions specific for each HWP category and industrial process (i.e. default factors and methods outlined in the methodological guidelines (see section C.3.3 in Chapter C) or higher tier methods developed by the taxpayer, providing that the methods used are demonstrated to be transparent, verifiable, applicable and accurate.
- d) Annual inflows into the HWP mass balance equation ( $m_{CRM}$ ) shall only include:
  - i. Domestic timber harvested from company owned or leased land or timber purchased from registered taxpaying companies or 3<sup>rd</sup> parties which is used for production of HWP produced by the company owned manufacture facility.

<sup>12</sup> Justification for gross-net accounting is provided in section 10.1 of final report.

<sup>13</sup> It is recommended that net-net accounting be introduced when the industry has capacity to use models and projected emissions/removals as a base line (Section 12.1 of final report).



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- ii. To avoid double accounting, recycled pulp or mill residues produced by the taxpayer and used for production of the HWP shall not be considered as inflows because these are already included in the mass balance calculations.
  - iii. All inflows shall not have previously been accounted as HWP sequestration by a registered 3<sup>rd</sup> party or the registered company.
  - iv. Inflows should exclude purchased processed wood products from registered and 3<sup>rd</sup> parties or cascaded wood products.
  - v. Purchased sawmill or pulp waste residues from other registered taxpayer can be included as inflows. For example, saw mill residues from sawn wood production can be included as inflows if purchased by a wood-based panel manufacturing facility. Similarly, if a registered taxpayer has different processing facilities, the wood-based waste from other production lines can be used of inflows only if it can be demonstrated that removals are not double accounted (i.e. verifiable information must be provided to show that waste inflows are not already included in the mass flow balance of the seller).
  - vi. Timber originating from deforested land must be excluded from HWP inflows in the year deforestation is detected.
- e) Accountable outflows shall include:
- i. Biogenic gaseous CO<sub>2</sub> emissions. These shall be reported but are discounted by 100% in the C Tax Act. N<sub>2</sub>O and CH<sub>4</sub> emissions are reported in accordance with the NGER and accounted as "E" in the C Tax Act.
  - ii. Solid or liquid waste emissions shall also be reported if the defined thresholds set out in the C Tax Act are exceeded. Accounting of all waste emissions are 100% discounted in the C Tax Act.
  - iii. CO<sub>2</sub>eq from CH<sub>4</sub> and N<sub>2</sub>O emissions from waste should be reported under HWP IPCC category 3D1 as set out in the NGER.
- f) The accounting of HWP removals shall acknowledge that long term storage of C is greater in sawn wood and wood-based panels than paper. It is also acknowledged that the half-life decay approach as set out under the IPCC may conservatively overestimate HWP emissions and underestimate long term storage. Therefore, to facilitate accounting of reported mC<sub>HWP</sub> for each HWP category and/or subcategories will be weighted and discounted based on long-term C retention potentials (96 years, see LCA approach in section C.3.3. in Methodological Guidelines (Chapter C))<sup>14</sup>.
- g) Should mass flow factors for a particular processing facility (i.e. tier 2 or 3) not be available, a taxpayer may use default recovery fractions (see Methodological Guidelines, Annex C, section C.3.3) to estimate HWP removals.
- h) If tier 2 mass flow and recovery factors are confidential, then this information can be provided during the verification under a non-disclosure agreement between DEFF and the taxpayer.
- i) HWP removals for use as fuels, such as firewood, charcoal and matches, are not considered as long term HWP pools and are excluded from "S" in the tax equation.

<sup>14</sup> See section A.8.3.2 of Chapter A for justification and arguments for application of the LCA approach and recommendation for implementation of the 100 year accounting approach when required national data is available.





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- j) Additional information on annual (tax period) harvested timber owned and sold by the taxpayer and timber purchased from other companies within the tax scheme for production of HWP should be provided when accounting, including:
- i. The total harvest from eligible forest areas owned by the taxpayer.
  - ii. Timber harvested by the taxpayer and used for production of company owned HWP production facilities.
  - iii. Timber purchased from other registered taxpayers for production of company owned HWP production facilities.
  - iv. Timber purchased for HWP from accounted forest areas owned by a 3<sup>rd</sup> party.
  - v. All HWPs produced by the company in the tax period, by type of HWP.

### B.3.3. Permanence

- a) Once emissions and removals are reported and accounted by a taxpayer, these forest areas should continue to be reported for subsequent accounting periods.
- i. The permanence condition B.3.3.a will not apply if a registered taxpayers production facility is sold and/or the threshold to account to E under the C Tax Act is not met<sup>15</sup>.
  - ii. If deforestation occurs in registered forest areas, biomass, litter and deadwood C pools will be assumed to be immediately / instantaneously oxidised. Tier 1 emission factors can be used for deadwood pools if no company specific data exists.
  - iii. SOC and F<sub>SOM</sub> emissions or removals on deforested land shall not be reported or accounted because other land uses are not included in the 2019 C Tax Act.
  - iv. If there is a change in ownership after deforestation occurs, all emissions and removals are the liability of the new landowner.
  - v. All eligible deforestation emissions and removals will be accounted as a debit in the year the deforestation event takes place.
  - vi. If the registered forest area is clear felled and not replanted before sale or lease to a new owner, whom is not eligible for registration or reporting under the scheme, the entity that reported HWP will be debited all emissions from biomass, litter, deadwood and HWP pools in the year before the clear fell event took place (i.e. from all C pools (except for SOC and F<sub>SOM</sub>) on land and from HWP, using the immediate oxidation assumption applied in clause B.3.3(a)ii).
  - vii. The registered area may be withdrawn from the scheme without any penalties (and not accounted) in the event of rescinding or withdrawal of a water use licence under the National Water Act (Act No. 36 of 1998), removal of plantations from river courses (includes wetlands) as defined in the National Water Act (No. 36 of 1998), or as a result of successful land claims, mandatory clearing of invasive species (Conservation of Agricultural Resource Act, 1983 (Act No. 43 of 1983); National Environmental Management: Biodiversity Act: Alien and Invasive Species Regulations). However, proof of a withdrawal notice should be submitted in the year areas are withdrawn.
- b) Each registered company shall account for all changes in the following carbon pools: above-ground biomass, below-ground biomass, litter, dead wood, soil organic and harvested wood products (see Table B.1). A company may choose not to account for litter, deadwood and soil

<sup>15</sup> Note: liability for accounting of E and S is based on ownership as defined in the act, therefore companies cannot be liable for sold land and strict adherence to the permanence principle cannot be satisfied. However, this may lead to leakage of emissions or emission avoidance. (also applies to B.5.3 iv)



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pools if transparent and verifiable information is provided that the pool is not a source. However, once a pool is reported under an activity, they it must continue to be reported for subsequent tax periods.

- c) When accounting, a taxpayer should distinguish temporary unplanted (TUP) land from deforested land. TUP areas that have not been replanted within a period of 5 years after a clear-fell, or where there is clear evidence of land use change, shall be deemed to be deforested. Emissions from these disturbed areas shall be accounted when land use change occurs or when the 5-year period between clear-fell and replanting has expired (whichever occurs first).
- d) If previously accounted mandatory forest areas are sold or where the lease has expired, the following information shall be provided [in the relevant year of submission]:
  - i. The name and registration identification of owner reporting to the NAEIS or the name of unregistered owner;
  - ii. The carbon stock for biomass at the time the registered areas were sold.
- e) In order to minimise liability due to force majeure disturbances such as wildfires, a natural disturbance provision may be applied in the future (see section A.12.4 of Chapter A). However, the current legislature does not require the accounting of emissions from forest fires.

### B.3.4. Accounting periods and intervals

- a) Reporting Period: The period for all reporting will be from the beginning (1 January) to the end of the tax year (31<sup>st</sup> December) preceding the reporting cycle.
- b) Reporting cycle: Data for the preceding year must be reported to NAEIS by 31 March each year.

### B.3.5. Robustness

- a) The treatment of any accounted activities will be based on sound science.
- b) All activities shall be reported using the prescribed tier 1 methods if company specific activity data does not exist. Company or manufacturing process specific methods (tier 2) or models (tier 3) methods can be used if the approach is transparently documented and justified by references
- c) The reversal of any removal due to land-use change and forestry activities will be accounted for in the year when the activities occur.
- d) Taxpayers may choose not to include in their accounts changes in carbon stocks provided that it can be demonstrated that the carbon pool is not a source. However, the option shall not apply to the carbon pools of biomass and harvested wood products in the land accounting category of managed forest land and afforestation.
- e) Reported emissions and removals must be verified by DEFF in accordance with the Verification Guidelines before debit or credits can be accounted (see Chapter D).
- f) The pools and emission sources considered for reporting and accounting of emissions removals are outlined in Table B.1.



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### B.3.6. Additionality

- a) The mere presence of carbon stocks is excluded from reporting and accounting<sup>16</sup> (i.e. only C stock change is reported for the accounting year and activity, and not the C stocks cumulated from the past).
- b) Accounting should exclude removals resulting from indirect human activities:
  - i. elevated carbon dioxide concentrations above their pre-industrial level;
  - ii. indirect nitrogen deposition; and
  - iii. the dynamic effects of age structure resulting from activities and practices before the accounting year, assuming robust scientific information becomes available.

Note: the gross-net accounting rule does factor out indirect human induced activities, particularly for forest management. However, the SA forestry industry currently does not have capacity to implement a net-net accounting system (see section A.12.3 of Chapter A);

- c) Only managed forest land is eligible to comply. Therefore, natural forests or woodlands are excluded from accounting, but only if they are not managed.

### B.3.7. Incentives and policy alignment

- b) The information required to report and account for forestry related activities under the Carbon Tax Act 2019 is consistent with the information required under the NGER with some additional elements:
  - i. Different eligibility criteria to facilitate inclusion of 3<sup>rd</sup> party harvest in HWP accounting.

***Additional reporting requirements for deforestation and HWP to ensure the principles of carbon accounting are adhered to (***

- ii. Table A.3, see section A.7 of Chapter A);
- iii. Reporting but not accounting for emissions from fires and fertiliser application;
- iv. Discounting of waste carbon emissions associated with wood processing under HWP;
- v. Additional verification and validation data requirement to ensure adherence to accounting rules.
- c) In order to incentivise afforestation and to disincentivise deforestation, activities should be accounted on a gross-net basis.
- d) Forest management activities should be accounted for on a gross-net basis. However, future rules should consider a net-net accounting in cases such as:

***Where forests with declining stock due to legacy management practice, age class structure changes or natural phenomena can be fairly accounted without penalising as an owner or entity for indirect human induced effects (see additionality principle in***

<sup>16</sup> For example, produced HWP stock cannot be considered as an accountable removal amount without considering emissions due to product life cycle or harvest emissions.



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- i. Table A.3 of Chapter A). This may be best done using a net-net accounting approach but gross-net approach is currently recommended until such time modelling capacity is developed.
- ii. Incentivised management actions in cases where forest stocks are increasing or where improvement to stock changes are brought about by management or genetic improvement for successive rotations, forests (managed forest land) land removals and emissions should be accounted for based on a net-net approach relative to a reference period. However, a gross-net approach is recommended until such time modelling capacity is developed.

### B.3.8. Leakage

- a) Increased emissions of GHGs or decreased carbon removals should not result outside the accounting framework boundary. For example: use of timber sourced from outside South Africa for production of HWPs could result in increased emission or deforestation in other regions.
- b) HWP inflows are only permitted from domestically produced timber harvested or purchased from registered and reporting forest owners under the C tax scheme, or from 3<sup>rd</sup> parties which implement the current rules.

### B.3.9. Double accounting

- a) Where carbon credits have been claimed by a manufacturer for HWPs these products cannot be included as a carbon inflow into the HWP pool for a taxpayer.
- b) Emissions and removals cannot be accounted for under more than one accounting category.

### B.3.10. Significance

- a) In order to reduce the administrative burden of reporting very small emissions that do not have a significant impact on overall emission or removals, a threshold test for significance pools can be applied:
  - i. Emissions may be excluded from reporting and accounting if it is smaller than a significance threshold which is a percentage of the total emissions for all, energy, processing, forest and HWP activities (i.e. sum of absolute emissions from "E" and "S").
  - ii. The threshold for exclusion is <0.05% of the total emissions for both "E" and "S".

### B.3.11. Global Warming Potentials

In line with the updated reporting requirements of the NGER, entities will report GHGs separately (CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O). Thereafter, based on their relative Global Warming Potentials (GWPs), a CO<sub>2</sub>eq amount is calculated and used to estimate 'S' using Equation B.1. The C Tax Act specifies the use of GWP values set out in the IPCC third assessment (IPCC, 2001) report be used for calculation of CO<sub>2</sub> equivalent values, namely N<sub>2</sub>O - 296 CO<sub>2</sub>eq, and CH<sub>4</sub> - 23 CO<sub>2</sub>eq.



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### **B.3.12. References**

- IPCC (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp.
- Knowles, T and Christie, S. (2018). Technical guidance for the reporting of GHG emissions from plantation forests, biogenic fuels and harvested wood products within the South African plantation forest and forest products sector. Draft report, GIZ, Pretoria
- Skog K & Nicholson G.A. (1998). Carbon cycling through wood products: The role of wood and paper products. Forest Products Journal 48(7):75-83.

## **Chapter C: Methodological Guidelines for Land Activities in Forest Plantations**

### **C.1. Introduction**

The methodological guidelines serve as a background document to facilitate the understanding and completion by companies of the Carbon Tax Sequestration MRV Tool for Forest Plantations and Timber Processing Industry (hereafter referred to as 'MRV tool') for reporting, and the verification of the information reported. The guidelines are underpinned by the Forestry Accounting Rulebook (hereafter referred to as the 'Accounting Rulebook') for the accounting of forest plantations and timber processing industry greenhouse gas emissions and removals under the Carbon Tax Act (Act No. 15) of 2019 (hereafter referred to as 'C Tax Act').



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### C.1.1. Carbon Sequestration in the Carbon Tax Act

The Accounting Rulebook (Chapter B, Section B.3, equation B.1 of this document) defines the net sequestration by forest and forest products,  $S$ , as:

$$S = -S_{HWP} - \Delta C - S_{fire} - S_{fert}$$

Where:

- $S_{HWP}$  = The amount of carbon located in harvested wood products (expressed in t CO<sub>2</sub>eq). Note that it is an IPCC convention that a flux into the atmosphere (emissions) is denoted as a positive flux and sequestration (removals) as a negative flux;
- $\Delta C$  = Annual change in plantation carbon stocks, expressed in t CO<sub>2</sub>eq. Note that it is an IPCC convention that a flux into the atmosphere (emissions) is denoted as a positive flux and sequestration (removals) as a negative flux;
- $S_{fire}$  = Emissions from fire (N<sub>2</sub>O and CH<sub>4</sub> expressed in t CO<sub>2</sub>eq);
- $S_{fert}$  = The fraction of emissions from applied fertiliser (N<sub>2</sub>O expressed in t CO<sub>2</sub>eq) growth of wood.

Note: Emissions from fires and fertilisation are to be reported, but not accounted. The reporting conversion for net sequestration is that it should be denoted as a negative value i.e. removal of CO<sub>2</sub>eq, however, when entering  $S$  into the C Tax formulae [equation 1 main project report] it should have a positive sign.

In accordance to the Accounting Rulebook, the four activities to be reported are:

- 1) Forest Management;
- 2) Afforestation;
- 3) Deforestation; and
- 4) HWP production.

The emission pools or sources included under the various activities are outlined in the Accounting Rulebook (Table B.1).

### C.1.2. Purpose of methodological guidelines

Greenhouse gas (GHG) emissions represented by the variable “E” in the C Tax formula are calculated in accordance with the methodology set out in the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry (DEA, 2017). The purpose of these guidelines is to provide guidance on the methodology for determining the sequestration or “S” factor in the C Tax formula. The guidelines aim to facilitate the understanding and completion by companies of the MRV tool for reporting, and the verification of the information reported. The guidelines are in line with the Accounting Rulebook that contain the accounting rules for the C Tax Act (Accounting Rulebook, Chapter B of this document).

## C.2. Structure of the Methodological Guidelines

The following sections describe the methods for the estimate of emissions/removals from the different sources and sinks contained within the MRV tool and Accounting Rulebook. Firstly, the source is described, then the calculation method is presented followed by a list of the data required for the estimates in the MRV tool. Examples of calculations are shown within the orange boxes. Finally,



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there are three sections which state the data that is to be reported by the companies, the data that is to be verified and the reference to the Accounting Rulebook for the corresponding source.

#### C.2.1. **Relation to Accounting Rulebook and MRV Tool**

These methodological guidelines are complementary to the Accounting Rulebook and the MRV tool.

The corresponding section of the Accounting Rulebook is referred to throughout these methodological guidelines as:

##### **Section [name of section] in the Accounting Rulebook**

The **MRV tool** is a Microsoft Excel file which aims to collect information on emissions and removals from companies that are subject to reporting and/or accounting obligations. The emission/removal estimate methods implemented in the MRV tool are explained in these methodological guidelines. The corresponding sheet in the MRV tool is referred to throughout these methodological guidelines as:

##### **Sheet [name of sheet] in the MRV tool**

The MRV tool contains various sheets with different purposes: introduction and instruction, textual data collection, variable/parameters used, emissions/removal estimates, accounting and verification. Therefore, the MRV tool allows simultaneously for the Reporting, Accounting and Verification of the emission/removal estimates.





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**Table C.1: Content of the MRV tool: sheets and purpose**

Sheet name and colour	Description
<b>Content and Instructions</b>	This sheet contains information on the MRV tool content and general instructions for its use. It contains the list of sheets in the MRV tool, the colour coding used, an acronym list and a reference list.
<b>Company Details</b>	This sheet contains general organisation details to be filled by the user.
<b>Facility Register</b>	This sheet contains the main plantation details to be filled by the user.
<b>3<sup>rd</sup> Party Register</b>	This sheet contains the details of the 3rd parties from which the reporting facility has purchased wood. The 3rd Party ID should match the 3rd Party entered in the "Ownership" column in the 'Land Stock-Difference Method'/'Land Gain-Loss Method' tabs.
<b>Parameters</b>	This sheet contains default IPCC 2006 Guidance and country-specific parameters to support the estimates.
<b>BCEF Lookups</b>	This sheet contains factors for expansion of merchantable growing stock volume to standing above-ground biomass (BCEF <sub>S</sub> ), for conversion of net annual volume increment to biomass growth (BCEF <sub>G</sub> ) and for conversion of wood and fuelwood removal volume to above-ground biomass removal (BCEF <sub>R</sub> ).
<b>Supporting Calculations</b>	This sheet provides suggested calculations for generating activity data/emissions/removals estimates to be used in the yellow compilation sheets. Defaults are provided where available, but if alternative data which is considered to be more representative for the company circumstances and is justifiable and verifiable is available, this should be used.
<b>Land Stock-Difference method*</b>	This sheet provides emissions/removals estimates due to the change in Carbon Stock in living biomass using the gain-loss method.
<b>Land Gain-Loss method*</b>	This sheet provides emissions/removals estimates due to the change in Carbon Stock in living biomass using the stock-difference method.
<b>HWP</b>	This sheet provides emissions/removals estimates due to HWP.
<b>Wildfires</b>	This sheet provides emission estimates due to wildfires
<b>Controlled burning</b>	This sheet provides emission estimates due to controlled burning.
<b>Fertilisation</b>	This sheet provides emission estimates due to fertilisation
<b>Reporting &amp; Accounting</b>	This sheet provides the summary of estimates for reporting and accounting purposes.
<b>Verification</b>	This sheet provides a list of checks that can be completed for verification purposes.
<b>List</b>	This sheet contains the values for the dropdown lists used in the MRV tool.

\* Either the Gain-Loss or Stock-Difference method should be used, not both. The other should be left empty.

The MRV tool includes instructions to allow its use as a standalone file. However, further explanation on the methods implemented is presented in these methodological guidelines. In addition, the MRV tool utilises colour coding for the fields to facilitate its use:



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**Table C.2: Colour coding used in the MRV tool**

<b>Input data:</b> data required to be included by the user
<b>Emissions/removals:</b> calculated emissions/removals
<b>Calculation/linked cells:</b> cells with formulae, automatically updated. Do not change
<b>Conversion factors &amp; constants</b>
<b>Assumptions/assumed values</b>
<b>Checks</b>

Note on input data: these methodological guidelines include tables to show the data that is required to complete the estimates in the MRV tool. The user has the option to use the **Sheet Supporting calculations in the MRV tool** to estimate some of the variables needed in other sheets in the MRV tool, these cases are highlighted throughout these guidelines.

Note on the use of different tiers: the estimation methods included in the MRV tool allows for reporting of emissions and removals using different tiers:

- **Tier 1:** using the equations for the estimates as implemented in the MRV tool and default IPCC 2006<sup>17</sup> or country specific values for the required parameters. These factors are included in the **Sheet Parameters in the MRV tool** and can found in Appendix C.1.D. Tier 1 methods and country-specific parameters have been specially selected for the South African forestry sector.
- **Tier 2:** using the equations for the estimates as implemented in the MRV tool and facility-specific values for several parameters.
- **Tier 3:** when other methods, different from those implemented in the MRV tool are used. The MRV tool allows for the reporting of emissions/removals and the parameters required for verification.

The MRV tool has formulae implemented for Tier 1 and Tier 2 estimates. When applying Tier 2 with facility-specific parameters, justification of the appropriateness of those parameters must be provided. In the case of Tier 3, less input data is needed in the MRV tool since Tier 3 estimates are only reported, not calculated, using the MRV tool. When applying Tier 3, a description of the methods used, and justification of their appropriateness must be provided as part of the annual reporting. In addition, inputs required for verification must also be provided.

Each of the columns in the MRV tool tables where data has to be reported have the following structure, showing the variable, instructions and tier.

**Table C.3: Structure of the columns in reporting tables in the MRV tool**

<b>e.g.: Facility ID</b>	1 <sup>st</sup> row (title row): Name of the variable
<i>e.g.: INFORMATION ROW (do not delete)</i>	2 <sup>nd</sup> row: instructions to fill in the column
<i>e.g.: INFORMATION ROW - TIERS (do not delete)</i>	3 <sup>rd</sup> row: Tier for which the column is to be filled

<sup>17</sup> The only exception is the stock change factors for SOC which are taken from IPCC 2019 Refinement.



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### Implementation of Tiers in the MRV Tool

The MRV tool implements Tier 1 and provides default values, sourced from both IPCC 2006 and country specific values, sourced from various publications.

Companies can use their own parameters where information is available and is justified with supporting documentation.

Complete the Methodology Information Boxes included at the top of each of the yellow compilation sheets to provide a description of which tier, or combination of tiers has been applied.

Tier used for carbon stock change:	Methodology Information Box
T1	
T2	
T3	

### C.3. Methodological Guidelines for Reporting and Accounting Carbon Sequestration in Forest Plantations

It should be noted that increases in carbon stocks, i.e. positive (+) stock changes, represent a removal (or 'negative' emission) from the atmosphere, while decreases in carbon stocks, i.e. negative (-) stock changes, represent a positive emission to the atmosphere.

Forest plantations represent three different carbon pools, i.e. living biomass, dead organic matter (DOM, that includes dead wood and litter) and soil organic carbon (SOC). Management practices (e.g. thinning and harvesting, application of fertiliser and controlled burning) and natural disturbances (e.g. wildfires) results in CO<sub>2</sub> removals enhancement and GHG emissions. Table B.1 in Chapter B of this document indicates which pools or emission sources are mandatory for reporting or accounting.

#### C.3.1. Area tracking for the reporting of Annual Change in Plantation Carbon Stocks, $\Delta C$

As determined in the Accounting Rulebook, and in line with IPCC 2006, the afforestation areas shall include all forest for the first 20 years. After 20-years, these areas shall transition to the managed forest land category. The variable/column "age category" in the tables in the MRV tool allows for the tracking of areas:

- Afforestation: "age category" indicates the number of years since the afforestation occurred. This cannot be 0, it should be 1 in the year of the afforestation and up to 20 years ( $\leq 20$  years), because starting the year 21<sup>st</sup> the land will be subject to forest management (see Box C.1 for example). The age information is considered in the estimates of carbon stock change in DOM and SOC. The first year the land is afforested (age category = 1), previous land use can be Grassland, Annual Cropland, Perennial cropland or Other. The following years, the previous land use should be Afforestation.



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- Forest management: “age category” indicates the number of years of the rotation. This should be  $\geq 21$  years for the first rotation and can be any value for the following rotations.
- Deforestation: “age category” indicates the age of the managed forest land deforested or the age of the afforested land deforested. The age information in the deforested lands is considered in the estimates of carbon stock change in DOM. Taxpayers should have a system for distinguishing between deforestation and temporary unplanted (TUP) land.

### Box C.1. Reporting of Afforested areas

In the facility AX32, 2 ha of grassland are afforested with *Pinus patula* in 2020, 4 ha in 2021 and 3 ha in 2022. The reported data in the reporting year 2022 should be:

Facility ID	Activity	Previous land use category	Species/Genus	Age Category	Area (ha)
AX32	Afforestation	Grassland	<i>Pinus patula</i>	1	3
AX32	Afforestation	Afforestation	<i>Pinus patula</i>	2	4
AX32	Afforestation	Afforestation	<i>Pinus patula</i>	3	2

### C.3.2. Annual Change in Plantation Carbon Stocks, $\Delta C$

There are two main methods for GHG estimates in the LULUCF sector as presented in 2006 IPCC Guidelines (IPCC, 2006):

- The Gain-Loss Method estimates the net balance based on the estimation of gains and losses separately for each individual reported year.
- The Stock-Difference Method is based on carbon stocks in relevant pools measured at two points in time to assess carbon stock changes.

In the MRV tool, both methods have been implemented for the estimates of carbon stock change in living biomass. However, the gain-loss method for DOM and SOC pools requires models that simulate DOM and SOC dynamics and these are not implemented in the MRV tool. Therefore, the estimates of DOM and SOC carbon stock change in the **Sheet Land Gain-loss method in the MRV tool** applies stock-difference method so that all carbon stock changes in all pools can be estimated in one single sheet of the MRV tool, regardless the method used for living biomass.

For transparency, the estimation method for DOM and SOM are explained in different sections of these methodological guidelines (see sections C.3.2.3 and C.3.2.4 below).

#### C.3.2.1. Living biomass pool: Gain-loss method

##### Sheet Land Gain-Loss Method in the MRV tool

The gain loss method, as presented in the 2006 IPCC guidelines, requires the biomass carbon loss to be subtracted from the biomass carbon gain<sup>18</sup>.

<sup>18</sup> For further explanation of the gain-loss method, refer to Volume 4, Chapter 2 of 2006 IPCC Guidelines.



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### Calculation method in the MRV tool

The calculations for emissions/removals from the change in carbon stock in living biomass are based on the IPCC 2006 Tier 1 Biomass Gain-Loss Method (Equation 2.7 in IPCC 2006 volume 4, chapters 2 and 4). Emissions/removals are calculated based on the following equations:

$$\Delta C_B = \Delta C_G - \Delta C_L \quad \text{Equation C.1}$$

Where:

- $\Delta C_B$  = annual change in carbon stocks in biomass (the sum of above-ground and below-ground biomass) for each land sub-category, considering the total area, t C yr<sup>-1</sup>
- $\Delta C_G$  = annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, t C yr<sup>-1</sup>
- $\Delta C_L$  = annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, t C yr<sup>-1</sup>

**Annual increase in biomass carbon stocks** due to biomass increment in land remaining in the same land-use category are calculated based on the following equation (Equation 2.9 in IPCC 2006 volume 4, chapter 2) with examples provided in Box C.2 and C.3:

$$\Delta C_G = \sum_{i,j} (A_{i,j} \times G_{TOTAL_{i,j}} \times CF_{i,j}) \quad \text{Equation C.2}$$

Where:

- $\Delta C_G$  = annual increase in biomass carbon stocks due to biomass growth in land remaining in the same land-use category by vegetation type and climatic zone, t C yr<sup>-1</sup>
- $A$  = area of land remaining in the same land-use category or in conversion, ha
- $G_{TOTAL}$  = mean annual biomass growth, t d.m. ha<sup>-1</sup> yr<sup>-1</sup>
- $i$  = ecological zone ( $i = 1$  to  $n$ )
- $j$  = climate domain ( $j = 1$  to  $m$ )
- $CF$  = carbon fraction of dry matter, t C (t d.m.)<sup>-1</sup>

Average annual increment in biomass are calculated based on the following equation (Equation 2.10 in IPCC 2006 Volume 4, Chapter 2):

$$\text{Tier 1: } G_{TOTAL} = \Sigma \{G_W \times (1 + R)\}$$

Biomass increment data (dry matter) are used directly

$$\text{Tiers 2 and 3: } G_{TOTAL} = \Sigma \{I_V \times BCEF_i \times (1 + R)\} \quad \text{Equation C.3}$$

Net annual increment data are used to estimate  $G_w$  by applying a biomass conversion and expansion factor.

Where:

- $G_{TOTAL}$  = average annual biomass growth above and below-ground, t d.m. ha<sup>-1</sup> yr<sup>-1</sup>
- $G_w$  = average annual above-ground biomass growth for a specific woody vegetation type, t d.m. ha<sup>-1</sup> yr<sup>-1</sup>



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- $R$  = ratio of below-ground biomass to above-ground biomass for a specific vegetation type, in  $\text{t d.m. below-ground biomass} / (\text{t d.m. above-ground biomass})^{-1}$ .  $R$  must be set to zero if assuming no changes of below-ground biomass allocation patterns (Tier 1).
- $I_v$  = average net annual increment for specific vegetation type,  $\text{m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ . This is the current annual increment of standing volume, i.e. the actual increment in volume, referred as CAI.

**NOTE.** Mean Annual Increment (MAI), i.e. the mean increment over the entire lifetime of the plantation, is not an adequate substitute of Current Annual Increment (CAI), as MAI only represents the net cumulated volume or biomass at the end of the rotation. The use of MAI generally leads to underestimation of the annual increment in the early ages of the plantations. However, if MAI is the only data available, it can be used, while transparent information is provided on it.

Note that if standing tons are stated as wet white tonnes (wwt), i.e. at field wet basis moisture level, then the values need to be converted from wwt to  $\text{m}^3$ . For this conversion, Standard Industry Conversion Factors (ICFs) for round wood can be used.

**Table C.4: Standard Industry Conversion Factors (ICF) for Round wood**

Product	Species	ICF	Unit
Sawlogs	Softwood	0.94	$\text{m}^3/\text{t}$ (wet)
Sawlogs	Eucalyptus Grandis	0.94	$\text{m}^3/\text{t}$ (wet)
Sawlogs	Other Eucalyptus Species	0.78	$\text{m}^3/\text{t}$ (wet)
Matchwood	Poplar	1.03	$\text{m}^3/\text{t}$ (wet)

- $BCEF_i$  = biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to above-ground biomass growth for specific vegetation type, tonnes above-ground biomass growth  $(\text{m}^3 \text{ net annual increment})^{-1}$ .
- If  $BCEF_i$  values are not available and if the biomass expansion factor (BEF) and basic wood density ( $D$ ) values are separately estimated, then the following conversion can be used:

$$BCEF_i = BEF_i \times D$$

Where, Biomass Expansion Factors ( $BEF_i$ ) expand merchantable volume to total above-ground biomass volume to account for non-merchantable components of increment.  $BEF_i$  is dimensionless.

To convert wood harvest data without bark, i.e. under bark, into merchantable wood removals including bark, i.e. over bark, multiply by the bark factor. Default and country-specific bark factors are included in the **Sheet Parameters in the MRV tool** and can be found in Appendix C.1.D. If the wood harvest data is already over bark, the bark fraction should be 0.



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### Box C.2. Information for the example for C stock change in biomass using Gain-Loss method in Box C.3.

For a forest area of 10 ha in temperate zone, it is assumed the forest species have a rotation age of 32 years and is thinned twice at 12 and 22 years (**Error! Reference source not found.**). To calculate gains and losses, current annual increment (CAI) and losses (harvest) data are needed.

All volumes are expressed as over bark.

**Table C.5: Hypothetical stand characteristics of *Pinus patula* showing volume data (merchantable over bark volume)**

Stand age (years)	Volume m <sup>3</sup> /ha			Increment m <sup>3</sup> /ha/year	
	Thinning	Standing vol	Cumulative Vol	MAI	CAI
0.001			0.0001		0.001
7		82.0	82.0	11.7	11.7
12	123.0	95.0	218.0	18.2	27.2
17		265.0	388.0	22.8	34.0
22	120	428.0	548.0	24.9	32.0
27		580.0	703.0	26.0	31.0
32		714.0	837.0	26.2	26.8





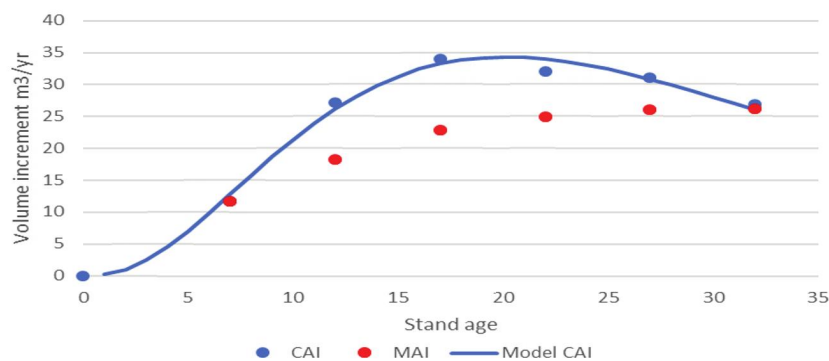
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### Box C.3. Annual increase in biomass carbon stocks due to biomass increment in land remaining in the same land-use category

#### Sheet Land Gain-Loss method in the MRV tool; column Living Biomass GAIN. Sheet Supporting calculations

It is possible to model CAI using a Chapmans growth function or another function as suggested by forest expert, using the information provided in Table C.6. CAI is the recommended increment value to use because it reflects the actual annual increment rate for volume. MAI (derived as the cumulative volume over stand age) is not suitable for growth projections. MAI is generally only used for stand management decision such as determining theoretical stand rotation age (i.e. where CAI and MAI intersect, see Figure C.1).



**Figure C.1: Derived CAI and MAI from cumulative volume production data and the interpolated CAI using the Chapmans growth function (blue line).**

The danger of using MAI is that volume increment and thus biomass growth will be underestimated and hence a lower carbon stock change will be calculated, until age 32 in Figure C.1.

Considering the example forest in Box C.2, in year 17 the CAI,  $BCEF_i$  and  $R$  are:

$$CAI = 34.0 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$$

$$BCEF_i = 0.69 \text{ t m}^{-3} \text{ (IPCC 2006, Volume 4, Chapter 4, Table 4.5, climatic zone temperate, forest type pine and growing stock level } 265 \text{ m}^3 \text{ ha}^{-1}, \text{ i.e. } > 200 \text{ m}^3 \text{ ha}^{-1})$$

$$R = 0.28 \text{ (Du Toit B. et al. 2016).}$$

$$CF = 0.47 \text{ (IPCC 2006).}$$

**Average annual increment ( $G_{\text{Total}}$ ) is calculated as:**

$$G_{\text{TOTAL}} = 34.0 \times 0.69 \times (1+0.28) = 30.02 \text{ t d.m. ha}^{-1} \text{ yr}^{-1} \text{ (Note that if MAI is used, this would be: } G_{\text{TOTAL}} = 22.8 \times 0.240 = 20.24 \text{ t d.m. ha}^{-1} \text{ yr}^{-1} \text{)}$$

In the MRV tool, the Factor for conversion to C biomass growth  $0.69 \times (1+0.28) \times 0.45 = 0.40$  (can be calculated in **Sheet Supporting calculations**); and the total Gain in living biomass (t C) is calculated in **Sheet Land Gain-Loss Method** as:

$$\text{Living Biomass GAIN (ABG+BGB, t C)} = 34 \text{ m}^3 \text{ ha}^{-1} \times 0.42 \text{ t C m}^{-3} \times 10\text{ha} = \mathbf{141.14 \text{ t C}}$$



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**Annual biomass loss** is the sum of losses from wood removal (harvest), fuelwood removal (not counting fuelwood gathered from woody debris), and other losses resulting from disturbances, such as fire, storms, and insect and diseases.

$$\Delta C_L = L_{\text{wood-removed}} \quad \text{Equation C.4}$$

Where:

- $\Delta C_L$  = annual decrease in carbon stocks due to biomass loss in land remaining in the same land-use category, t C yr<sup>-1</sup>
- $L_{\text{wood-removed}}$  = annual carbon loss due to wood removals, t C yr<sup>-1</sup>, includes harvest, regardless its use as fuelwood, and tree parts removals for fuelwood.

And annual biomass carbon loss due to wood-removals is:

$$L_{\text{wood-removed}} = H \times BCEF_R \times (1 + R) \times CF + FG_{\text{part}} \times D \quad \text{Equation C.5}$$

Where:

- $L_{\text{wood-removed}}$  = annual carbon loss due to biomass removals, t C ha<sup>-1</sup> yr<sup>-1</sup>
- $H$  = annual wood removals, roundwood, m<sup>3</sup> yr<sup>-1</sup>
- $R$  = ratio of below-ground biomass to above-ground biomass, in t d.m. below-ground biomass (t d.m. above-ground biomass)<sup>-1</sup>.  $R$  must be set to zero if assuming no changes of below-ground biomass allocation patterns (Tier 1).
- $BCEF_R$  = biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark), t biomass removal (m<sup>3</sup> of removals)<sup>-1</sup>. However, if  $BCEF_R$  values are not available and if the biomass expansion factor for wood removals ( $BEF_R$ ) and basic wood density ( $D$ ) values are separately estimated, then the following conversion can be used:

$$BCEF_R = BEF_R \times D$$

To convert wood harvest data without bark into merchantable wood removals including bark, multiply by bark factor. Default IPCC 2006 bark factors and country-specific bark factors are provided. These factors are included in the **Sheet Parameters in the MRV tool** and can be found in the Appendix. If volume is already over bark, then bark fraction should be 0.

- $CF$  = carbon fraction of dry matter, t C (t d.m.)<sup>-1</sup>
- $FG_{\text{part}}$  = annual volume of fuelwood removal as tree parts (where trees are not felled), m<sup>3</sup> yr<sup>-1</sup>. Assumed 0 in Tier 1.
- $D$  = basic wood density, t d.m. m<sup>-3</sup>



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### Box C.4. Annual decrease in Carbon stocks due to Wood removals in land remaining in the same land-use category.

Sheet Land Gain-Loss method in the MRV tool; column  $\Delta C$  Living Biomass.

#### Sheet Supporting calculations

This example uses BEF and Wood density (D), instead of BCEF used in Box C.3.

Harvest volume – whole tree ( $\text{m}^3 \text{yr}^{-1}$ ) =  $500 \text{ m}^3 \text{yr}^{-1}$  harvest. There is not fuelwood exploitation of tree parts, i.e.  $\text{FG}_{\text{part}} = 0$ .

$$\text{BEF}_R = 3.1 \text{ m}^3 \text{t}^{-1}$$

Bark fraction = 0.13 (default)

Wood density =  $0.354 \text{ t m}^{-3}$  (*Pinus patula* Du Toit B. et al. (2016))

$R = 0.28$  (Du Toit B. et al. 2016)

$\text{CF} = 0.47$  (IPCC 2006)

Then,  $L_{\text{wood-removed}} = 500 \text{ m}^3 \times 3.1 \times (1 + 0.13) \times 0.354 \text{ t m}^{-3} \times (1 + 0.28) \times 0.47 = 373.01 \text{ t C}$

In the MRV tool, the Factor for conversion to C biomass loss  $3.1 \times (1 + 0.13) \times 0.354 \text{ t m}^{-3} \times (1 + 0.28) \times 0.47 = 0.75$  (can be calculated in **Sheet Supporting calculations**); and the total Living Biomass LOSS (ABG+BGB, t C) is calculated in **Sheet Land Gain-Loss Method** as:

Living Biomass LOSS (ABG+BGB, t C) =  $500 \text{ m}^3 \text{yr}^{-1} \times 0.75 = 373.01 \text{ t C}$

Continuing with the example forest from previous boxes: Therefore, the annual change in carbon stocks in biomass in the 10 ha is:

$$\Delta C_B = \Delta G_G - \Delta G_L = 141.14 - 373.01 = -231.9 \text{ t C}$$



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### Data required for the estimates in the MRV tool

This method requires activity data (e.g. area) and forest parameters (e.g. increment, harvest) at either the aggregated (e.g. plantation management units) or disaggregated (e.g. compartment) scale of the land.

Data needs to be disaggregated by the activity, i.e. Forest management.

**Table C.6: Data required for estimating  $\Delta C$  living biomass (gain-loss method)**

<b>Facility ID</b>	Enter the unique facility ID
<b>Activity</b>	Forest Management, Afforestation or Deforestation
<b>Previous land use category</b>	Forest Management, Afforestation, Deforestation, Grassland, Annual Cropland, Perennial Cropland or Other
<b>Ownership</b>	Company owned or 3 <sup>rd</sup> party (please specify)
<b>Species/Genus</b>	Predominant species name
<b>Age Category</b>	Enter value, for afforested areas this should be the years since afforestation occurred
<b>Area</b>	Enter value in ha
<b>Growing stock volume annual net increment</b>	CAI or MAI* (optional for T3)
<b>Factor for conversion to C biomass growth</b>	Enter value or refer to <b>Sheet Supporting Calculations</b> (optional for T3)
<b>Harvest volume, whole tree</b>	Enter value in m <sup>3</sup> /yr
<b>Factor for conversion to C biomass loss</b>	Enter value or refer to <b>Sheet Supporting Calculations</b> (optional for T3)
<b>Living Biomass LOSS - Fuelwood Tree parts</b>	Enter value in t C, assumed 0 in Tier 1 approach

\* CAI = current annual increment, MAI = mean annual increment

### C.3.2.2. Living biomass pool: Stock-difference method

#### Sheet Land Stock-Difference Method in the MRV tool

The Stock-Difference method, as presented in the 2006 IPCC guidelines, requires biomass carbon stock inventories for a given land area, at two points in time<sup>19</sup>. Per unit of area at time  $t_2$ , the annual stock change is the difference between the carbon stock at time  $t_2$  and time  $t_1$ , divided by the number of years between the two inventories<sup>20</sup>.

<sup>19</sup> For further guidance on the stock-difference method, refer to Volume 4, Chapter 2 of 2006 IPCC Guidelines. <https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html>

<sup>20</sup> For further guidance on the stock-difference method, refer to Chapter 2 of 2013 IPCC KP Supplement. <https://www.ipcc-nggip.iges.or.jp/public/kpsg/index.html>



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### Calculation in the MRV tool

The calculations for emissions/removals from the change in carbon stock in living biomass are based on the IPCC 2006 Tier 1 Biomass Stock-Difference Method (IPCC 2006 volume 4, chapters 2 and 4). Emissions/removals are calculated based on the following equations (Equation 2.8 in IPCC 2006 volume 4, chapters 2):

$$\Delta C_B = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

$$C = \sum_{i,j} \{A_{i,j} \times V_{i,j} \times BCEF_{S_{i,j}} \times (1 + R_{i,j}) \times CF_{i,j}\} \quad \text{Equation C.6}$$

Where:

- $\Delta C_B$  = annual change in carbon stocks in biomass (the sum of above-ground and below-ground biomass terms) in land remaining in the same category (e.g. *forest land remaining forest land*), tonnes C yr<sup>-1</sup>
- $C_{t_2}$  = total carbon in biomass for each land sub-category at time  $t_2$ , t C
- $C_{t_1}$  = total carbon in biomass for each land sub-category at time  $t_1$ , t C
- $C$  = total carbon in biomass for  $t_1$  to  $t_2$ , t C
- $A$  = area of land remaining in the same land-use category, ha
- $V$  = merchantable growing stock volume (over bark), m<sup>3</sup> ha<sup>-1</sup>
- $i$  = ecological zone  $i$  ( $i=1$  to  $n$ )
- $j$  = climate domain  $j$  ( $j=1$  to  $m$ )
- $R$  = ratio of below-ground biomass to above-ground biomass, t dm below-ground biomass (t d.m. above ground biomass)<sup>-1</sup>
- $CF$  = carbon fraction of dry matter, tonne C (t d.m.)<sup>-1</sup>
- $BCEF_S$  = biomass conversion and expansion factor for expansion factor for expansion of merchantable growing stock volume to above-ground biomass, t above-ground biomass (m<sup>3</sup> growing stock volume)<sup>-1</sup>

As indicated in 2013 Kyoto Protocol (KP) Supplement, when using this method for a specific activity, it is important to ensure that the area of land in that activity at times  $t_1$  and  $t_2$  is identical, to avoid confounding changes in stock caused by area changes. If the forest area is changing, then carbon stock changes can occur as a result of the transfer of land between activities. Indeed, if the area subject to an activity increases from the beginning to the end of the reporting year, then the reported carbon stocks reflect the transfer of area (and the associated carbon stocks) into the activity; similarly, carbon stocks will decrease, if area is removed from an activity. The issue is of particular concern when areas outside the scheme enter into the reporting system.

It is good practice to implement the calculations of annual carbon stock changes in the following sequence: (1) for any carbon pool of each activity and for each area, the annual carbon stock change should be calculated for the year of interest on the area at time  $t_2$ , (2) these stock changes should be



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summed for all areas subject to the activity. Annual carbon stock changes and non-CO<sub>2</sub> GHG emissions with the area of the activity at the end of the inventory year should be calculated. The same approach should be used consistently over time.

When land-use change events occur, the associated fluxes are reported in the new land-use category (e.g. afforestation or deforestation/conversion from forest plantation to non-forest lands).

The following example, extracted from 2013 IPCC KP Supplement, shows the correct and incorrect way to implement the stock-change method.

### Box C.5. Suggested alternative: Example of Stock-difference calculation

Sheet Land Stock-Different method in the MRV tool; column  $\Delta C_{AGB+BGB}$  in the year  $i$

#### Sheet Supporting calculations

There is 10 ha of *Pinus patula* that has been under forest management for 10 years.

Total standing volume in previous year (year  $t_{i-1}$ ) in vol merch. m<sup>3</sup> over bark = 425 m<sup>3</sup>

Total standing volume in current year (year  $t_i$ ) in vol merch. m<sup>3</sup> over bark = 200 m<sup>3</sup>

If volume is expressed as under bark then the bark fraction needs to be added.

Wood density = 0.354 t m<sup>-3</sup> (*Pinus patula* Du Toit B. et al. (2016))

BEF for CAI = 0.6861 m<sup>3</sup> ha<sup>-1</sup> yr<sup>-1</sup>

R = 0.28 (default)

Bark fraction = 0.13 (default)

CF = 0.47 (IPCC 2006)

In the MRV tool, the Factor for conversion to standing C stock  $0.6861 \times 0.354 \text{ t m}^{-3} \times (1 + 0.13) \times (1 + 0.28) \times 0.47 = 0.17$  (can be calculated in tab Supporting calculations).

Therefore, the Standing C stock in year  $t_{i-1} = 425 \text{ m}^3 \times 0.17 = 72.3 \text{ t C}$ ;

the Standing C stock in year  $t_i = 200 \text{ m}^3 \times 0.17 = 34.0 \text{ t C}$

$\Delta C_{AGB+BGB} = 34.0 - 72.3 = -38.3 \text{ t C}$



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### Box C.6. Example of Stock-difference calculation. Source KP Supplement

During a year of the CP the area of land reported under FM varies because new forest land (natural forest expansion or previously unmanaged forest land that becomes subject to management) is added to the FM area and because of deforestation activities:

	At the start of year	At the end of year
Area of forest lands that was subject to FM in the previous year	1,000,000 ha	990,000 ha
Area of lands subject to FM converted to non-forest land	0 ha	10,000 ha
Area of new forest lands subject to FM	0 ha	10,000 ha
Total area subject to FM	1,000,000 ha	1,000,000 ha

The carbon stocks measured at times  $t_1$  and  $t_2$  in those lands are:

	At the start of year	At the end of year
Average per hectare biomass carbon stock of forest lands subject to FM	100 tC ha <sup>-1</sup>	105 tC ha <sup>-1</sup>
Average per hectare biomass carbon stock of new forest lands subject to FM	80 tC ha <sup>-1</sup>	84 tC ha <sup>-1</sup>
Average per hectare biomass carbon stock in deforested lands	100 tC ha <sup>-1</sup>	20 tC ha <sup>-1</sup>

A correct procedure will calculate stock changes in the three land categories:

- managed forest lands that were subject to FM since the beginning of the year,
- forest lands where the FM activity started during the year,
- managed forest lands subject to FM that were deforested and converted to cropland in the year.

Then, the sum of stock changes calculated for the two types of lands subject to FM will be reported under the FM activity, while the change in stock calculated for deforested land will be reported under D (Article 3.3).

A. Total stock-change in area subject to FM that was subject to FM in the previous year	$990,000 \text{ ha} * (105 - 100) \text{ tC ha}^{-1} = 4,950,000 \text{ tC}$
B. Total stock-change in area subject to FM for the first time in this year	$10,000 \text{ ha} * (84 - 80) \text{ tC ha}^{-1} = 40,000 \text{ tC}$
C. Total stock-change in deforested areas	$10,000 \text{ ha} * (20 - 100) \text{ tC ha}^{-1} = -800,000 \text{ tC}$
Total stock-change in FM areas (A+B)	$4,950,000 + 40,000 = 4,990,000 \text{ tC}$
Stock change reported in Forest Land converted to Cropland under UNFCCC and in D under Article 3.3 (C)	$-800,000 \text{ tC}$

It would be incorrect, for instance, to calculate the total aboveground biomass carbon stock on the total land subject to FM at times  $t_1$  and  $t_2$  and then subtract  $C_1$  from  $C_2$  e.g.:

$C_1$ Total stock in land subject to FM at the start of year	$1,000,000 \text{ ha} * 100 \text{ tC ha}^{-1} = 100,000,000 \text{ tC}$
$C_2$ Total stock in land subject to FM at the end of year	$990,000 \text{ ha} * 105 \text{ tC ha}^{-1} + 10,000 \text{ ha} * 84 \text{ tC ha}^{-1} = 103,950,000 + 840,000 = 104,790,000 \text{ tC}$
$C_2 - C_1$ – yields the incorrect result	$104,790,000 - 100,000,000 = 4,790,000 \text{ tC}$





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### Data required for the estimates in the MRV tool

This method requires activity data (i.e. area) and forest parameters (i.e. standing volume) *at very disaggregated level*, e.g. for each forest compartment of the land under administration by the entity for previous and current year subject to reporting.

Data is needed for the two calendar years, i.e. end of two years, subject to reporting.

Forest compartment would be identified in MRV tool as of records from forest management planning.

As indicated in Table C.6 above and Table C.7 below, the user has the option to use the calculations in the **Sheet Supporting calculations in the MRV Tool** to estimate some of the data required for the estimates. At least Species and Growing stock volume level data are required.

Parameters needed for the estimate of carbon stock change in living biomass are outlined in Table C.7. Defaults are provided where available, but if alternative data which is considered to be more representative and is justifiable and verifiable is available, this should be used. The default parameters are included in the **Sheet Parameters in the MRV tool** and can found in Appendix C.1.C.

**Table C.7: Data required for estimating  $\Delta C\text{ AGB} + B\text{GB}$  (stock-difference method)**

<b>Facility ID</b>	Enter the unique facility ID
<b>Activity</b>	Forest Management, Afforestation or Deforestation
<b>Previous land use category</b>	Forest Management, Afforestation, Deforestation, Grassland, Annual Cropland, Perennial Cropland or Other
<b>Ownership</b>	Company owned or 3 <sup>rd</sup> party (please specify)
<b>Species/Genus</b>	Predominant species name
<b>Age Category</b>	Enter value, for afforested areas this should be the years since afforestation occurred
<b>Harvest volume, whole tree</b>	Enter value in m <sup>3</sup> /yr
<b>Area in the current year <math>t_i</math></b>	Enter value in ha
<b>Total standing volume in previous year (year <math>t_{i-1}</math>)</b>	Enter value in merchantable volume over bark m <sup>3</sup> , 0 = default for afforested land in age category 1 (optional for T3)
<b>Total standing volume in current year (year <math>t_i</math>)</b>	Enter value in merchantable volume over bark m <sup>3</sup> , 0 = default for deforestation (optional for T3)
<b>Factor for conversion to standing C stock in the previous year <math>t_{i-1}</math></b>	Use <b>Sheet Supporting Calculations</b> if value is not known (species and growing stock volume must be entered) (optional for T3)
<b>Factor for conversion to standing C stock in the current year <math>t_i</math></b>	Use <b>Sheet Supporting Calculations</b> if value is not known (species and growing stock volume must be entered) (optional for T3)
<b>Standing C stock in the previous year <math>t_{i-1}</math> C AGB+BGB (t C)</b>	Use <b>Sheet Supporting Calculations</b> if value is not known (species and growing stock volume must be entered) (optional for T3)



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*Standing C stock in the current year t, C  
AGB+BGB (t C)*

Use **Sheet Supporting Calculations** if value is not known (species and growing stock volume must be entered) (optional for T3)

### C.3.2.3. Dead Organic Matter, $\Delta\text{DOM}$

In line with the Accounting Rulebook, for the estimates of carbon stock change in Dead Organic matter pool (Dead wood and litter) the following has been assumed:

- there is no change in DOM pool on forest plantations where there is a continuous forest management as forest plantation (> 20 years as forest), therefore carbon stock change in DOM is only estimated in the case of Afforestation and Deforestation activities.
- If deforestation occurs litter and deadwood C pools are assumed to be immediately / instantaneously oxidised, therefore carbon stock change in DOM is estimated and reported in the year when the Deforestation occurs (Box C.7). If afforested land is deforested before 20 years then only the amount of DOM accumulated over the afforestation period is oxidised (Box C.8).
- If afforestation occurs, afforested areas accumulate DOM for the first 20 years of the established 1<sup>st</sup> rotation. After 20-years or the rotation, DOM reaches an equilibrium value specific to continuous forest plantations.
- Because plantations are under very intensive management and there is no Dead Wood present only carbon stock in Litter is considered.

#### Calculation method in the MRV tool

Since it is assumed that the carbon stock in DOM pool only changes in the case of Afforestation or Deforestation activities, the IPCC 2006 method for Land conversions is used.

Two methods can be used: either track inputs and outputs (the Gain-Loss Method) or estimate the difference in DOM pools at two points in time (Stock-Difference Method). These estimates require either detailed inventories that include repeated measurements of dead wood and litter pools, or models that simulate dead wood and litter dynamics (IPCC, 2006, volume 4 chapter 2).

The MRV tool allows for the estimates using the stock-difference. The Tier 1 assumption is that DOM pools in non-forest land categories after the conversion are zero, i.e., they contain no litter or dead wood. The Tier 1 assumption for land converted from forest to another land-use category is that all DOM carbon losses occur in the year of land-use conversion. Conversely, conversion to Forest Land results in build-up of litter and dead wood carbon pools starting from zero carbon in those pools. DOM carbon gains on land converted to forest occur linearly, starting from zero, over a transition period (IPCC, 2006, volume 4 chapter 2).

Equation C.7 is the stock-difference method applied in the MRV tool and examples are provided in Boxes 7-9.

$$\Delta C_{\text{DOM}} = \frac{(C_n - C_o) \times A_{on}}{T_{on}}$$

**Equation C.7**

Where:

- $\Delta C_{\text{DOM}}$  = annual change in carbon stocks in dead wood or litter, t C yr<sup>-1</sup>



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- $C_o$  = dead wood/litter stock, under the old land-use category,  $t\ C\ ha^{-1}$
- $C_n$  = dead wood/litter stock, under the new land-use category,  $t\ C\ ha^{-1}$ , for forest land the default stock is  $20\ t\ C\ ha^{-1}$  at 20 years
- $A_{on}$  = area undergoing conversion from old to new land-use category, ha
- $T_{on}$  = time period of the transition from old to new land-use category, yr. The Tier 1 default is 20 years for carbon stock increases and 1 year for carbon losses.

### Data required for the estimates in the MRV tool

**Table C.8: Data required for estimating  $\Delta C$  Dead Organic Matter (DOM)**

<b>Facility ID</b>	Enter the unique facility ID
<b>Activity</b>	Forest Management, Afforestation or Deforestation
<b>Previous land use category</b>	Forest Management, Afforestation, Deforestation, Grassland, Annual Cropland, Perennial Cropland or Other
<b>Ownership</b>	Company owned or 3 <sup>rd</sup> party (please specify)
<b>Age Category</b>	Enter value, for afforested areas this should be the years since afforestation occurred
<b>Area / Area in the current year <math>t_i</math></b>	Enter value in ha
<b>DOM</b>	DOM in $t\ C/ha$ , use of <b>Sheet Supporting Calculations</b> is possible if value is not known. Note that the calculated $\Delta C$ DOM should be positive (+) in the case of Forest Management and Afforestation; and negative (-) in the case of Deforestation
<b>DOM in previous land use</b>	DOM in non-forest use $t\ C/ha$ , the default value is 0. This field is optional.

As a minimum, forest type needs to be known for the use of **Sheet Supporting Calculations in the MRV Tool**. Default values of DOM by forest types are sourced from IPCC 2006 Guidelines, these factors are included in the **Sheet Parameters in the MRV tool** and can found in Appendix C.1.D.



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### Box C.7. Annual change in Carbon stocks in DOM due to land use conversion: Afforestation

#### Sheet Land Gain-Loss method in the MRV tool; column $\Delta C$ DOM

##### Sheet Supporting calculations

The default method applied in the MRV tool uses a steady state stock of C in DOM at 20 years.

The stock change for 10 ha of afforested areas of *Pinus patula* in climatic zone warm temperate for the first 20 years is:

C in DOM (equilibrium value for specific continuous forest plantation): 20.3 t C ha<sup>-1</sup> (for Needleleaf evergreen, IPCC 2006, volume 4, chapter 2, Table 2.2, Climate: Warm temperate)

C in DOM in non-forest land: 0 t C ha<sup>-1</sup> (IPCC 2006 Tier 1 assumption)

Then,  $\Delta C_{DOM} = (20.3 \text{ t C ha}^{-1} - 0 \text{ t C ha}^{-1}) \times 10 \text{ ha}/20 \text{ years} = \mathbf{10.15 \text{ t C yr}^{-1}}$

### Box C.8. Annual change in Carbon stocks in DOM due to land use conversion: Deforestation of previous Forest management

#### Sheet Land Gain-Loss method in the MRV tool; column $\Delta C$ DOM

##### Sheet Supporting calculations

For deforestation all DOM is assumed to be immediately oxidised. The stock change for 10 ha of deforested area of *Pinus patula* in climatic zone warm temperate is:

C in DOM (equilibrium value for specific continuous forest plantation): 20.3 t C ha<sup>-1</sup> (for Needle leaf evergreen, IPCC 2006, volume 4, chapter 2, Table 2.2, Climate: Warm temperate)

C in DOM in non-forest land: 0 t C ha<sup>-1</sup> (IPCC 2006 Tier 1 assumption)

Then,  $\Delta C_{DOM} = (0 \text{ t C ha}^{-1} - 20.3 \text{ t C ha}^{-1}) \times 10 = \mathbf{-203 \text{ t C yr}^{-1}}$  to be reported only in the event year



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### Box C.9. Annual change in Carbon stocks in DOM due to land use conversion: from Afforestation to Deforestation

Sheet Land Stock-Difference method in the MRV tool; column  $\Delta C_{DOM}$

#### Sheet Supporting calculations

If 10 ha of *Pinus patula* in climatic zone warm temperate in afforested lands are deforested before reaching 10 years after establishment of the 1<sup>st</sup> rotation (e.g. at 3 years) then the DOM stock change is:

C in DOM (equilibrium value for specific continuous forest plantation): 20.3 t C ha<sup>-1</sup> (for Needle leaf evergreen, IPCC 2006, volume 4, chapter 2, Table 2.2, Climate: Warm temperate)

C in DOM in non-forest land: 0 t C ha<sup>-1</sup> (IPCC 2006 Tier 1 assumption)

$$\Delta C_{DOM} = ((0 \text{ t C ha}^{-1} - 20.03 \text{ t C ha}^{-1}) / 20 \text{ years}) \times 3 \text{ years} \times 10 \text{ ha} = - 30.45 \text{ t C yr}^{-1}$$

#### C.3.2.4. Soil Organic Carbon, $\Delta SOC$

In line with the Accounting Rulebook, for the estimates of carbon stock change in Dead Organic Matter pool (dead wood and litter) the following has been assumed:

- there is no change in SOC pool in Forest management, therefore carbon stock change in SOC is only estimated in the case of Afforestation and Deforestation.
- SOC stock changes associated with Deforestation generally occurs for a period after deforested. However, SOC emissions or removals shall not be reported or accounted because other land uses are not included in the 2019 Carbon Tax Act.
- Therefore, carbon stock change in SOC is only reported when Afforestation occurs and for Forest Management, if Tier 2 or Tier 3 methodologies are applied.
- If afforestation occurs, the default Tier 1 assumption is that afforested areas accumulate SOC for the first 20 years. After 20-years of the rotation, SOC reaches an equilibrium value.

#### Calculation method in the MRV tool

Since it is assumed that the carbon stock in the SOM pool only changes in the case of Afforestation or Deforestation activities, the IPCC 2006 method for Land conversions is used.

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-t)})}{D}$$

$$SOC = \sum_{c,i,j} (SOC_{REF_{c,s,j}} \times F_{LU_{c,s,j}} \times F_{MG_{c,s,j}} \times F_{I_{c,s,j}})$$

Equation C.8

Note:  $T$  is used in place of  $D$  in this equation if  $T \geq 20$  years

Where:

- $\Delta C_{Mineral}$  = annual change in carbon stocks in mineral soils, t C yr<sup>-1</sup>



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- $SOC_0$  = soil organic carbon stock in the last year of an inventory time period, t C
- $SOC_{(0-t)}$  = soil organic carbon stock at the beginning of the inventory time period, t C
- $SOC_0$  and  $SOC_{(0-T)}$  are calculated using the SOC equation in the box where the reference carbon stocks and stock change factors are assigned according to the land-use and management activities and corresponding areas at each of the points in time (time = 0 and time = 0-T)
- T = number of years over a single inventory time period, yr
- D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr. Commonly 20 years, but depends on assumptions made in computing the factors  $F_{LU}$ ,  $F_{MG}$  and  $F_I$ . If T exceeds D, use the value for T to obtain an annual rate of change over the inventory time period (0-T years).
- c = represents the climate zones, s the soil types, and i the set of management systems that are present in a country.
- $SOC_{REF}$  = the reference carbon stock, t C ha<sup>-1</sup>
- $F_{LU}$  = stock change factor for land-use systems or sub-system for a particular land-use, dimensionless.
- $F_{MG}$  = stock change factor for management regime, dimensionless
- $F_I$  = stock change factor for input of organic matter, dimensionless
- A = land area of the stratum being estimated, ha. All land in the stratum should have common biophysical conditions (i.e. climate and soil type) and management history over the inventory time period to be treated together for analytical purposes.

### Data required for estimates in the MRV tool

**Table C.9: Data required for the estimates, Soil Organic Carbon (SOC)**

<b>Facility ID</b>	Enter the unique facility ID
<b>Activity</b>	Forest management, Afforestation or Deforestation
<b>Previous land use category</b>	Forest Management, Afforestation, Deforestation, Grassland, Annual Cropland, Perennial Cropland or Other
<b>Ownership</b>	Company owned or 3 <sup>rd</sup> party (please specify)
<b>Area / Area in the current year <math>t_i</math></b>	Enter value in ha
<b>SOC</b>	SOC in t C/ha, use of <b>Sheet Supporting Calculations</b> is possible if value is not known.  Note that the calculated $\Delta C$ SOM should be positive (+) in the case of Forest Management and Afforestation; and negative (-) in the case of Deforestation



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### *SOC in previous land use*

Change in SOC in non-forest use in t C/ha.  
Use of **Sheet Supporting Calculations** is possible if value is not known.

As a minimum, climate zone and soil type needs to be known for the use of **Sheet Supporting Calculations in the MRV Tool**. Default values of SOC for forest, cropland and grassland are sourced from South Africa NIR 2017. These values are included in the **Sheet Parameters in the MRV tool** and can found in Appendix C.1.D.

### **Box C.10. Annual change in Carbon stocks in SOC due to land use conversion: Afforestation**

#### **Sheet Land Gain-Loss Method in the MRV tool; column $\Delta C$ SOC**

#### **Sheet Supporting calculations**

The default method applied in the MRV tool uses a steady state stock of C in SOC by ha at 20 years. Carbon stock in SOC in non-forest land uses is assumed to be in equilibrium before the first afforestation.

The stock change for 10 ha of afforested areas of *Pinus patula* converted from annual crop in climatic zone warm temperate – moist and sandy soils, for the first 20 years is:

C in SOC in forest after 20 years: 34 t C ha<sup>-1</sup> (SA NIR 2017)

C in SOC in annual cropland: 22.59 t C ha<sup>-1</sup> (SA NIR 2017)

Then,  $\Delta C_{SOC} = (34 \text{ t C ha}^{-1} - 22.59 \text{ t C ha}^{-1}) / 20 \text{ years} \times 10 \text{ ha} = 5.7 \text{ t C yr}^{-1}$





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### Box C.11. Annual change in Carbon stocks in SOC due to accumulation of SOC: Forest management

#### Sheet Land Stock-Difference Method in the MRV tool; column $\Delta C$ SOC

The default Tier 1 method applied in the MRV tool uses a steady state stock of C in SOC by ha in Forest Management areas. However, if facility-specific data is available i.e. a Tier 2 or 3 method is applied, then SOC from Forest Management areas can be estimated.

To estimate the stock change for 10 ha area *Eucalyptus grandis* which has been under forest management for 5 years, it is assumed that:

C in SOC in forest reached equilibrium at 48 t C ha<sup>-1</sup> after 15 years

C in SOC in non-forest use: NA (not applicable)

Then,  $\Delta C_{SOC} = (48 \text{ t C ha}^{-1} / 15 \text{ years}) \times 10 \text{ ha} = 32 \text{ t C yr}^{-1}$

*Note: the values used in this example do not represent real data.*

### Accounting of Annual Change in Plantation Carbon Stocks, $\Delta C$

All emissions and removals from annual changes in plantation carbon stocks that are reported are accounted within the MRV Tool. **Refer to the Accounting Rulebook** (see Chapter B, section B.2) for further information.

#### C.3.3. Harvested Wood Products, $S_{HWP}$

##### C.3.3.1. The mass balance approach

#### Calculation method in the MRV tool

A mass balance approach (Ado\_Paku, 2015) can be used to determine the mass of carbon in the HWP emanating from a mill as follows:

$$mC_{HWP} = mC_{RM} - mC_E - mC_{SW} - mC_{LW} \quad \text{Equation C.9}$$

Where:

- $mC_{HWP}$  = mass of biogenic carbon in HWP leaving the mill. This should include pulp, paper, solid wood products, saw milling waste sold for pulping if applicable, fines or lignin by products, t C
- $mC_{RM}$  = mass of biogenic carbon entering the mill in the timber raw materials, t C

Biogenic carbon  $mC_{RM}$  can be calculated based on the mass of timber processed and default conversion. It also included the mass of recycled wood/pulp.

$$mC_{RM} = V_{(OB)} \times D \times CF + mC_{recycled} \quad \text{Equation C.10}$$



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Country specific values for bark fraction<sup>21</sup>, wood density and carbon fraction are included in the MRV tool. Same factors should be used for species in calculating C stock change in forest land and HWP.

$V_{(OB)}$  = overbark volume,  $m^3$ . If under bark values are used, then  $V \times (1 + \text{Bark fraction})$  should be used. This parameter is needed in order to apply consistently the default factors (e.g. fractions, mass flow factors) provided in this guideline.

$mC_{\text{recycled}}$  is the mass (tC) of inflow from other timber processing facilities that have not been accounted previously. The reported must demonstrate that inclusion of recycled inflows is not double accounting.

- $mC_E$  = mass of biogenic carbon leaving the mill as gaseous emissions, determined as a fraction of  $mC_{RM}$  entering the mill based on the mass flow into biogenic energy, expressed as a fraction of  $mC_{RM}$  ( $FmC_E$ ), t C

$$mC_E = mC_{RM} \times FmC_E \quad \text{Equation C.11}$$

- $mC_{SW}$  = mass of biogenic carbon exiting the mill as solid waste determined as a fraction of  $mC_{RM}$  entering the mill based on the mass flow into biogenic energy, expressed as a fraction of  $mC_{RM}$  ( $FmC_{SW}$ ), t C

$$mC_{SW} = mC_{RM} \times FmC_{SW} \quad \text{Equation C.12}$$

- $mC_{LW}$  = mass of biogenic carbon exiting the mill as liquid waste (effluent) determined as a fraction of  $mC_{RM}$  entering the mill based on the mass flow into biogenic energy, expressed as a fraction of  $mC_{RM}$  ( $FmC_{LW}$ ), t C

$$mC_{LW} = mC_{RM} \times FmC_{LW} \quad \text{Equation C.13}$$

Note: waste discharge threshold applies to  $mC_{SW}$  and  $mC_{LW}$  and emissions are only reported if these thresholds are exceeded (see IPCC code 4 schedule 2 of the 2019 Carbon Tax Act).

Since biogenic and waste emissions are discounted (D) when accounting under the 2019 Carbon Tax Act Equation C.9 can be rewritten as Equation C.14.

$$mC_{HWP} = mC_{RM} - \left(mC_E \times \frac{D}{100}\right) - \left(mC_{SW} \times \frac{D}{100}\right) - \left(mC_{LW} \times \frac{D}{100}\right) \quad \text{Equation C.14}$$

The discount is currently set at 100% in the 2019 Carbon Tax Act, but these emissions will still be reported. The derived  $mC_{HWP}$  value from equation 10 can be used as the  $S_{HWP}$  variable in the S of the C tax equation outlined in the 2019 Carbon Tax Act.

The mass flow approach can be used for all production facilities including the pulp/paper, lignin-based compounds, sawn products or primary wood-based products, or other products well defined as entering or exiting the mill gate. However, certain accounting rules regarding the eligibility of  $mC_{RM}$  need to be considered to avoid double accounting, leakage and conserved mass balance with harvest

<sup>21</sup> Bark fraction is the factor for converting under bark to total merchantable wood i.e. the inclusion of the mixture of bark, wood, branches etc, which is separated from the pulp wood during the process of barking.



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coming from forest areas included in the scheme (see section B.5.2.4.d of Accounting rules in Annex B).

The final removal or emissions from HWP pool ( $S_{HWP}$ ) for different HWP categories ( $i$ ) is derived as a fraction of HWP remaining based on the landfill approach whereby the fraction of C decayed over 96 years ( $fLC_{96}$ ) by different HWPs ( $i$ ) is applied to the reported  $mC_{HWP}$  value submitted by companies:

$$S_{HWP(i)} = mC_{HWP(i)} \times fLC_{96(i)} \quad \text{Equation C.15}$$

The retention potential is expressed as default  $fLC_{96}$  value for different products and is based on the estimated maximum proportions of wood and paper converted to  $CO_2$  or  $CH_4$  in landfills over 96 years (Skog & Nicholson, 1998). The value for pulp is based on the average for all paper products (see **Sheet Parameters in the MRV tool** and Appendix C.1.C).

The industry can use their own Tier 2 values, but this should be demonstrated to be applicable, verifiable and based on sound science, with references included in the annual report.

### C.3.3.2. Paper mills

System boundaries, in line with the over-riding concepts outlined above:

- Any pulp bought in or recovered pulp from other companies as wood products ( $mC_{HWP}$ ) cannot be included in  $mC_{RM}$ , since this would represent double accounting as the credits would have already been claimed as  $mC_{HWP}$  by the company selling the pulp or recovered pulp.
- Sawmill residues or recovered pulp used in production of product cannot be included in  $mC_{RM}$ , as these are already included in the mass flow balance as waste of the reporting company.
- Therefore, there is no need to distinguish between integrated and non-integrated mills.
- However, bought in recovered pulp or wood waste residues provided by other parties (i.e. waste bought in by a non-integrated mill) is considered as  $mC_{RM}$ , since these were not accounted elsewhere (Figure C.2: A mass flow accounting for paper mills).
- Gaseous ( $mC_E$ ), liquid ( $mC_{LW}$ ) and solid waste ( $mC_{SW}$ ) are fully discounted under the C tax rules so this falls outside the system boundary (Figure C.2: A mass flow accounting for paper mills). These emissions could include lime kiln emissions which are considered as a biogenic source of C as part of the recovery in the Kraft process (Adu Poku, 2015).



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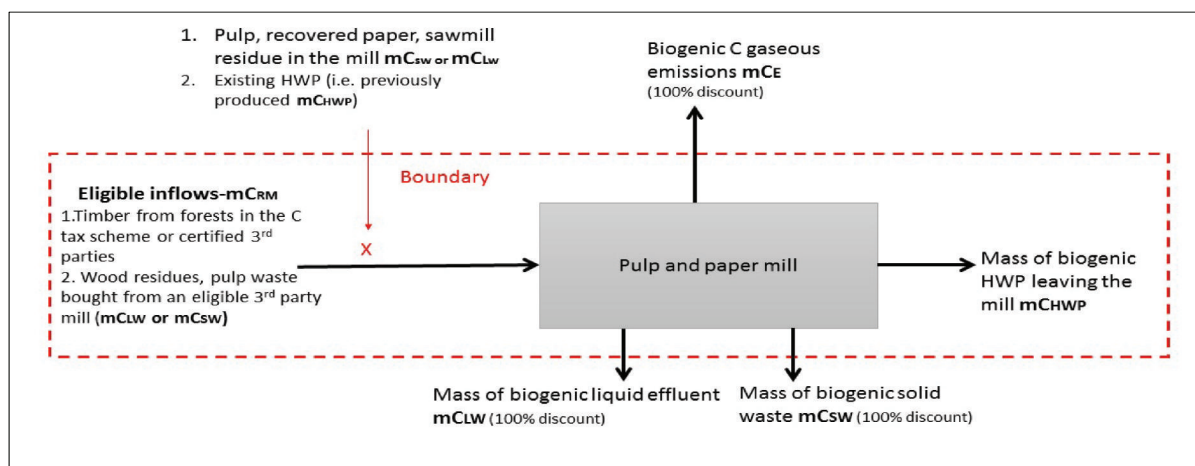


Figure C.2: A mass flow accounting for paper mills

**Mass flow factors for paper mills** are derived from the thesis of Adu Poku (2015), where factors can be categorised based on different milling processes. These factors are included in the **Sheet Parameters in the MRV tool** and can be found in Appendix 1.D. Individual companies can calculate their own mass flow fractions for carbon leaving the mill based on the latest data available where information is available and can be verified with supporting documentation.

### C.3.3.3. Sawmills

**Error! Reference source not found.** Figure C.2: A mass flow accounting for paper mills **Tier 1 option: Mass flow factors for all sawn wood.** Appropriate mass flow factors have not been identified, so tier 1 estimates are based on the fraction recovery of product based on raw timber inputs by HWP category ( $F_{HWPrec}$ ).

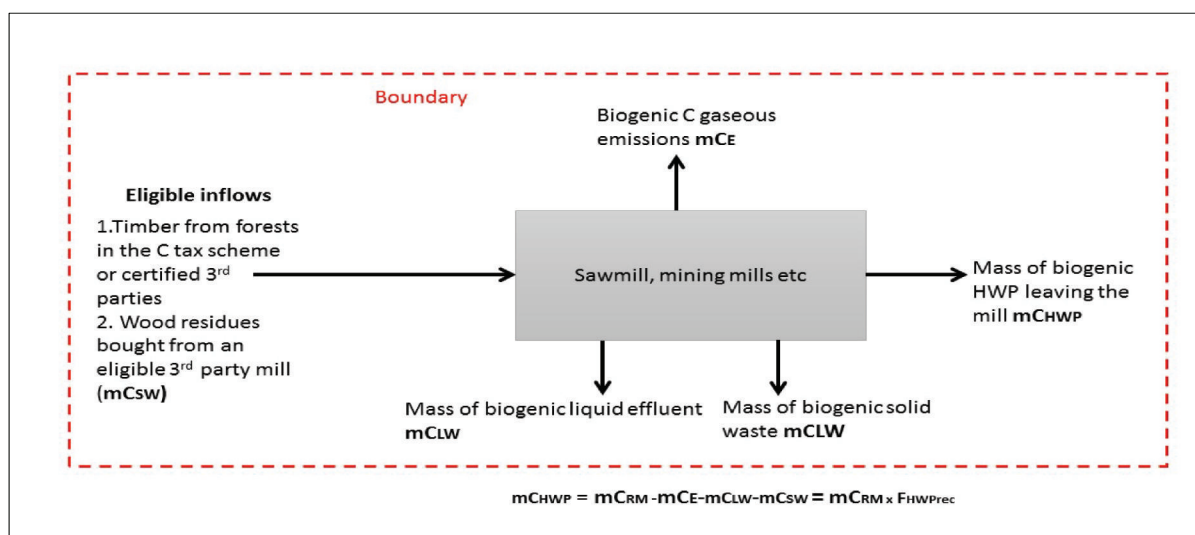


Figure C.3. Mass flow accounting tier 1 (default) option for the sawmill, panels, mining and pole production



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In the absence of any country specific data for  $F_{HWPrec}$ , it is recommended to use the UNECE/FAO conversion factors for the timber industry as a default. Hence Equation C.9 can be restructured for this sector if no specific  $mC_E$ ,  $mC_{SW}$ ,  $mC_{LW}$  data is available:

$$mC_{HWP} = mC_{RM(i)} \times F_{HWP\ rec(i)} \quad \text{Equation C.16}$$

Where:

- $F_{HWPrec}$  is the recovery of product based on raw timber inputs and  $i$  is the HWP category.

In the default approach  $mC_{RM}$  only includes timber inflow from forest areas within the C tax scheme and recovered waste wood or pulp purchased from 3<sup>rd</sup> parties within the C tax scheme. Although the presented recovery ratios do not consider use of by products such as wood chips, saw dust used in other processes such as wood-based panels from particles (WBP) and pulp, processing residues are considered as eligible inflows (Figure C.3).

The approach also means that biogenic and waste emissions are reported but these are fully discounted for this sector (Figure C.3).

Default values for  $F_{HWPrec}$  by HWP category are included in the **Sheet Parameters in the MRV tool** and can be found in Appendix C.1.D.

Higher tier methodologies can use complete C mass flow or models if they are available and verifiable. Hence, individual companies may use their own recovery factors or data relating to biogenic emissions, other wood by-products and C lost in waste from the plant as outlined in Figure C.3, based on the latest available information. Use of such an approach must be verified by supporting production data for each product. It is recommended that the South African milling sector develops specific mass flow factors for each type of mill process. This may be particularly useful if the discount on waste and energy emissions are changed in future amendments to the C Tax Act.

Individual processing facilities should use their own mass flow factors based on the latest available information, which should be verified with supporting documentation.

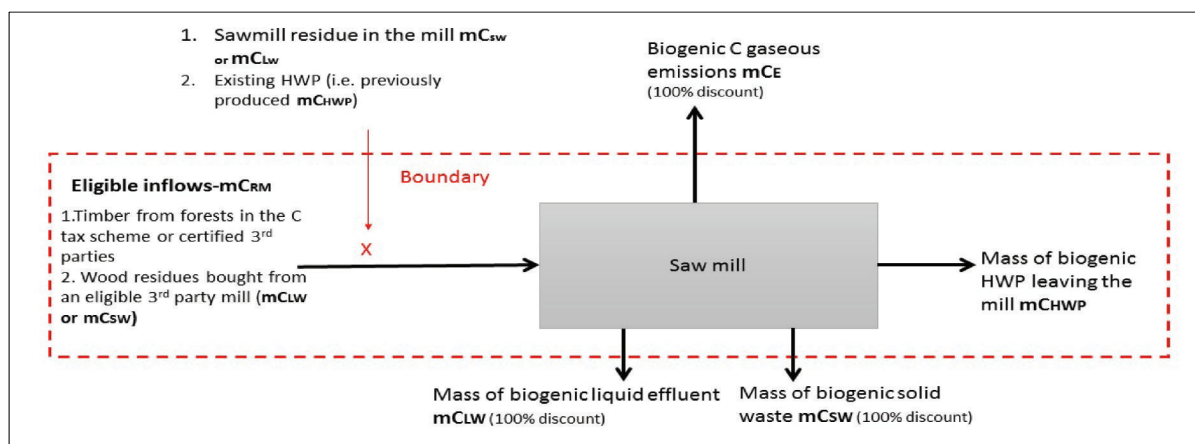
**Tier 2 option.** The mass flow principle can also be applied to the milling and solid wood processing sector (Figure C.3). Carbon mass balance studies are at present only available for production of sawn wood (unpublished data, Kerr 2019). But there are no known publications on mass flow balances for mining poles, wood based panels, plywood or pole production in South Africa. If companies have specific information to calculate sawmill HWP mass balance then the same approach can be used as outlined for the paper and pulp sector using equation C.10, the relevant discounts and waste thresholds (Figure C.2).

Note that if standing tons are stated as wet white tons (wwt), i.e. at field wet basis moisture level, then the values need to be converted from wwt to  $m^3$ . For this conversion, Standard Industry Conversion Factors (ICFs) for round wood can be used (see Table C.4). It needs also to be ensured that the biomass entering the mill is overbark.



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**Figure C.4: Mass flow tier 2 accounting option for the sawmill, panels, mining and pole production**

### Data required for estimates in the MRV tool

In line with the Accounting Rulebook (see Chapter B, section B.3.2), the MRV tool allows for the estimation of the HWP contribution differentiated by Activity (forest management, afforestation or deforestation). However, the HWP estimates in afforested areas can be reported under forest management. HWP estimates in deforested areas are to be reported separately (see column Fraction of harvest from registered forests that is from deforested land), because these are not to be accounted.

The method used requires the following data for Paper mills and Sawmills. Data on the total mass of carbon entering the mills is also required (see Table C.10). The Tier 2 methodology for Sawmills matches the Paper mill methodology with the exception that HWP type rather than the process has to be reported (see Table C.10 below). The Tier 1 methodology for Sawmills is presented in Table C.12.

**Table C.10: Data required for estimating HWP, mass carbon entering the mill**

Ownership	Company owned, 3 <sup>rd</sup> party (please specify) or other registered company
Species/ Genus	Predominant species name
Volume entering the mill underbark	Enter a value in m <sup>3</sup> , or leave blank is 'Biomass entering the mill (t d.m.)' is provided
Biomass entering the mill (t d.m.)	Enter a value in t d.m, or leave blank is 'Volume entering the mill (m <sup>3</sup> )' is provided. Ensure it includes bark

Mass C Entering the mill (t m<sup>3</sup>) can be estimated using the MRV tool within Table C.10 based on:

- Volume Entering the Mill (m<sup>3</sup>) by species
- Mean wood density (t m<sup>-3</sup>) (default by species provided)
- Carbon fraction, CF (default by species provided)
- Bark fraction (default provided)



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Note that when using the MRV tool the volume entering the mill should express under bark, since the bark fraction is then applied. If the volume entering the mill is over bark, then the bark fraction should be 0.

**Table C.11: Data required for estimating HWP, pulp/ paper mills**

Mill name	Enter mill name
Activity	Forest management, Afforestation, or Deforestation If it is not possible to split the data by activity, then select Forest management.
Process	Kraft, Sulphite, Soda (Bagasse), Thermomechanical, NSSC, Mechanical & Kraft, NSSC & Kraft or User defined
Solid waste per year	Enter value, t d.m.
Liquid waste per day	Enter value, m <sup>3</sup> /day
mC recycled inflow	Enter value, t C, the default value is 0
Mass C Entering the Mill	Enter value, t C. Reported separately for 3 <sup>rd</sup> party and other register company inflows
Fraction of harvest from registered and/or 3 <sup>rd</sup> party forest under the C tax act 2019	Enter fraction





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### Box C.12. Estimates for HWP contribution: Pulp mill example

#### Sheet HWP in the MRV tool

In a pulp mill produces thermomechanical pulp from wood of *Eucalyptus grandis*. The annual volume under bark entering the mill is 337 240 m<sup>3</sup>. Pulp rejects are minimized by continuously recycling fibres back into the process.

It is not possible to differentiate the origin of the wood by activity (i.e. Forest management, Afforestation or Deforestation). Solid waste per year is 24 400 t d.m. and Liquid waste output per day is 50 m<sup>3</sup> day<sup>-1</sup>.

Applying Tier 1, the Total inflow: Mass C Entering the Mill (t C) is

Species = *Eucalyptus grandis*

Volume Entering the Mill (m<sup>3</sup>) under bark = 337 240 m<sup>3</sup>

Mean wood density (t m<sup>3</sup>) = 0.42

Carbon fraction (CF) = 0.47 (default)

Bark fraction = 0.13 (default)

Activity = Forest management.

Total inflow: Mass C Entering the Mill (t C) = 337 240 x 0.42 x (1+0.13) x 0.47 = 75 225 t C

mC recycled wood/pulp inflow (t C) = 0, because it is already included in the mass flow balance.

mC<sub>RM</sub> (t C) = 75 225 t C

FmC<sub>E</sub> = 0.11; FmC<sub>SW</sub> = 0.04; FmC<sub>LW</sub> = 0.1

mC<sub>E</sub> = 9 152 t C

Does solid waste threshold exceed amount specified in C tax act? No

Does waste water threshold exceed amount specified in C tax act? No

mC<sub>SW</sub> (t C) = NO

mC<sub>LW</sub> (t C) = NO

mC<sub>HWP</sub> from milling processing facility (t C) = 66 951 t C

fLC<sub>96</sub> = 0.74 (default provided)

S<sub>HWPi</sub> Reporting = - 181 659 t CO<sub>2</sub>

S<sub>HWPi</sub> Accounting = -204 112 t CO<sub>2</sub>



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**Table C.12: Data required for the estimating HWP, sawmill Tier 1**

Mill name	Enter mill name
Activity	Forest management, Afforestation, or Deforestation If it is not possible to split the data by activity, then select Forest management.
HWP type	User defined, e.g. Sawn wood, Sawn wood (Pine), Sawn wood (Eucs), Veneer and plywood, Particle board, OSB and wafer board, Fibreboard (all), Mining timber, Poles or User defined
mC recycled wood/pulp inflow	Enter value, t C, the default is 0
Mass C Entering the mill	Enter value, t C. Report separately for 3 <sup>rd</sup> party and other register company inflows
Fraction of harvest from registered and/or 3 <sup>rd</sup> party forests under the C tax act 2019	Enter fraction

**Table C.13: Data required for estimating HWP, sawmill Tier 2**

Mill name	Enter mill name
Activity	Forest Management, Afforestation or Deforestation If it is not possible to split the data by activity, then select Forest management.
Solid waste per year	Enter value, t
Liquid waste per day	Enter value, m <sup>3</sup> day <sup>-1</sup>
HWP type	User defined, e.g. Sawn wood, Sawn wood (Pine), Sawn wood (Eucs), Veneer and plywood, Particle board, OSB and wafer board, Fibreboard (all), Mining timber, Poles or User defined
mC recycled wood/pulp inflow	Enter value, t C, the default is 0
Mass C Entering the mill	Enter value, t C. Report separately for 3 <sup>rd</sup> party and other register company inflows
Fraction of harvest from registered and/or 3 <sup>rd</sup> party forests under the C tax act 2019	Enter fraction
FmC <sub>E</sub>	Enter value, no defaults available
FmC <sub>SW</sub>	Enter value, no defaults available
FmC <sub>LW</sub>	Enter value, no defaults available



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### Box C.13. Estimates for HWP contribution: Saw mill example

#### Sheet HWP in the MRV tool

A saw mill produces poles from wood of *Eucalyptus grandis*. The annual volume under bark entering the mill is 337 240 m<sup>3</sup>. No recycled wood is used.

It is not possible to differentiate the origin of the wood by activity (i.e. Forest management, Afforestation or Deforestation). Solid waste per year is 24 400 t d.m. and Liquid waste output per day is 50 m<sup>3</sup> day<sup>-1</sup>.

Applying Tier 1, the Total inflow: Mass C Entering the Mill (t C) is

Species = *Eucalyptus grandis*

Volume Entering the Mill (m<sup>3</sup>) under bark = 337 240 m<sup>3</sup>

Mean wood density (t m<sup>3</sup>) = 0.42 (default)

Carbon fraction (CF) = 0.47 (default)

Bark fraction = 0.13 (default)

Activity = Forest management.

Total inflow: Mass C Entering the Mill (t C) = 337 240 x 0.42 x (1+0.13) x 0.47 = 75 225 t C

mC recycled wood/pulp inflow (t C) = 0, because it is already included in the mass flow balance.

mC<sub>RM</sub> (t C) = 75 225 t C

f<sub>HWPrec</sub> = 0.83;

mC<sub>HWP</sub> from milling processing facility (t C) = **62 437 t C**

f<sub>LC96</sub> = 0.97 (default provided)

S<sub>HWPi</sub> Reporting = **-222 068 t CO<sub>2</sub>**

S<sub>HWPi</sub> Accounting = **-267 552 t CO<sub>2</sub>**

#### C.3.4. 1Emissions from Fire, S<sub>fire</sub>

Biomass burning entails the emissions of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O gases. Two types of fires are described in this section: wildfires and controlled burning. The MRV tool includes separate sheets for each of them:

- Controlled burning covers the burning of the remaining residue and litter following the removal of wood to mills and the burning of vegetation in firebreaks. This vegetation is considered to be savanna grassland.
- Wildfires are limited to those affected forest areas within the plantation, i.e. wildfires occurring in grassland areas within the plantation are not estimated nor reporting.



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### Calculation method in the MRV tool

The calculations for emissions from fires ( $S_{\text{fires}}$ ) are based on the IPCC 2006 methodology (volume 4, chapter 2, equation 2.27). Emissions from fires are calculated based on the following equations:

$$L_{\text{fire}} = A_{\text{disturbed}} \times M_B \times C_f \times G_{\text{ef}} \times 10^{-3} \quad \text{Equation C.17}$$

Where:

- $L_{\text{fire}}$  = amount of greenhouse gas emissions from fire, t's of each GHG e.g., t CH<sub>4</sub>, t N<sub>2</sub>O, etc.
- A = area burnt, hectares
- $M_B$  = mass of fuel available for combustion, t d.m. ha<sup>-1</sup>. This includes all biomass, ground litter and dead wood. When Tier 1 methods are used then litter and dead wood pools are assumed to be zero, except where there is a land-use change, therefore:
  - If the activity is Forest management, the total emissions from DOM burnt is assumed to be 0 for tier 1<sup>22</sup>. For higher tier total DOM C stock needs to be provided.
  - If Activity is Afforestation, then total C in DOM depends on the age of the afforestation.
  - If the activity is Deforestation, total C in DOM depends on the age of the afforestation or forest
- $C_f$  = combustion factor, dimensionless. Tier 1 assumption uses the fraction biomass lost based on the type of disturbance and assume the same fraction for AGB and DOM.
- $G_{\text{ef}}$  = emission factor, grams per kilogram of dry matter burnt (default values in Appendix C.1).

### Wildfires - Data required for estimates in the MRV tool

The method requires data on the biomass burnt.

**Table C.14: Data required for estimating emissions from wildfires.**

<b>Facility ID</b>	Enter the unique facility ID
<b>Activity</b>	Forest Management, Afforestation or Deforestation
<b>Total area</b>	Enter value in ha
<b>Mass of fuel available for combustion,</b>	It can be estimated based on total biomass and fraction damaged.
<b>Area disturbed</b>	Enter value in ha
<b>Type of damage</b>	Slight loss, Serious damage or Total loss. This is used to provide default values for the fraction of biomass lost, facility-specific values can be used instead of defaults.

<sup>22</sup> Because the C stock change in DOM in Forest management is 0, i.e. loss should not be reported because gains are not reported.



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In the case of Wildfires, the amount of biomass burnt can be estimated based on:

- Total biomass: input by the user
- fraction damaged: input by the user or default provided based on type of damage (slight loss - 1% lost; serious damage - 60% lost, and total loss - 100% lost according to SA NIR 2017).
- Biomass burnt (t C) =  $M_B$  (t d.m.) x Fraction biomass lost

Emissions of CH<sub>4</sub> and N<sub>2</sub>O are converted to CO<sub>2</sub>eq applying GWP of IPCC third assessment report (TAR).

### Box C.14. Emission estimates due biomass burning: wildfires, forest fires

#### Sheet Wildfires in the MRV tool

Applying tier 1, the biomass loss and gases emissions due to a wildfire affecting 5 ha, producing serious damage in a forest management of Extra tropical forest with a total biomass (living biomass and DOM) per ha of 150 t d.m. ha<sup>-1</sup> are:

Area disturbed = 5 ha

$M_B = 150 \text{ t d.m. ha}^{-1}$

Fraction damage = 0.6 (SA NIR 2019)

$G_{\text{ef-CO}_2} = 1569 \text{ g (kg d.m. burnt)}^{-1}$  (default IPCC 2006)

$L_{\text{fire-CO}_2} = 5 \text{ ha} \times 150 \text{ t d.m. ha}^{-1} \times 0.6 \times 1569 \times 10^{-3} = \mathbf{706.05 \text{ t CO}_2}$

$G_{\text{ef-CH}_4} = 4.7 \text{ g (kg d.m. burnt)}^{-1}$  (default IPCC 2006)

$L_{\text{fire-CH}_4} = 5 \text{ ha} \times 150 \text{ t d.m. ha}^{-1} \times 0.6 \times 4.7 \times 10^{-3} = \mathbf{2.12 \text{ t CH}_4}$

$G_{\text{ef-N}_2\text{O}} = 0.26 \text{ g (kg d.m. burnt)}^{-1}$  (default IPCC 2006)

$L_{\text{fire-N}_2\text{O}} = 5 \text{ ha} \times 150 \text{ t d.m. ha}^{-1} \times 0.6 \times 0.26 \times 10^{-3} = \mathbf{0.12 \text{ t N}_2\text{O}}$

$L_{\text{fire-CO}_2\text{eq}} = 706.05 + 2.12 \times 23 + 0.12 \times 296 = \mathbf{789.3 \text{ t CO}_2\text{eq}}$

*Note that emission factors are expressed in g/kg, therefore 10<sup>-3</sup> needs to be included in the calculation of emissions.*

CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O are first estimated and reported separately. The emissions are then converted to CO<sub>2</sub>eq and reported as a summed total. CO<sub>2</sub> emissions have to be reported in case of deforestation, while it is assuming short term recovery of C in all C pool in the case of forest Management and Afforestation, and therefore CO<sub>2</sub> emissions are not reported.

The estimates must be reported by wildfire.



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### Wildfires – Accounting of emissions from Fire, $S_{\text{fire}}$

This source is not accounted. See Chapter B, section 3 (Accounting Rulebook).

### Controlled burning - Data required for estimates in the MRV tool

The method requires data on the biomass burnt.

*Table C.15: Data required for estimating emissions from controlled burning*

<b>Facility ID</b>	Enter the unique facility ID
<b>Activity</b>	Forest management, Afforestation or Deforestation
<b>Species/Genus</b>	Predominant species name
<b>Area burnt</b>	Enter value in ha
<b>Controlled burning category</b>	Select from the dropdown (11 options available)

In the case of controlled burning, the amount of biomass burnt could can be estimated (see Box C.15 for example) using **Sheet Controlled burning in the MRV Tool**:

- For the controlled burning category post-harvest burning, the amount of biomass burnt is the product of biomass in litter and harvest residues, that is input by the user or default provided, and the combustion fraction, that is input by user or default provided (0.9) sourced from Dovey (2012) in Cirrus report, p.55, table 6.2).
- For the controlled burning category Firebreaks, the amount of biomass burnt is input by the user or the default provided sourced from IPCC 2006, vol 4, ch. 6, table 6.1 t d.m. ha<sup>-1</sup> and the combustion factor 0.77 sourced from IPCC 2006, vol 4, ch. 2, table 2.6, type of vegetation savanna grasslands (mid/late dry season burns), surface layer combustion only.

Emissions of CH<sub>4</sub> and N<sub>2</sub>O are converted to CO<sub>2</sub>eq applying GWP of IPCC third assessment report (TAR).



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### Box C.15. Emission estimates due biomass burning: controlled burning

#### Sheet Controlled burning in the MRV tool

Applying tier 1, the biomass loss and gases emissions due to controlled burning post-harvest in 100 ha of *Eucalyptus grandis* under forest management is:

Area disturbed = 100 ha

Biomass in litter and harvest residues (t d.m. ha<sup>-1</sup>) = 31.4 t d.m. ha<sup>-1</sup> (default provided)

C<sub>f</sub> = 0.9 (default IPCC 2006)

G<sub>ef</sub>-CO<sub>2</sub> = 1569 g (kg d.m. burnt)<sup>-1</sup> (default IPCC 2006)

L<sub>fire-CO<sub>2</sub></sub> = 100 ha × 31.4 t d.m. ha<sup>-1</sup> × 0.9 × 1569 × 10<sup>-3</sup> = **4434.0 t CO<sub>2</sub>**

G<sub>ef</sub>-CH<sub>4</sub> = 4.7 g (kg d.m. burnt)<sup>-1</sup> (default IPCC 2006)

L<sub>fire-CH<sub>4</sub></sub> = 100 ha × 31.4 t d.m. ha<sup>-1</sup> × 4.7 × 10<sup>-3</sup> = **13.3 t CH<sub>4</sub>**

G<sub>ef</sub>-N<sub>2</sub>O = 0.26 g/kg d.m. burnt (default IPCC 2006)

L<sub>fire-N<sub>2</sub>O</sub> = 100 ha × 31.4 t d.m. ha<sup>-1</sup> × 0.26 × 10<sup>-3</sup> = **0.7 t N<sub>2</sub>O**

L<sub>fire-CO<sub>2</sub>eq</sub> = 4377,51 + 13.3 × 23 + 0.7 × 296 = **4957.0 t CO<sub>2</sub>eq**

CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O are first estimated and reported separately. The emissions are then converted to CO<sub>2</sub>eq and reported as a summed total.

The estimates must be reported by controlled burning (harvest residues and litter or firebreaks).

#### Controlled burning – Accounting of emissions from fire, S<sub>fire</sub>

This source is not accounted. See Chapter B, section 3 (Accounting Rulebook).

#### C.3.5. Applied Fertiliser, S<sub>fert</sub>

The application of fertilisers results in human-induced net N additions to soils (e.g. organic fertilisers such as deposited manure, crop residues, sewage sludge and synthetic fertilisers) and consequentially N<sub>2</sub>O emissions. Commercial fertilizers may contain a fraction of nitrogen which represents the activity data for estimation (N inputs). Formally termed “direct emissions from the application of fertiliser”, it does not include the emissions generated through the production and supply of the fertiliser, only the N<sub>2</sub>O emissions generated where they are applied. Only synthetic N fertilisers are assumed to be used, i.e. methodology to estimate emissions due to the use of organic fertilisers is not included in the MRV tool or this document.





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### Calculation method in the MRV tool

The calculations for emissions from applied fertiliser ( $S_{fert}$ ) are based on the IPCC 2006 Tier 1 methodology (volume 4, chapter 11). Emissions from fertiliser are calculated based on the following equations (see Box C.16 for example):

$$N_2O_{Direct-N} = N_2O-N_{N\ inputs} \quad \text{Equation C.18}$$

$$N_2O-N_{N\ inputs} = F_{SN} \times EF_N \quad \text{Equation C.19}$$

Where:

$N_2O\ Direct-N$  = annual direct  $N_2O-N$  emissions produced from managed soils, kg  $N_2O-N\ yr^{-1}$  (N which is available for conversion to  $N_2O$ )

- $N_2O-N\ inputs$  = annual direct  $N_2O-N$  emissions from N inputs to managed soils, kg  $N_2O-N\ yr^{-1}$
- $F_{SN}$  = annual amount of synthetic fertiliser N applied to soils, kg N  $yr^{-1}$ 
  - $F_{SN} = F_{TOTAL} \times Fraction_N$
  - where  $F_{TOTAL}$  = Total fertiliser applied (kg), Fraction N = the fraction of N in fertiliser
- $EF_N$  = emission factor for  $N_2O$  emissions from N inputs (0.01 t  $N_2O-N\ tN^{-1}$ )

Conversion of  $N_2O-N$  emissions to  $N_2O$  emissions for reporting purposes is performed by using the following equation:

$$N_2O = N_2O - N \times \frac{44}{28}$$

Emissions of  $CH_4$  and  $N_2O$  are converted to  $CO_2eq$  applying GWP of IPCC third assessment report (TAR).

#### Box C.16. Emission estimates due to Synthetic fertiliser application

##### Sheet Fertilisation in the MRV tool

$N_2O$  emissions due to the application of 10,000 kg of N synthetic fertilisers in a forest plantation are:

$$F_{SN} = 10,000\ kg\ N$$

$$EF_N = 0.01\ kg\ N_2O - N\ (kg\ N)^{-1}\ (\text{default IPCC 2006})$$

$$N_2O-N_{N\ inputs} = 10,000\ kg\ N \times 0.01\ kg\ N_2O-N\ (kg\ N)^{-1} = 100\ kg$$

$$N_2O\ emissions = 100 \times \frac{44}{28} \times 10^{-3} = 0.16\ t$$

$$CO_2eq\ emissions = 0.16 \times 296 = 46.5\ t\ CO_2eq$$



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### Data required for estimates in the MRV tool

Registered companies must provide their annual total fertiliser application in kg of N. Default values are provided for other parameters required to calculate the total N applied and N<sub>2</sub>O.

**Table C.16: Data required for estimating emissions from applied fertiliser**

<b>Fertiliser type</b>	Enter fertiliser type
<b>Activity</b>	Forest Management, Afforestation or Deforestation
<b>N in fertiliser applied (kg)</b>	Use of Supporting Calculations is possible if value is not known. At least the amount of C in the fertiliser amount applied is required.

If the total amount of N applied is not known this can be estimated based on the total amount of fertiliser applied and a default content of N in fertiliser, sourced from Cirrus report.

Companies should report the total emissions both in t N<sub>2</sub>O and t CO<sub>2</sub>eq from fertiliser application.

### Accounting of applied Fertiliser, S<sub>fert</sub>

This source is not accounted. Refer to Annex B, section 5 (Accounting Rulebook).

### C.3.6. Land Tracking

There is a need for land tracking under the C tax that is covered in the **sheet Facility Register in the MRV tool**. This is required to ensure accounted emissions/removals are permanent and that once an area is accounted it will continue to be accounted for subsequent years. General information is requested by Facility unit.

**Table C.17: General information by Facility unit**

<b>Facility ID</b>	Enter unique facility ID
<b>Province</b>	Select from dropdown
<b>Region</b>	Select from dropdown
<b>Geospatial verification</b>	Provide file reference e.g. paper maps, or geospatial reference
<b>Species/genus</b>	Predominate species name, this should be consistent with the calculation sheets
<b>Area</b>	Enter the area in ha, this should be consistent with the areas entered in either the <b>Land Gain-Loss Method</b> or <b>Land Stock-Difference Method</b> sheets
<b>TUP area</b>	Enter temporary unplanted area in ha.

### C.3.7. 3rd Party register

There is a need to track the 3<sup>rd</sup> parties from which the taxpayer is purchasing wood. This is done within the **sheet 3<sup>rd</sup> Party Register in the MRV tool**. This is required to ensure accounted emissions/removals are eligible. General information is requested by 3<sup>rd</sup> Party Name.



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**Table C.18: General information by Facility unit**

<b>3<sup>rd</sup> Party Name</b>	Enter 3 <sup>rd</sup> party name
<b>Facility ID</b>	Enter unique facility ID
<b>Area harvested</b>	Enter the area of the Facility that is harvested
<b>Proportion of harvest bought</b>	Enter value
<b>Harvest amount</b>	Enter value
<b>Units of harvest</b>	Provide the units of the harvest amount
<b>Geospatial verification</b>	Provide file reference e.g. paper maps, or geospatial reference
<b>Is there an agreement with the 3<sup>rd</sup> Party?</b>	Yes or no
<b>Has a certificate been provided?</b>	Yes or no
<b>Are forest emissions/reported?</b>	Yes or no

### C.3.8. Verification

A separate document has been prepared to provide detailed information for the verification process (see Chapter D of this report). In the **sheet Verification in the MRV tool** some information relating to verification is provided. It is not mandatory to complete this sheet, but taxpayers are encouraged to do so as it would assist the verification process and could shorten the time for the approval process.

### C.3.9. Guidance for the Use of Models

Companies can develop their own tier 3 methods for estimating carbon sources and sinks. Tier 3 methods make use of measurements and/or modelling, with the goal of improving the estimation of GHG emissions and removals, first in order to reach Tier 2 or go beyond what is possible with Tier 1 or 2 methods. The IPCC Refinement Volume 4, chapter 2, section 2.5. provides guidance on the development of such models.

If tier 3 models are applied in C tax accounting it is essential to have detailed and transparent documentation to accompany the model. The following details are required in the documentation:

- a) Model selection or development:
  - i. A description of the model;
  - ii. Reasons for choosing the model (e.g. suitability to C tax reporting and accounting);
  - iii. Discussion on any likely consequences if the model is used outside of the domain that the model is parameterised to simulate;
- b) Model calibration:
  - i. Description of the process undertaken to calibrate the model;
  - ii. Documentation of the data sources informing the manual or automatic calibration;
- c) Model behaviour evaluation:
  - i. Results of the analysis verifying model behaviour using independent measurements to confirm that the model is capable of estimating carbon stocks, stock changes and/or emissions and removals in the source/sink categories of interest;
  - ii. Source of independent data;
- d) Model implementation:
  - i. Overview of procedures that are used to apply the model;
- e) Quantifying uncertainties:
  - i. Description of the approach taken to estimate uncertainty in the model outputs;



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- f) Verification of estimates:
  - i. Summary of the verification results for the model;
- g) Reporting and documentation:
  - i. Information on the quality assurance and quality control step taken throughout the process.

This documentation would need to be submitted along with the C Tax sequestration submission to DEFF.

### C.4. References

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## Appendix C.1

### Appendix C.1.A: Functionalities in the MRV Tool & User Tips

It is recommended that users familiarise themselves with the Methodology Guidelines before using the MRV Tool. The key functionalities of the MRV Tool and user tips are provided below. This information is also provided within the **Sheet Content and Instructions in the MRV tool**.

- Detailed information is provided within each sheet as well as within the Methodological Guidance. Read this information carefully before entering any data into the tool.
- Complete all green cells (input data cells) which are relevant for the tier being applied, note that users should:
  - Use either the gain-loss of the stock-difference method for calculating the carbon stock change in living biomass.
  - Use either the tier 1 or tier 2 tables provided for Saw Mills in the 'HWP' sheet.
- Complete the methodology boxes at the top of each sheet
- Add new rows under the tables as needed, the formula will be copied automatically.
- Some tables are pre-filled with data for demonstration purposes, references are provided to the Methodological Guidelines. This data should be overridden/ removed before submitting this file.
- The formula within the compilation tables are provided to help with the calculations but can be overridden, it is recommended that users first review the examples provided within the MRV Tool.
- Default parameters are provided for some categories, users may use their own parameters as long as justification is provided. Detailed information is provided within the methodology.
- Some activity data/emissions/removals estimates required for the yellow compilation sheets can be generated in the **Sheet Supporting Calculations in the MRV Tool**.
- The **Sheet Reporting & Accounting in the MRV Tool** is filled automatically, ensure that the appropriate methods are selected in the dropdowns

Where no emissions/removals are generated from a source/pool the appropriate notation keys should be applied (see below).



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### Appendix C.1.B: Country specific Mass flow factors for sawn wood

Mass flow factors for all sawn wood production systems based on inflows of round wood. The only available mass flow factors for the sawn wood products are provided by Kerr (unpublished thesis, 2019) as shown in

Table C.19. These are based on mass flow for all sawn wood products in South Africa, so these estimates are not suitable for use by individual mills because recovery rates could vary from 28 to 100 % (Christie and Scholes, 1995). These are not considered to be suitable for reporting of HWP flow for individual companies.

**Table C.19: Mass flow factors for sawn wood. Not to be used for Tier 1**

Mass flow factor	Value (t C/t C of roundwood inflows)
$fmC_E$	0.061
$fmC_{LW}^*$	NA
$fmC_{sw}$	0.092

\* There are no liquid waste emission C flows in the sawn wood processing sector (NA= not applicable)

## Appendix C.1.C: BCEF default values (see "BCEF lookups" in MRV tool)

Table C.20: BCEF default values

Lookup	Climatic Zone	Species	Growing stock level (m <sup>3</sup> )	BCEF <sub>i</sub> (t/m <sup>3</sup> )	BCEF <sub>R</sub> (t/m <sup>3</sup> )	BCEF <sub>s</sub> (t/m <sup>3</sup> )
Hardwoods/Eucalyptus < 20	Temperate	Hardwoods/Eucalyptus	< 20	1.5	3.33	3
Hardwoods/Eucalyptus 21 - 40	Temperate	Hardwoods/Eucalyptus	21 - 40	1.3	1.89	1.7
Hardwoods/Eucalyptus 41 - 100	Temperate	Hardwoods/Eucalyptus	41 - 100	0.9	1.55	1.4
Hardwoods/Eucalyptus 101 - 200	Temperate	Hardwoods/Eucalyptus	101 - 200	0.6	1.17	1.05
Hardwoods/Eucalyptus > 200	Temperate	Hardwoods/Eucalyptus	> 200	0.48	0.89	0.8
Pines < 20	Temperate	Pines	< 20	1.5	2	1.8
Pines 21 - 40	Temperate	Pines	21 - 40	0.75	1.11	1
Pines 41 - 100	Temperate	Pines	41 - 100	0.6	0.83	0.75
Pines 101 - 200	Temperate	Pines	101 - 200	0.67	0.77	0.7
Pines > 200	Temperate	Pines	> 200	0.69	0.77	0.7
Acacia < 20	Temperate	Acacia	< 20	1	3.33	3
Acacia 21 - 40	Temperate	Acacia	21 - 40	0.83	1.55	1.4
Acacia 41 - 100	Temperate	Acacia	41 - 100	0.57	1.11	1
Acacia 101 - 200	Temperate	Acacia	101 - 200	0.53	0.83	0.75
Acacia > 200	Temperate	Acacia	> 200	0.6	0.77	0.7

Source: IPCC (2006) Volume 4, Chapter 4, Table 4.



## Appendix C.1.D: Default and country-specific parameters included in the MRV tool

Type	Parameter	Value	Units	Data Source
General factors <i>named ranges set</i>	C to CO <sub>2</sub>	-3.67	-	IPCC 2006
	N to N <sub>2</sub> O	1.57	-	IPCC 2006
	GWP CH <sub>4</sub>	23	-	IPCC third assessment report (TAR)
	GWP N <sub>2</sub> O	296	-	IPCC third assessment report (TAR)
	kg to t / g to kg	0.001	-	-
Carbon Fraction				
Combustion factors	CF: Default	0.47	t C/ d.m.	IPCC 2006, V4, Chp4, Table 4.3 Default value
	Eucalyptus grandis - Both treatments, spread- and piled- slash	0.92	fraction	Nadel (2005) (Knowles & Christie, 2018, p.55, table 6.2)
	Eucalyptus grandis - 36.4 t.ha-1 pre-fire, 4.2 t.ha-1 post-fire	0.9	fraction	Dovey (2012) (Knowles & Christie, 2018, p.55, table 6.2)
	Firebreaks: grassland	1	fraction	IPCC (2006)
	R: above-ground to below-ground ratio			
	R: Eucalyptus grandis	0.24	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: Eucalyptus dunii	0.24	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: Eucalyptus macarthurii	0.24	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: Eucalyptus nitens	0.24	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: Eucalyptus smithii	0.24	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: E. grandis x E.urophylla	0.24	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016

Type	Parameter	Value	Units	Data Source
	R: <i>E.grandis</i> x <i>E.nitens</i>	0.24	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: <i>E.grandis</i> x <i>E.camaldulensis</i>	0.24	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: <i>Pinus patula</i>	0.28	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: <i>Pinus elliottii</i> (13 yrs)	0.28	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: <i>Pinus radiata</i>	0.28	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: <i>Pinus taeda</i> (12 yrs)	0.28	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: <i>Pinus pinaster</i>	0.28	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	R: <i>Acacia mearnsii</i>	0.28	ratio	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
D: Mean wood density				
	D: <i>Eucalyptus grandis</i>	0.42	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: <i>Eucalyptus dunii</i>	0.534	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: <i>Eucalyptus macarthurii</i>	0.541	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: <i>Eucalyptus nitens</i>	0.483	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: <i>Eucalyptus smithii</i>	0.569	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: <i>E.grandis</i> x <i>E.urophylla</i>	0.487	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: <i>E.grandis</i> x <i>E.nitens</i>	0.512	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: <i>E.grandis</i> x <i>E.camaldulensis</i>	0.588	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016

Type	Parameter	Value	Units	Data Source
	D: Pinus patula	0.354	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: Pinus elliottii (13 yrs)	0.42	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: Pinus radiata	0.382	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: Pinus taeda (12 yrs)	0.416	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: Pinus pinaster	0.44	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
	D: Acacia mearnsii	0.655	t/m <sup>3</sup>	Du Toit B. et al. (2016) Carbon sequestration in South Africa plantation forests, Progress report number 1. Prepared for PAMSA, February 2016
Bark fraction				
	Bark fraction: default	0.13	fraction	IPCC 2006, V4, Ch12, Table 12.5, default value from notes
Default living biomass in other land uses				
	Total biomass: Grassland	6.1	t C/ d.m.	IPCC 2006, V4, Ch6, Table 6.4, Climate: Warm temperate, dry
	Total biomass: Annual Cropland	5	t C/ d.m.	IPCC 2006, V4, Ch5, Table 5.9
	Total biomass: Perennial Cropland	2.1	t C/ d.m.	IPCC 2006, V4, Ch5, Table 5.9, Climate: Temperate
	Total biomass: Other	0		
Default DOM carbon stocks				
	DOM: Broadleaf deciduous	28.2	t C/ha	IPCC 2006, V4, Ch2, Table 2.2, Climate: Warm temperate, dry
	DOM: Needleleaf evergreen	20.3	t C/ha	IPCC 2006, V4, Ch2, Table 2.2, Climate: Warm temperate, dry
Default mass flow fraction for C leaving the mill as a proportion of timber entering the mill under different milling processes. Paper/pulp mill				
	FmCE: Kraft	0.49	fraction	Adu Poku, 2015; Published yield range %: 40-50
	FmCE: Sulphite	0.42	fraction	Adu Poku, 2015; Published yield range %: 29
	FmCE: Soda (Bagasse)	0.62	fraction	Adu Poku, 2015; Published yield range %: 28-42
	FmCE: Thermomechanical	0.11	fraction	Adu Poku, 2015; Published yield range %: 72-95
	FmCE: NSSC	0.13	fraction	Adu Poku, 2015; Published yield range %: 63-76
	FmCE: Mechanical & Kraft	0.36	fraction	Adu Poku, 2015; Published yield range %: 46

Type	Parameter	Value	Units	Data Source
	FmCE: NSSC & Kraft	0.28	fraction	Adu Poku, 2015; Published yield range %: 57
	FmCSW: Kraft	0.03	fraction	Adu Poku, 2015; Published yield range %: 40-50
	FmCSW: Sulphite	0.01	fraction	Adu Poku, 2015; Published yield range %: 29
	FmCSW: Soda (Bagasse)	0.05	fraction	Adu Poku, 2015; Published yield range %: 28-42
	FmCSW: Thermomechanical	0.04	fraction	Adu Poku, 2015; Published yield range %: 72-95
	FmCSW: NSSC	0.15	fraction	Adu Poku, 2015; Published yield range %: 63-76
	FmCSW: Mechanical & Kraft	0.09	fraction	Adu Poku, 2015; Published yield range %: 46
	FmCSW: NSSC & Kraft	0.09	fraction	Adu Poku, 2015; Published yield range %: 57
	FmCLW: Kraft	0	fraction	Adu Poku, 2015; Published yield range %: 40-50
	FmCLW: Sulphite	0.27	fraction	Adu Poku, 2015; Published yield range %: 29
	FmCLW: Soda (Bagasse)	0.015	fraction	Adu Poku, 2015; Published yield range %: 28-42
	FmCLW: Thermomechanical	0.1	fraction	Adu Poku, 2015; Published yield range %: 72-95
	FmCLW: NSSC	0	fraction	Adu Poku, 2015; Published yield range %: 63-76
	FmCLW: Mechanical & Kraft	0	fraction	Adu Poku, 2015; Published yield range %: 46
	FmCLW: NSSC & Kraft	0.04	fraction	Adu Poku, 2015; Published yield range %: 57
FHWPPrec values for different categories and sources of data for the saw mill default approach.				
	FHWPPrec: Sawn wood	0.43	fraction	Mean value. South African Forestry and Forest Industry Facts 1980-2017
	FHWPPrec: Sawn wood (Pine)	0.5	fraction	CHRISTIE, S. & SCHOLLES, R. 1995
	FHWPPrec: Sawn wood (Eucs)	0.28	fraction	CHRISTIE, S. & SCHOLLES, R. 1995
	FHWPPrec: Veneer and plywood	0.46	fraction	UNECE/FAO, 2010
	FHWPPrec: Particle board	0.82	fraction	UNECE/FAO, 2010
	FHWPPrec: OSB and waferboard	0.9	fraction	UNECE/FAO, 2010
	FHWPPrec: Fibreboard (all)	0.85	fraction	UNECE/FAO, 2010
	FHWPPrec: Mining timber	0.74	fraction	Median value (data not normally distributed). South African Forestry and Forest Industry Facts 1980-2017
	FHWPPrec: Poles	0.83	fraction	Median value (data not normally distributed). South African Forestry and Forest Industry Facts 1980-2017
fLC96 values for different mill inputs				

Type	Parameter	Value	Units	Data Source
	flC96: Solid wood	0.97	fraction	Skog & Nicholson, 1998
	flC96: Newsprint	0.84	fraction	Skog & Nicholson, 1998
	flC96: Coated paper	0.82	fraction	Skog & Nicholson, 1998
	flC97: Boxboard	0.68	fraction	Skog & Nicholson, 1998
	flC97: Office paper	0.62	fraction	Skog & Nicholson, 1998
	flC97: Mean paper used for pulp	0.74	fraction	Skog & Nicholson, 1998
Fires				
	Extra tropical forest CO2 EF	1569	g/kg d.m. burnt	Andrae and Merlet (2001). IPCC 2006, V4, Ch2, Table 2.5
	Extra tropical forest CH4 EF	4.7	g/kg d.m. burnt	Andrae and Merlet (2001). IPCC 2006, V4, Ch2, Table 2.5
	Extra tropical forest N2O EF	0.26	g/kg d.m. burnt	Andrae and Merlet (2001). IPCC 2006, V4, Ch2, Table 2.5
	Slight loss	0.01	fraction	South Africa 2017 GHI inventory
	Serious damage	0.6	fraction	South Africa 2017 GHI inventory
	Total loss	1	fraction	South Africa 2017 GHI inventory
Biomass burning Post-harvest				
	Biomass burning Post-harvest: Eucalyptus grandis	31.4	t d.m./ha	du Toit et al. (2004) (Knowles & Christie, 2018)
	Biomass burning Post-harvest-spread slash: Eucalyptus grandis	15	t d.m./ha	Nadel (2005) (Knowles & Christie, 2018)
	Biomass burning Post-harvest-piled slash: Eucalyptus grandis	79	t d.m./ha	Nadel (2005) (Knowles & Christie, 2018)
	Biomass burning Post-harvest-mean: Eucalyptus grandis	15.4	t d.m./ha	Nadel (2005) (Knowles & Christie, 2018)
	Biomass burning Post-harvest-harvest residue: Eucalyptus grandis	26	t d.m./ha	Dovey (2012) (Knowles & Christie, 2018)
	Biomass burning Post-harvest-litter: Eucalyptus grandis	24.6	t d.m./ha	
	Biomass burning Post-harvest-litter-sawn timber regime: Pinus patula	15 - 138	t d.m./ha	Ross 2004 (Knowles & Christie, 2018)
	Biomass burning Post-harvest-litter-pulp wood regime: Pinus patula	23 - 53	t d.m./ha	Ross 2004 (Knowles & Christie, 2018)

Type	Parameter	Value	Units	Data Source
	Biomass burning Post-harvest-harvest residue-sawn timber regime: Pinus patula	54.6	t d.m/ha	Ross 2004 (Knowles & Christie, 2018)
	Biomass burning Post-harvest-harvest residue - pulpwood regime: Pinus patula	55.6	t d.m/ha	Ross 2004 (Knowles & Christie, 2018)
	Biomass burning grassland: firebreaks	10	t d.m/ha	IPCC 2006, V4, Ch2, Table 2.4, All savanna grasslands (mid/late dry season burns)*
Fertilisers				
	EF for N additions from mineral fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon	0.01	kg N <sub>2</sub> O-N (kg N) <sup>-1</sup>	IPCC 2006 V4, Ch11, Table 11.1. Uncertainty range 0.003 - 0.03
	N in synthetic fertiliser (NPK)	0.175	Fraction N	Knowles & Christie, 2018: NPK fertiliser (REF?), Table 7.2. N elemental = 5/(5+1+0) * 0.21
Discount for emissions				
	Fires	100		Accounting Rulebook and C tax Bill 2019
schedule 2 of the act	Fertilisation	100		Accounting Rulebook and C tax Bill 2019
SOC values				
	Managed forest - Cold, temperate, dry - High activity clay	50	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold, temperate, dry - Low activity clay	33	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold, temperate, dry - Sandy soils	34	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold, temperate, dry - Volcanic soils	20	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold, temperate, dry - Wetland soils	87	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold temperate, moist - High activity clay	95	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)

Type	Parameter	Value	Units	Data Source
	Managed forest - Cold temperate, moist - Low activity clay	85	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold temperate, moist - Sandy soils	71	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold temperate, moist - Spodic soils	115	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold temperate, moist - Volcanic soils	130	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Cold temperate, moist - Wetland soils	87	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, dry - High activity clay	38	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, dry - Low activity clay	24	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, dry - Sandy soils	19	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, dry - Volcanic soils	70	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, dry - Wetland soils	88	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, moist - High activity clay	88	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, moist - Low activity clay	63	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, moist - Sandy soils	34	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, moist - Spodic soils	NA	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, moist - Volcanic soils	80	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Managed forest - Warm temperate, moist - Wetland soils	88	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold, temperate, dry - High activity clay	33.56	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)



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# Government Gazette Staatskoerant

REPUBLIC OF SOUTH AFRICA  
REPUBLIEK VAN SUID AFRIKA

Vol. 666

4 December 2020  
Desember

No. 43962

PART 2 OF 3

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ISSN 1682-5843



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Type	Parameter	Value	Units	Data Source
	Perennial crop - Cold, temperate, dry - Low activity clay	22.15	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold, temperate, dry - Sandy soils	22.83	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold, temperate, dry - Volcanic soils	3	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold, temperate, dry - Wetland soils	58.41	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold temperate, moist - High activity clay	63.77	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold temperate, moist - Low activity clay	57.06	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold temperate, moist - Sandy soils	47.66	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold temperate, moist - Spodic soils	77.2	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold temperate, moist - Volcanic soils	87.27	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Cold temperate, moist - Wetland soils	58.41	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, dry - High activity clay	25.51	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, dry - Low activity clay	16.11	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, dry - Sandy soils	12.76	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, dry - Volcanic soils	46.99	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, dry - Wetland soils	59.08	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, moist - High activity clay	59.084	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, moist - Low activity clay	42.29	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)

Type	Parameter	Value	Units	Data Source
	Perennial crop - Warm temperate, moist - Sandy soils	22.83	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, moist - Spodic soils	NA	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, moist - Volcanic soils	53.71	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Perennial crop - Warm temperate, moist - Wetland soils	59.07	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold, temperate, dry - High activity clay	36.73	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold, temperate, dry - Low activity clay	24.24	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold, temperate, dry - Sandy soils	24.98	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold, temperate, dry - Volcanic soils	14.69	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold, temperate, dry - Wetland soils	63.91	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold temperate, moist - High activity clay	63.97	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold temperate, moist - Low activity clay	57.24	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold temperate, moist - Sandy soils	47.81	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold temperate, moist - Spodic soils	77.44	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold temperate, moist - Volcanic soils	87.54	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Cold temperate, moist - Wetland soils	58.58	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, dry - High activity clay	27.58	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, dry - Low activity clay	17.42	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)

Type	Parameter	Value	Units	Data Source
	Annual crop - Warm temperate, dry - Sandy soils	13.79	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, dry - Volcanic soils	50.81	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, dry - Wetland soils	63.87	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, moist - High activity clay	58.47	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, moist - Low activity clay	41.86	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, moist - Sandy soils	22.59	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, moist - Spodic soils	NA	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, moist - Volcanic soils	53.15	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Annual crop - Warm temperate, moist - Wetland soils	58.47	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold, temperate, dry - High activity clay	50	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold, temperate, dry - Low activity clay	33	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold, temperate, dry - Sandy soils	34	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold, temperate, dry - Volcanic soils	20	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold, temperate, dry - Wetland soils	87	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold temperate, moist - High activity clay	95	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold temperate, moist - Low activity clay	85	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold temperate, moist - Sandy soils	71	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)

Type	Parameter	Value	Units	Data Source
	Natural grassland - Cold temperate, moist - Spodic soils	115	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold temperate, moist - Volcanic soils	130	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Cold temperate, moist - Wetland soils	87	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, dry - High activity clay	38	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, dry - Low activity clay	24	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, dry - Sandy soils	19	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, dry - Volcanic soils	70	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, dry - Wetland soils	88	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, moist - High activity clay	88	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, moist - Low activity clay	63	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, moist - Sandy soils	34	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, moist - Spodic soils	NA	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, moist - Volcanic soils	80	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Natural grassland - Warm temperate, moist - Wetland soils	88	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold, temperate, dry - High activity clay	46.4	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold, temperate, dry - Low activity clay	30.64	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold, temperate, dry - Sandy soils	31.55	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)

Type	Parameter	Value	Units	Data Source
	Moderately degraded grassland - Cold, temperate, dry - Volcanic soils	18.56	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold, temperate, dry - Wetland soils	80.74	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold temperate, moist - High activity clay	88.16	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold temperate, moist - Low activity clay	78.89	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold temperate, moist - Sandy soils	65.89	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold temperate, moist - Spodic soils	106.72	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold temperate, moist - Volcanic soils	120.64	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Cold temperate, moist - Wetland soils	80.74	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, dry - High activity clay	35.492	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, dry - Low activity clay	22.42	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, dry - Sandy soils	17.75	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, dry - Volcanic soils	65.38	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, dry - Wetland soils	82.192	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, moist - High activity clay	82.72	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, moist - Low activity clay	59.22	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, moist - Sandy soils	31.96	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)



Type	Parameter	Value	Units	Data Source
	Moderately degraded grassland - Warm temperate, moist - Spodic soils	NA	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, moist - Volcanic soils	75.2	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)
	Moderately degraded grassland - Warm temperate, moist - Wetland soils	82.72	t C/ha	SA NIR 2017 (IPCC 2006 SOC Ref and IPCC 2019 stock change factors)



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# Chapter D: Verification Guidelines for Carbon Sequestration in Forest Plantations

## D.1. Overview

An overview of the verification process is shown in Table D.1. The Carbon Tax Sequestration MRV Tool (referred to as “MRV Tool” throughout this document) is the tool which should be submitted via the NAEIS system. The collection of data and calculation of emissions/removals should follow the rules provided in the Accounting Rulebook (Chapter B) and the methods provided in the Methodological Guidelines for Land Activities in Forest Plantations (Chapter C). The competent authority to undertake the review in this case is the Department of Environment, Forestry and Fisheries (DEFF).

**Table D.1: Overview of verification process.**

Process stage	Details of the validation and verification guideline section	Applicable guideline section
<b>1 Data collection</b>	The taxpayer is required to collect and store relevant data and supporting evidence related to its sequestration. It is regarded as good practice that the facility establishes a Monitoring Plan.	Section D.2
<b>2 Submission of data</b>	The taxpayer is required to complete the self-declaration and MRV Tool and submit the requested documentation on the NAEIS. Taxpayers who have voluntarily submitted an acceptable verification statement on the NAEIS from an accredited or approved Independent Verifier (in accordance with process stages 4 and 5) alongside their MRV Tool, may have their data immediately approved by the DEFF for that facility, provided the requirements of Section D.2 have been met.	Section D.3
<b>3 DEFF review</b>	Once the taxpayer has submitted the required data to the NAEIS, the DEFF will conduct a series of post submittal data and risk assessment checks (see Section D.4.1). The results of the post-submittal checks will be used by the DEFF to determine which taxpayers should undergo inspection or independent verification and which taxpayers should have their MRV Tools approved.	Section D.4
<b>4 Independent verification</b>	If a taxpayer is selected for independent verification, they will be required to select an Independent Verifier approved by the DEFF prior to undertaking the verification assessment based on their competence being aligned to the SANAS accreditation requirements as outlined in Section D.5. This is a transitional arrangement and Independent Verifiers will need to be SANAS accredited from 2023 to undertake independent verification. Additional detail on this is provided in Section D.5. The verification process must be completed within 90 days of notification. Once a signed Verification Opinion and final Verification Report has been issued by the Independent Verifier and the DEFF has conducted final checks on the MRV Tool and Verification Report and is satisfied with the outcome, the MRV Tool outputs will be approved.	Section D.5
<b>5 Data approved</b>	The taxpayers' MRV Tool is deemed accepted if the DEFF does not respond to the taxpayer with questions for clarification or corrections within 60 days of having received the Verification Report. If a taxpayer is required to undergo independent	Section D.6



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	verification as outlined in Step 4, the DEFF will notify the taxpayer once the MRV Tool has been checked.	
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### D.2. Data collection

Taxpayers must ensure transparency of the MRV Tool by archiving all data, calculations, algorithms, procedures and technical references used to estimate GHG emissions/removals. This information relates to the calculations performed for the listed activities in line with the requirements of the Accounting Rulebook (Chapter B) and the Methodological Guidelines for Land Activities in Forest Plantations (Chapter C). This is done to ensure that verification of submissions made in terms of the C Tax Act can take place. Data Providers must keep a record of the information submitted to the DEFF for at least five years, and at least between two successive independent verifications, and such records must, on request, be made available for inspection by the DEFF.

Documents to be kept are:

- Archiving all reports submitted for at least 5 years or since last independent verification;
- Documents to support the extent of the plantations area and wood/biomass productivity;
- Documentation of assessments made over excluded emission sources (e.g. annual amount of liquid and solid waste);
- Data management system documentation, including descriptions of the processes for data collection, input, calculation, and management;
- Results of any relevant internal audit or third-party verification activities;
- Facility level breakdowns of data used to generate the sequestration estimated in the MRV Tool for forest land and HWP;
- Records of incidents or events on site that may impact on production or other emission/sequestration drivers (e.g. disease or fires);
- Justification of the quantification methodology and emission factors used, including documented references and citations, and root data upon which any site-specific factors were derived;
- Documentation of any key assumptions and uncertainties associated with the sequestration data;
- Description of GHG reduction projects;
- Description of operational incidents that impact GHG performance;
- Explanation of trends in sequestration emissions from historical data and forecasts;
- Supporting MRV Tool detailing source data;
- Green Mamba spreadsheets;
- GIS or paper maps identifying the plantation areas;
- Documentation on system for distinguishing TUP from deforested areas, including remote sensing data to track TUP and deforestation;
- Certification records;
- Correspondence with suppliers of harvested wood and 3<sup>rd</sup> party suppliers (e.g., invoices);
- Correspondence with suppliers of fertilisers (e.g., invoices);
- Self-implemented monitoring plan (optional).

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**D.3. Submission of data**

In accordance with C Tax Act, all taxpayers are required to submit their Sequestration Report on the NAEIS/SAGERS for the preceding calendar year, to the DEFF by 31 March of each year. Taxpayers who have submitted a Verification Report, in accordance with Section D.5 of this guideline, with the submission of their MRV Tool report via the NAEIS, may have their data immediately approved by the DEFF provided that:

- The independent verifier has issued a positive Verification Opinion (See Section D.5 for further detail) and any material misstatements detected in the independent verification process have been rectified;
- The DEFF is satisfied that the Verification Report and opinion produced by the independent verifier is in line with the requirements of the Validation and Verification Guideline; and
- A final check of the MRV Tool by the DEFF is completed.

Taxpayers who have been selected for independent verification, as an outcome of the process outlined in Section D.4.2, should submit the Verification Report to the DEFF within 90 days of being notified of the requirement to undertake independent verification by the DEFF.

**D.3.1. Submission reports**

Data Providers are required to submit the following information on the NAEIS by 31 March:

- I) MRV Tool: Taxpayers are required to complete the MRV Tool for each of its facilities.
- II) Self-declaration: As a part of the submission, taxpayers will be required to self-declare on the NAEIS that they have reviewed their MRV Tool for accuracy before submitting onto the NAEIS, and that all information submitted on the NAEIS is truthful, accurate, complete and in compliance with the Carbon Tax Act, to the best of their knowledge.
- III) Verification Reports (Optional): Taxpayers who have voluntarily completed an independent verification exercise in accordance with the Validation and Verification Guideline, may submit their facility level Verification Report and Verification Opinion at this stage of submission. Taxpayers may have their data immediately approved by the Competent Authority for that facility, if they have opted to have their emissions verified, provided the requirements of Section D.3.1 have been met.
- IV) Monitoring Plan (Optional): While it is not mandatory for taxpayers to submit monitoring plans to the competent authority in Phase 1 of the Verification Programme, taxpayers who have monitoring plans in place may do so.

**D.4. Review by DEFF****D.4.1. Post submittal checks**

Once the MRV Tool has been formally submitted on the NAEIS, the DEFF will run a number of post-submittal checks to evaluate the validity of submitted data and identify areas where risk of inconsistencies or inaccuracies exist. The post-submittal checks will entail a combination of automated system and manual checks. The outcome of the post-submittal checks will determine whether independent verification required. Examples of the types of checks that will be conducted are outlined



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in Table D.2 below. Examples of other suggested checks which DEFF can undertake to ensure the value ranges are in the correct range are provided in Appendix D.1.

**Table D.2: Examples of checks that will be completed as part of the review by competent authority.**

Type of check	Description	MRV tool reference
<b>Rulebook checks</b>	Check that all rules in the Rulebook have been adhered to.	
<b>Range checks</b>	Determine if Sequestration report data is within the expected range. Make comparisons with IPCC default values.	All sheets
<b>Statistical checks</b>	Evaluate data from similar taxpayers to identify outliers.	
<b>Calculation checks</b>	Check that columns have been added correctly.	All sheets
	Check balance between various input and output parameters	
	Check all appropriate data columns are completed	All sheets
	3rd party checks	
<b>Mass balance checks</b>	Check that the discount factors are correctly applied.	Accounting sheet
	Check the mass of carbon entering the mill is balanced with what is leaving the mills. Sum of inputs (tC) - sum of outputs (tC) = 0	HWP sheet
<b>Afforestation checks</b>	Check that afforested areas are not older than 20 years.	Land gain-loss method
<b>Deforestation and TUP checks</b>	Check the consistency in reporting of TUP and Deforestation areas	
<b>Biomass burning checks</b>	Check ratio of estimated gas emissions are equal to the GWP of that gas	Wildfires; Controlled burning
<b>Methodological checks</b>	Check changes in tier levels, and ensure methods are following IPCC methodology.	
	Ensure correct columns are completed for the selected Tier method	
<b>Unit checks</b>	Ensure consistency in units and check unit conversions.	
<b>Change in ownership and registration checks</b>	Determine if there have been any changes in ownership and whether this has affected outputs.	Verification sheet
<b>Outside data checks</b>	Data checks against an outside source, specifically Green Mamba forms (see Table D.3).	Verification sheet
<b>Missing data checks</b>	Identify gaps in emission/sequestration sources compared to the taxpayer activities.	
<b>Cross checks</b>	Cross-check with new data or common parameters used across sectors against that of other entities in the same sector or sector averages.	
	Cross-check with NGER submissions.	Verification sheet
<b>Boundary checks</b>	Assess whether data captured is in the correct reporting period, and that the data should be included as a part of the facilities data or not.	
	Ensure that roundwood stocks from previous years are not reported twice as input into HWP.	
<b>Trend analysis</b>	Identify unusual or unexpected trends or outliers which may be indicative of errors between years.	
<b>Land area checks</b>	Complete a land change matrix and check all land area is accounted for.	
	Check land change matrix for previous submission to check correspondence between previous and current stratification.	



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### Verification checks

Checks of the results of a previous verification completed in line with the validation and verification guideline.	
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In the MRV Tool a Verification sheet has been included (Table D.3). The completion of this sheet is optional but would assist in the verification process and may reduce the change of being selected for an independent review.

Where areas of unexplained risk are detected, the DEFF may contact the taxpayer to resolve failed checks or explain why the failed checks do not indicate an error. This may entail a process of documentation requests by the DEFF for additional evidence to explain sources of error in the Sequestration Report. Where necessary, the DEFF may request an on-site visit to the taxpayer's facility if the documentation provided still does not satisfy the DEFF that the error has been resolved. Taxpayers are given a period of 60 days to address errors otherwise a compliance issue is raised.

Table D.3: Verification table included in the Sequestration tool.

Element	Method	Reported Value	Units	Green Mamba Reference	Notes
Any land acquired or leased?		Yes	-	B.2 Page 3	
Area of land acquired/ leased from a 3rd party	G-L	0	ha	B.2.1 Page 3	Only area associated with purchases HWPs should be reported here
Total area at the beginning or the reporting period	S-D	30	ha	B.6 Page 5	
Area of plantation		0	t	Section C and D, Page 6 - 11	Consider total area by genus/species if possible
Total area by species: Softwood	S-D	[calculate manually]	ha	Section E Page 12	Aggregate softwood areas for comparison with Green Mamba
Total area by species: Eucalyptus grandis	S-D	0	ha	Section E Page 12	Aggregate Eucalyptus grandis areas for comparison with Green Mamba
Total area by species: Other eucalyptus	S-D	[calculate manually]	ha	Section E Page 12	Aggregate other eucalyptus areas for comparison with Green Mamba
Total area by species: Wattle	S-D	[calculate manually]	ha	Section E Page 12	Aggregate wattle areas for comparison with Green Mamba
Total area by species: Poplars	S-D	[calculate manually]	ha	Section E Page 12	Aggregate poplar areas for comparison with Green Mamba
Total area by species: Other hardwood	S-D	[calculate manually]	ha	Section E Page 12	Aggregate other hardwood areas for comparison with Green Mamba
Total volume Consumed and / or Processed from own forest management units		[calculate manually]	m3	Table F2.2 F.2.2 - Own Consumption and / or Processing	Only consider Total inflow: Mass C Entering the Mill (t) from company owned plantations
Total area affected by wildfires		5	ha	Section H.1 Page 15	Assumed that only wild/accidental fires are reported under Green Mamba



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**D.5. Independent verification****D.5.1. Selection of facilities for independent verification****D.5.1.1. Criteria for selection of independent verification**

There are several factors that the DEFF will consider that may trigger the need for a taxpayer to undergo independent verification of their facility. The main criteria that will be used in this determination includes the following:

- The results of the post-submittal checks completed in Table D.2;
- The completion of the Verification tab in the MRV Tool (Table D.3) and
- The total sequestration - taxpayers with high total sequestration are more likely to be required to undergo independent verification.

**D.5.1.2. Notification of independent verification**

Should the taxpayer MRV Tool be selected to undergo independent verification, the DEFF will notify the taxpayer. The notification for independent verification will at a minimum contain the following details:

- Indication of the reason for being selected for independent verification;
- Detail on the timelines for the finalisation of the independent verification process;
- The scope of the independent verification. Independent verification may in certain circumstance focus on specific elements of the Sequestration Reports submitted; and
- Additional administrative guidance on the independent verification process.

**D.5.2. Independent verification principles and requirements****D.5.2.1. Principles of verification**

The principles of verification described below are taken from section 3.1.2 of the Guidelines for Validation and Verification of Emissions (DEFF, 2020). The Independent Verifier shall adhere to the following principles of verification throughout any independent verification engagement:

- I) Independence and objectivity –The Independent Verifier and its verification team shall remain independent of the facility and activity being verified, and free from bias and conflict of interest. The verification teams shall maintain objectivity throughout the verification to ensure that the findings and conclusions will be based on objective evidence generated during the verification.
- II) Ethical conduct - Demonstrate ethical conduct through trust, integrity, confidentiality and discretion throughout the verification process.
- III) Fair presentation - Reflect truthfully and accurately verification activities, findings, conclusions and reports. Report significant obstacles encountered during the verification process, as well as unresolved, diverging opinions among verification team members, the Independent Verifier and the Data Provider.
- IV) Due professional care - Exercise due professional care and judgment in accordance with the importance of the task performed and the confidence placed by the Data Provider and Independent Verifier. Have the necessary skills and competencies to undertake the verification.



#### **D.5.2.2. Scope of verification**

The verification team shall plan and perform the verification to state with a reasonable level of assurance that the aggregated error in the total GHG emissions for the reporting period does not exceed the materiality limit.

These verification guidelines outline the type of verification procedures that shall be conducted (i.e. substantive testing, controls testing, site visit) to achieve a reasonable level of assurance. However, they are not intended to be prescriptive about the exact verification activities to be performed during verification. The exact verification activities shall be conducted based on the lead verifier's professional judgment.

#### **D.5.2.3. Reasonable level of assurance**

The level of assurance refers to the degree of assurance the intended user requires in a verification and this is defined in section 3.1.3 of the Guidelines for Validation and Verification of Emissions (DEFF, 2020).

#### **D.5.2.4. Materiality**

The prescribed materiality limit for independent verification engagements under these guidelines is **5%** based on international standards and norms (DEFF, 2020). The total emissions and removals, i.e. the total "S" value, determined by the independent verifier should not deviate by more than 5% of the taxpayers reported value in order for the verification team to issue a positive Verification Opinion statement).

#### **D.5.3. Independent verification process**

The independent verification process will follow that described in section 3.2 of the Guidelines for Validation and Verification of Emissions (DEFF, 2020).

### **D.6. Data approval**

A taxpayer's MRV Tool is deemed accepted if the DEFF does not respond to the taxpayer with questions for clarification, corrections or instruction for verification within 90 days of the submission. In the instance that a taxpayer is required to undergo independent verification, the DEFF will communicate with the taxpayer on the verification requirements and any necessary instructions and will provide confirmation once the verification process has concluded and the data has been approved by the DEFF.

Once the Sequestration Report is approved it will be submitted to SARS where it will be combined with the company's total fuel combustion related greenhouse gas emissions ("E" in the Carbon Tax Act). SARS will be responsible for checking that if the sequestration ("S") is actually a net emission (i.e.  $S < 0$ ) then  $E - S = E$ .



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## D.7. References

DEFF, 2020. Technical Guidelines for Validation and Verification of Greenhouse Gas Emissions: A companion to the South African National Greenhouse Gas Emission Reporting Regulations, Department of Environment, Forestry and Fisheries, Pretoria, South Africa.



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## Appendix D.1

Type of check	Description	MRV tool sheet reference
<b>Area checks</b>	Total area checked against reported area for FM, AR, D (i.e. Total = FM+AR-D).	Facility register; 3 <sup>rd</sup> party register; Land gain-loss method; Land stock-difference method
<b>Afforestation checks</b>	Check that Afforestation area is not older than 20yrs	Land gain-loss method; Land stock-difference method
<b>TUP check</b>	Check that TUP is not more than 5 years	Land gain-loss method; Land stock-difference method, check MRV tool if emission is deducted
<b>Deforestation check</b>	TUP area that was 5 years in previous submission and was not replanted should be now deforestation.	Land gain-loss method; Land stock-difference method
<b>Stratification checks</b>	Check previous submission to check correspondence between previous and current stratification (for C stock change method).	Facility register
<b>Gain-loss method checks</b>	Living Biomass GAIN (ABG+BGB, tC) / Living Biomass LOSS (ABG+BGB, tC) $\pm 1$ (or very close to 1, ideally smaller in sustainable forestry)	Land gain-loss method
	Total of [Total net removal (t CO <sub>2</sub> eq/yr)] / Total of [Total area (of AR, FM)] < approx. 5 (so in practice it should be equivalent to net biomass growth per 1 ha per year, as long as 1tCO <sub>2</sub> = 1 mc of wood), if annual roundwood increment is 10 m <sup>3</sup> that is 10tCO <sub>2</sub> , or slightly higher is entire ABG is included (foliage, roots) 12 tCO <sub>2</sub>	Land gain-loss method
	Total of [Harvest volume (m <sup>3</sup> /yr)] = Total of [Harvest volume (m <sup>3</sup> /yr)] from Afforestation and Forest Management	Land gain-loss method, Green Mamba
<b>Stock difference method checks</b>	Total of [Total net removal (t CO <sub>2</sub> eq/yr)] / Total of [Total area (of AR, FM)] < MAI	Land stock-difference method
	Total of [Harvest volume (m <sup>3</sup> /yr)] = Total of [Harvest volume (m <sup>3</sup> /yr)] from Afforestation and Forest Management	Land stock-difference method, Green Mamba
<b>Reporting and accounting checks</b>	Total accounted amount / Total of [Total area (of AR, FM)] < approx. 5	Reporting & accounting
<b>DOM checks</b>	20 * DOM $\Delta C$ (tC) = DOM (tC/ha) in afforestation	Land gain-loss method; Land stock-difference method
<b>Removals from forest</b>	to be consistent with harvest from CSC biomass (expected approx. Rem > 0.9 Harvest). Inflow cannot be bigger than removals	Land gain-loss method; Land stock-difference method
<b>Volume entering the mill</b>	to be consistent with Removal (expected approx. Entering > 0.9 Removal)	Land gain-loss method; Land stock-difference method; HWP



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<b>National level checks</b>	At national level, the sum of harvested from eligible must be the sum of inflow reported by all companies	
<b>HWP checks</b>	Total of [Volume Entering the Mill (m <sup>3</sup> )] (HWP sheet) = Total of [Harvest volume Whole tree (m <sup>3</sup> /yr)] from Afforestation and Forest management	HWP
<b>HWP mass balance checks</b>	Sum of inputs (tC) - sum of outputs (tC) = 0	HWP
<b>Biomass burning verification</b>	Ratio of estimated N <sub>2</sub> O emissions/ CO <sub>2</sub> emissions = GWP N <sub>2</sub> O	Wildfires; Controlled burning
	Ratio of estimated CH <sub>4</sub> emissions/ CO <sub>2</sub> emissions = GWP CH <sub>4</sub>	Wildfires; Controlled burning
	Ratio of estimated N <sub>2</sub> O emissions/ CH <sub>4</sub> emissions = GWP N <sub>2</sub> O/ GWP CH <sub>4</sub>	Wildfires; Controlled burning
<b>Fertiliser checks</b>	Verify quantity purchased correspond to usage	Fertilisers