CHAPTER 9

OTHER LAND

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9.1 INTRODUCTION

Chapter 3 of this Volume defines Other Land to include bare soil, rock, ice, and all land areas that do not fall into any of the other five land-use categories treated in Chapters 4 to 8. Other Land is often unmanaged, and in that case changes in carbon stocks and non-CO_2 emissions and removals are not estimated. Guidance is provided for the case of *Land Converted to Other Land*. This is because the conversion is associated with changes in carbon stocks or non-CO_2 emissions, most importantly those associated with conversions from Forest Land. Emissions and removals from this land should continue to be estimated following the conversion, as described below. Inclusion also enables checking the overall consistency of land area and tracking conversions to and from Other Land.

9.2 OTHER LAND REMAINING OTHER LAND

Emissions and removals on *Land Converted to Other Land* class are estimated using the methods described below, which also cover land remaining Other Land after conversion. All areas of *Other Land Remaining Other Land* should be included in the land-use change matrix as described in Chapter 3 as a check on the overall area. Emissions from land converted to bare soil as a result of development of settlements should of course be included in the Settlements land-use category (See Chapter 8, Settlements).

9.3 LAND CONVERTED TO OTHER LAND

This section provides guidance on methods for estimating carbon stock changes for *Land Converted to Other Land*. In general this is unlikely to be a key category, if it takes place at all, but land can be converted to Other Land, e.g., as a result of deforestation with subsequent severe degradation, release of carbon stocks and associated emissions. Figure 1.3 in Chapter 1 provides the decision tree which can be used to identify the appropriate tier-level for *Land Converted to Other Land*.

The fundamental equation for estimating change in carbon stocks associated with land-use conversions was introduced in Section 2.3.1.2 in Chapter 2. This basic method can be applied to estimate change in carbon stocks in Forest Land, Cropland, Grassland, Wetlands, and Settlements converted to Other Land. Extensions to the method are provided for the subsequent treatment of these land areas following the transition period to the Other Land category.

9.3.1 Biomass

The method requires estimates of carbon in biomass stocks prior to conversion, based on estimates of the areas of land converted during the period between land-use surveys. As a result of conversion to Other Land, it is assumed that the dominant vegetation is removed entirely, resulting in no carbon remaining in biomass after conversion. The difference between initial and final biomass carbon pools is used to calculate change in carbon stocks due to land-use conversion. In subsequent years, accumulations and losses in living biomass in Other Land is considered to be zero. Figure 2.2 provides the decision tree for identification of appropriate tier to estimate changes in carbon stocks in biomass.

9.3.1.1 CHOICE OF METHOD

The basic method (Equation 2.16 in Chapter 2) summarises how to estimate the change in carbon stocks in biomass on *Land Converted to Other Land*. Average change in carbon stocks on a per area basis are estimated to be equal to the change in carbon stocks due to the removal of living biomass from the initial land uses.

Tier 1
A Tier 1 method follows the approach in Equation 2.16 in Chapter 2 where the amount of above-ground biomass that is removed is estimated by multiplying the area (e.g., forest area) converted annually to Other Land by the average carbon content of biomass in the land prior to conversion (B_{BEFORE}). In this case, B_{AFTER} in Equation

2.16 is set to zero by default. The default assumption for the Tier 1 calculation is that all carbon in biomass (less harvested wood products removed from the area) is released to the atmosphere immediately (i.e., in the first year after conversion) through decay processes either on- or off-site.

Tier 2

A Tier 2 method can be developed and used if country-specific data on carbon stocks before conversion to Other Land (i.e., B_{BEFORE} in Equation 2.16) are obtainable. B_{AFTER} remains at zero. In addition, under Tier 2, carbon losses can be apportioned to specific conversion processes, such as burning or harvesting. This allows for more accurate estimation of non-CO_2 greenhouse gas emissions. A portion of biomass removed is sometimes used as wood products or as fuel wood. Chapter 2, Section 2.4 provides the basic method for estimating non-CO_2 greenhouse gas emissions from biomass burning. Chapter 12 provides guidance for estimation techniques for carbon stored in harvested wood products.

Tier 3

A Tier 3 method requires more detailed data/information than the Tier 2 approach, e.g.,:

- Geo-referenced disaggregated areas converted annually are used for each land use converted to Other Land;

- Carbon densities are based on locally specific information and; and

- Biomass stock values are based on inventories and/or the model estimations.

- Where data are available, Tier 3 methods may be used to track the dynamic behaviour of carbon stocks and greenhouse gas emissions following conversion. Where the land remains in a vegetation-free state (due to severe degradation), there will generally be a continuing decline in carbon stocks. If this is not the case, countries should consider whether the land should be classified under another land use, as indicated in Chapter 3.

9.3.1.2 CHOICE OF EMISSION/REMOVAL FACTORS

Tier 1

Default parameters are provided for biomass stocks before conversion to enable countries with limited data resources to estimate emissions and removals from this source. The method requires the estimation of carbon stocks before conversion for the initial land use (B_{BEFORE}) and assumes that the carbon stock after conversion (B_{AFTER}) is zero. Tables provided in Chapters 4, 5, 6, 7 and 8 of this report, for average above-ground biomass volume and below-ground to above-ground biomass ratio in different land uses, can be used to estimate carbon stocks before conversion.

Tier 2

The Tier 2 method requires country-specific information, which may be obtained, for example, through systematic studies of biomass carbon stocks in the various land-use categories. The default carbon stock values mentioned above can be applied to some parameters in a Tier 2 approach. Default parameters for emissions from biomass burning are provided in Chapter 2 Section 2.4. However, inventory compilers are encouraged to develop country-specific coefficients to improve the accuracy of estimates. B_{AFTER} is set to zero.

Tier 3

Under Tier 3, all model parameters should be country-specific and at a disaggregated level, and/or biomass stocks derived from periodic inventories should be used.

9.3.1.3 CHOICE OF ACTIVITY DATA

All tiers require estimate of the area of land converted to Other Land over a time period that is consistent with land-use surveys and the period used for conversions in the land-use change matrix. Chapter 3 provides guidance on the use of different types of data representing land so that they are applied as appropriately and consistently as possible in inventory calculations. The same aggregate area estimates should be used for both biomass and soil in the calculations of change in carbon stocks on land converted to Other Land. As described below, higher tiers require greater specificity of areas.

Tier 1

For a Tier 1 approach, activity data on areas of different land-use categories converted to Other Land are needed. If countries do not have these data, partial samples may be extrapolated to the entire land base, or historic

estimates of conversions may be extrapolated over time based on expert judgment. Forest areas converted to Other Land are particularly important.

Tier 2

Under Tier 2, inventory compilers should use actual area estimates for transitions from various land-use categories to Other Land. Full coverage of land areas can be accomplished either through analysis of periodic remotely sensed images of land-use and land cover patterns, through periodic ground-based sampling of land-use patterns, or hybrid inventory systems (Chapter 3, Annex 3A.3 provides guidance on sampling).

Tier 3

The activity data used should allow full accounting of all land-use category transitions to Other Land and should be disaggregated to account for different conditions within a country. Disaggregation can occur along political boundaries (county, province, etc.), biome, climate, or on a combination of these parameters. In many cases, information on multi-year trends in land conversion may be available (from periodic sample-based or remotely sensed inventories of land use and land cover).

9.3.1.4 UNCERTAINTY ASSESSMENT

Tier 1

Under Tier 1, the sources of uncertainty are the use of global or national averages for biomass carbon stocks in Forest Land or Other Land uses before conversion, and coarse estimates of areas converted to Other Land. Areas should be estimated using the methods outlined in Chapter 3. Carbon stocks will have the uncertainties associated with their estimation in the relevant section of the Guidelines. In the absence of other estimates, a default uncertainty level of $\pm75\%$ of the estimated mean CO_2 emission may be assumed.

Tier 2

Actual area estimates for *Land Converted to Other Land* will enable more transparent accounting and allow experts to identify gaps and double counting of land areas. The Tier 2 method uses at least some country-specific values, which will improve the accuracy of estimates, provided they better represent conditions relevant to the country. When country-specific values are developed, inventory compilers should use sufficient sample sizes and techniques to minimize standard errors. Probability density functions (i.e., providing mean and variance estimates) can be derived for all country-parameters. Such data can be used in more advanced uncertainty analyses such as Monte Carlo simulations. Volume 1, Chapter 3 of this report can be referred for guidance on developing such analyses. At a minimum, Tier 2 approaches should provide error ranges for each country-specific parameter.

Tier 3

Activity data should provide a basis to assign estimates of uncertainty to areas associated with land conversion. Combining emission/removal factors and activity data and their associated uncertainties can be done using Monte Carlo procedures to estimate means and confidence intervals for the overall inventory.

9.3.2   Dead organic matter

Tiers 1 and 2

For Tiers 1 and 2, it is assumed that no carbon remains in biomass or dead organic matter after conversion to Other Land. All biomass carbon stocks are assumed to be emitted in the year of conversion, thus there is no accumulation of DOM stocks. Under Tier 1, DOM in the various land-use categories are not estimated and thus there are no emissions or removals by sinks related to DOM to be estimated with conversions to Other Land. Under Tier 2, if countries estimate DOM stocks for land-use categories that are subject to conversion to Other Land, then (as for biomass) all DOM is assumed to be emitted in the year of conversion to Other Land.

Tier 3

At Tier 3, estimates should incorporate country-specific data on DOM.

9.3.3   Soil carbon

For *Land Converted to Other Land*, inventory compilers should estimate the change in carbon stocks in mineral soils under the initial land use relative to Other Land. Conversion of land to Other Land will result in a release of organic carbon previously held in soil if the conversion is to impervious surfaces such as bare rock.

General information and guidance on estimating changes in soil C stocks are provided in Chapter 2, Section 2.3.3 (including equations), and needs to be reviewed before proceeding with a consideration of specific guidelines below. The total change in soil C stocks for land converted to Grassland is estimated using Equation 2.24 for the change in soil organic C stocks for mineral soils and organic soils; and stock changes associated with soil inorganic C pools (Tier 3 only). This section provides specific guidance for estimating mineral soil organic C stock changes. It is assumed that the stock changes in organic soils are minimal because drainage is unlikely in "Other Lands" However, methods are provided in Section 2.3.3 (Chapter 2) to estimate stock changes for organic soils in addition to soil inorganic C.

9.3.3.1   CHOICE OF METHOD

Inventories can be developed using a Tier 1, 2 or 3 approach, with each successive tier requiring more detail and resources than the previous one. Decision trees are provided for mineral soils (Figure 2.4, in Chapter 2) to assist inventory compilers with selection of the appropriate tier. The approach at Tier 1 is that soil carbon stocks will decline to zero after conversion. If this is not the case, then the land should probably be classified under one of the Other Land uses. For Tier 2, country-specific estimates for C stocks on land that has been converted to Other Land should be used or the dynamics of carbon stocks in soils can be tracked at Tier 3 using country-specific data.

Mineral soils

Tier 1
Using Equation 2.25 in Chapter 2, the change in soil organic C stocks are estimated for mineral soils accounting for the impact of land-use conversion to Other Land. Annual rates of emissions (source) or removals (sink) are estimated based on the difference in stocks (over time) for the initial and last year divided by the time dependence of the stock change factors (D, default is 20 years).

Tier 2
The Tier 2 method for mineral soils also uses Equation 2.25, but involves country- or region-specific reference C stocks and/or stock change factors and more disaggregated land-use activity and environmental data.

Tier 3
Tier 3 methods will involve more detailed and country-specific models and/or measurement-based approaches along with highly disaggregated land-use and management data. It is *good practice* that Tier 3 approaches estimating soil C change from land-use conversions to Other Land, employ models, data sets and/or monitoring networks that are capable of representing transitions over time from other land uses, including Forest Land, Grassland, Cropland, and possibly Settlements. Tier 3 methods should, where possible, be integrated with estimates of biomass removal and the post-clearance treatment of plant residues (including woody debris and litter), as variation in the removal and treatment of residues (e.g., burning, site preparation) will affect C inputs to soil organic matter formation and C losses through decomposition and combustion.

9.3.3.2   CHOICE OF STOCK CHANGE AND EMISSION FACTORS

Mineral soils

Tier 1
The initial (pre-conversion) soil organic C stock ($SOC_{(0-T)}$) is computed from the default reference soil organic C stock (SOC_{REF}) and stock change factor for land-use systems (F_{LU}). The reference C stock at the end of the 20 year default transition period is assumed to be zero. See the appropriate section for specific information regarding the derivation of pre-conversion stock change factors for other land-use sectors (Forest Land in Section 4.2.3.2, Cropland in 5.2.3.2, Grassland in 6.2.3.2, and Settlements in 8.2.3.2).

Tier 2

A Tier 2 approach can be implemented in which country-specific data are used to derive reference C stock and stock change factors ($SOC_{(0-T)}$, F_{LU}, F_{MG}, F_I) that better represent conditions in different types of Other Land. Country-specific reference stocks at the end of the 20 year period can also be applied. Subsequently, emissions and removals are set to zero. See the appropriate section for specific information regarding the derivation of pre-conversion stock change factors for other land-use sectors (Forest Land in Section 4.2.3.2, Cropland in 5.2.3.2, Grassland in 6.2.3.2, and Settlements in 8.2.3.2).

Reference values should be consistent across land-use sectors (i.e., Forest Land, Cropland, Grassland, Settlements, and Other Land), which requires coordination among the various teams conducting soil C inventories for AFOLU.

Tier 3

Model parameters will be determined using country-specific data or soil stocks measures; using soil inventories with representative sampling as set out in Chapter 3.

9.3.3.3 CHOICE OF ACTIVITY DATA

Mineral soils

Tiers 1 and 2

For purposes of estimating soil carbon stock change, area estimates of land-use conversions to Other Land should be stratified according to major climate regions and soil types. If such information has not already been compiled, an initial approach would be to overlay available land cover/land-use maps (of national origin or from global datasets such as IGBP_DIS) with soil and climate maps of national origin or global sources, such as the FAO Soils Map of the World and climate data from the United Nations Environmental Program. Detailed descriptions of the default climate and soil classification schemes are provided in Chapter 3. Soil types are classified based on taxonomic description and textural data, and climate regions are based on mean annual temperatures and precipitation, elevation and potential evapotranspiration. See corresponding sections dealing with each land-use category for sector-specific information on activity data (Forest Land in Section 4.2.3.3, Cropland in 5.2.3.3, Grassland in 6.2.3.3, and Settlements in 8.2.3.3).

Activity data gathered using Approach 2 or 3 (see Chapter 3) provide the underlying basis for determining the previous land use for *Land Converted to Other Land*, but in its basic form at least, aggregate data (Approach 1) do not reveal specific transitions. In this case, conversions to Other Land will be reported with the *Other Land Remaining Other Land* and in effect transitions become step changes across the landscape. This makes it particularly important to achieve coordination among categories of land use to ensure consistency over time.

Tier 3

For application of dynamic models and/or a direct measurement-based inventory in Tier 3, similar or more detailed data on the combinations of climate, soil, topographic and management data are needed, relative to Tier 1 or 2 methods, but the exact requirements will be dependent on the model or measurement design.

9.3.3.4 UNCERTAINTY ASSESSMENT

Uncertainties in estimating soil C stock changes in *Land Converted to Other Land* are due to: (i) uncertainties in land-use and management activity prior to conversion; (ii) uncertainties in reference soil C stocks if using a Tier 1 or 2 approach for mineral soils only; and (iii) uncertainties in the stock change/emission factors for Tier 1 or 2 approaches (or equivalently for Tier 3, uncertainties due to model structure or parameter values, or in measurements with sample-based inventories). Uncertainties may be large at Tier 1 where global or nationally aggregated statistics on land conversion are used, and because of reliance on default reference carbon stocks. Table 3.7 in Chapter 3 provides default uncertainties ranges associated with the different approaches to area estimation, and the uncertainty in carbon stock estimation could exceed $\pm 50\%$ at Tier 1.

9.4 COMPLETENESS, TIME SERIES, QA/QC, AND REPORTING

COMPLETENESS

The total area of Other Land covered by the inventory methodology is the sum of *Other Land Remaining Other Land* and *Land Converted to Other Land* during the time period. Inventory compilers are encouraged to track through time the total area of land classified as Other Land within country boundaries, keeping transparent records on which portions are used to estimate change in carbon stocks. All land area in a country should be included in the reporting even if an inventory of emissions and removals has not been compiled for a portion of the land base, such as Other Land.

DEVELOPING A CONSISTENT TIME SERIES

To maintain a consistent time series, it is *good practice* for countries to apply the same inventory methods over the entire reporting time period, including definitions for land uses, area included in a C inventory, and calculation method. It is *good practice* to keep transparent records of any changes, and then re-calculate the C stock changes over the entire inventory time period. Guidance on re-calculation under these circumstances is given in Volume 1, Chapter 5. Consistent estimation and reporting of "Other Lands" also requires common definitions of climate and soil types across the entire time series for the period of the inventory.

INVENTORY QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

It is *good practice* to implement quality control checks and external expert review of inventory estimates and data. Specific attention should be paid to country-specific estimates of stock change factors and emission factors to ensure that they are based on high quality data and verifiable expert opinion.

REPORTING AND DOCUMENTATION

It is *good practice* to maintain and archive all information used to produce national inventory estimates. Metadata and data sources for information used to estimate country-specific parameters should be documented, and both mean and variance estimates provided. Actual databases and procedures used to process the data (e.g., statistical programs) to estimate country-specific factors should be archived. Activity data and definitions used to categorise or aggregate the activity data should be documented and archived.

REPORTING TABLES AND WORKSHEETS

The categories described in this section can be reported using the reporting tables in Volume1, Chapter 8. The estimates for carbon dioxide emissions and removals from soils resulting from *Land Converted to Other Land* are reported in IPCC Reporting Category 5D, changes in soil carbon. Worksheets are provided in Annex 1 for calculating emissions and removals of CO_2 from *Land Converted to Other Land*.