GHG inventories and overview of relevant methodologies in IPCC 2006 Inventory Guidelines and Good Practice Guidance in estimating greenhouse gases in Agriculture, Forestry and Other Land Use sector

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Outline of Presentation

- *Why we need GHG inventory Guidelines?*
- *Evolution of IPCC Guidance on Agriculture and LUCF/LULUCF*
- *Methodological approaches for estimating greenhouse gases for agriculture, Land Use, Land Use Change and Forestry (AFOLU) sector in the IPCC 2006 Inventory Guidelines*
- *Future developments of the IPCC 2006 Guidelines*
- *Summary*

Why do we need inventory guidelines?

- Any international agreement to limit climate change must set emission limits/targets/aims and monitor progress in an open and transparent way
- Currently, most national emissions can only be estimated, not measured and so we need a consensus on the best way of doing this.
  - ✓ Cannot measure all sources (e.g. road transport would be impractical; Remote sensing techniques not available)
- To do this we need reliable, generally accepted methods and guidelines

So what are GHG Inventories?

- GHG inventories are estimates of all emissions (and removals) of particular gases from given sources from a defined region in a specific period of time
- Here we are dealing with

✓ Greenhouse Gases

✓ National Estimates

✓ Annual Estimates

How are emissions/removals estimated?

- Emissions estimates are based on parameters associated with emission rates
  - CO_2 from fuel depends on carbon in fuel
  - CO_2 proportional to amount of fuel burnt
  - Changes on stocks of carbon in forests give emissions (or removals) of CO_2

$$E = EF \bullet AD$$

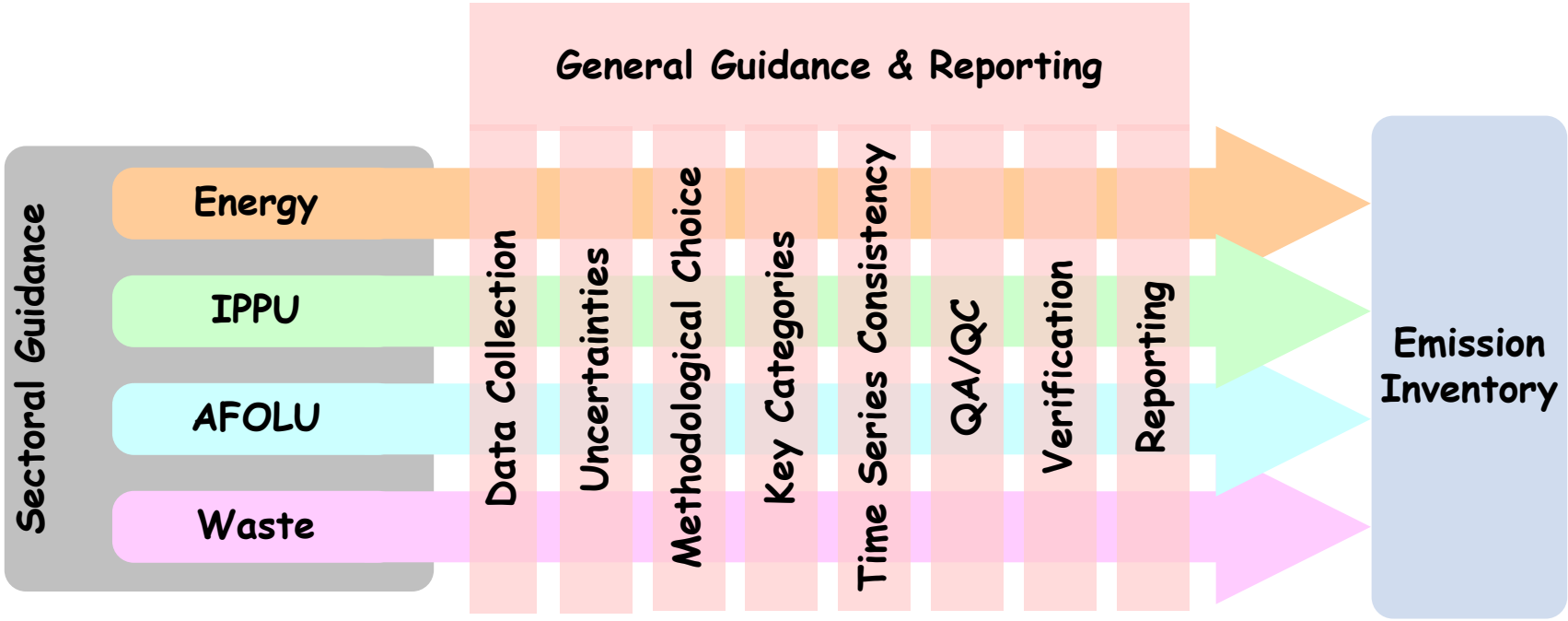
Where:

E = Emission

EF = Emission Factor

AD = Activity Data

Relationship of GPG and Sectoral Guidance



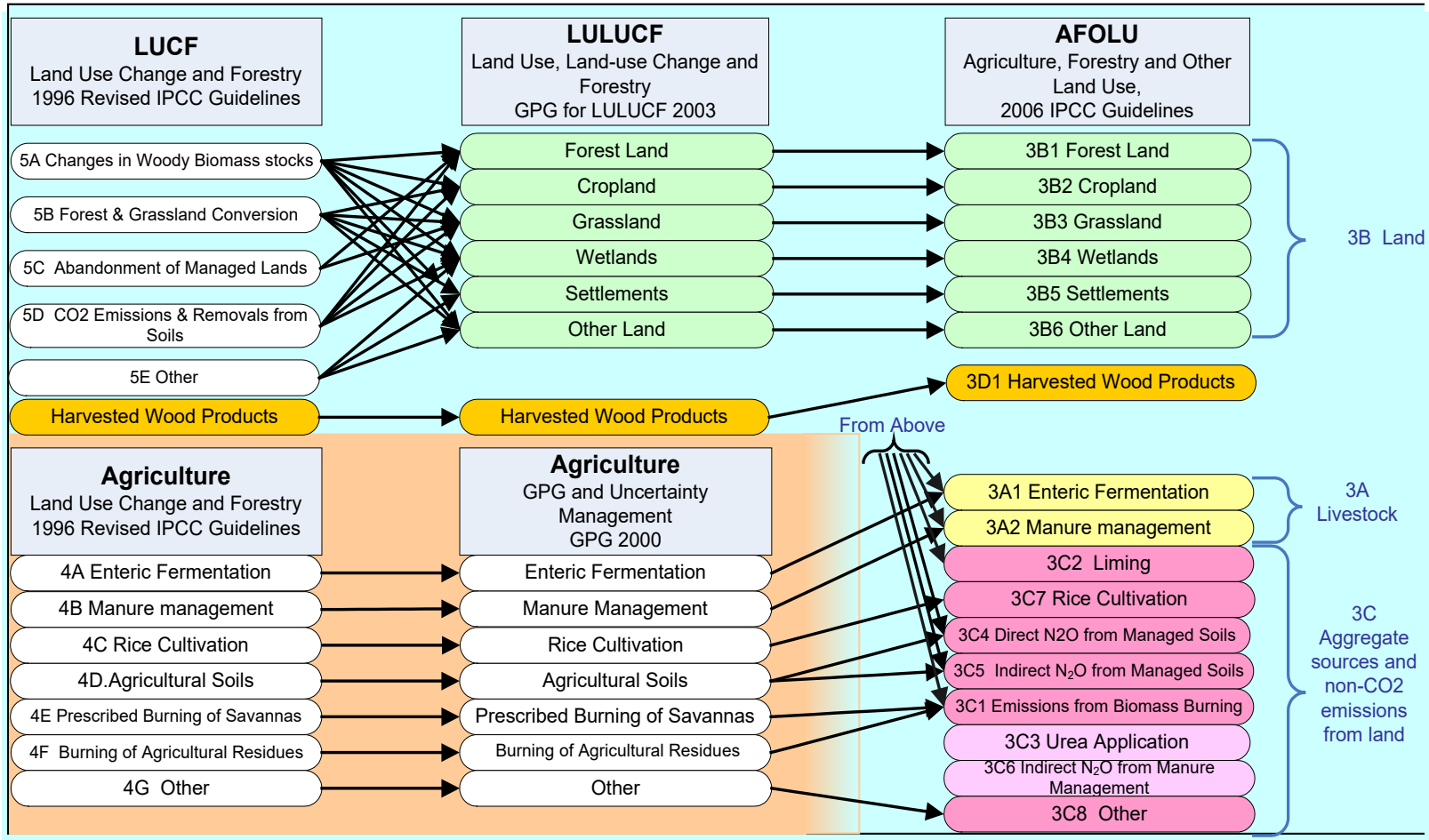
- Good Practice inventories are defined as "***those that contain neither over- nor under-estimates so far as can be judged, and in which uncertainties are reduced as far as is practical***"

✓ ***Gives a way to manage uncertainties***

✓ ***Identifies main "KEY" categories to focus resources***

✓ ***Documentation provides transparency***

Evolution of IPCC Guidance on Agriculture and LUCF/LULUCF



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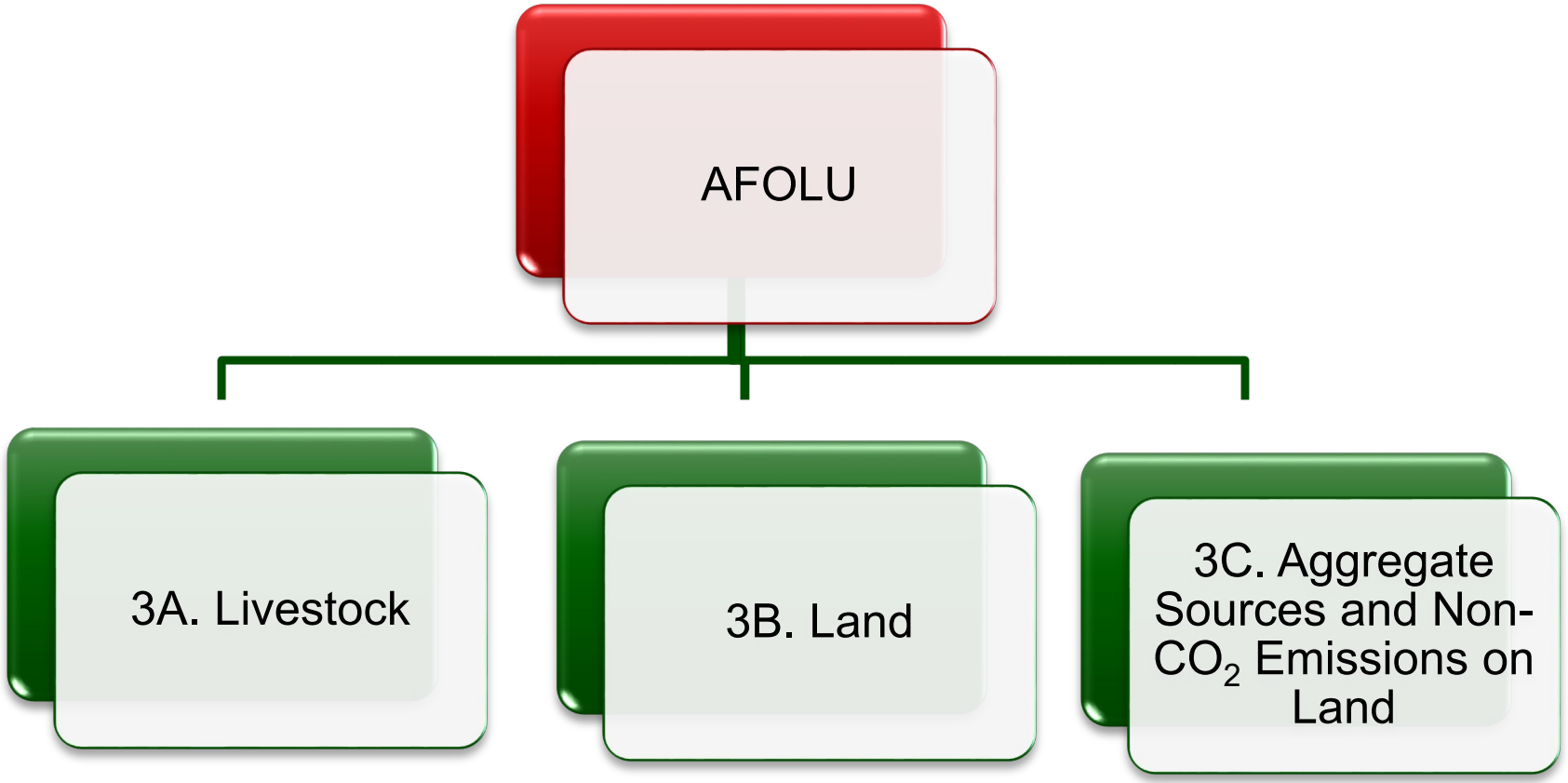
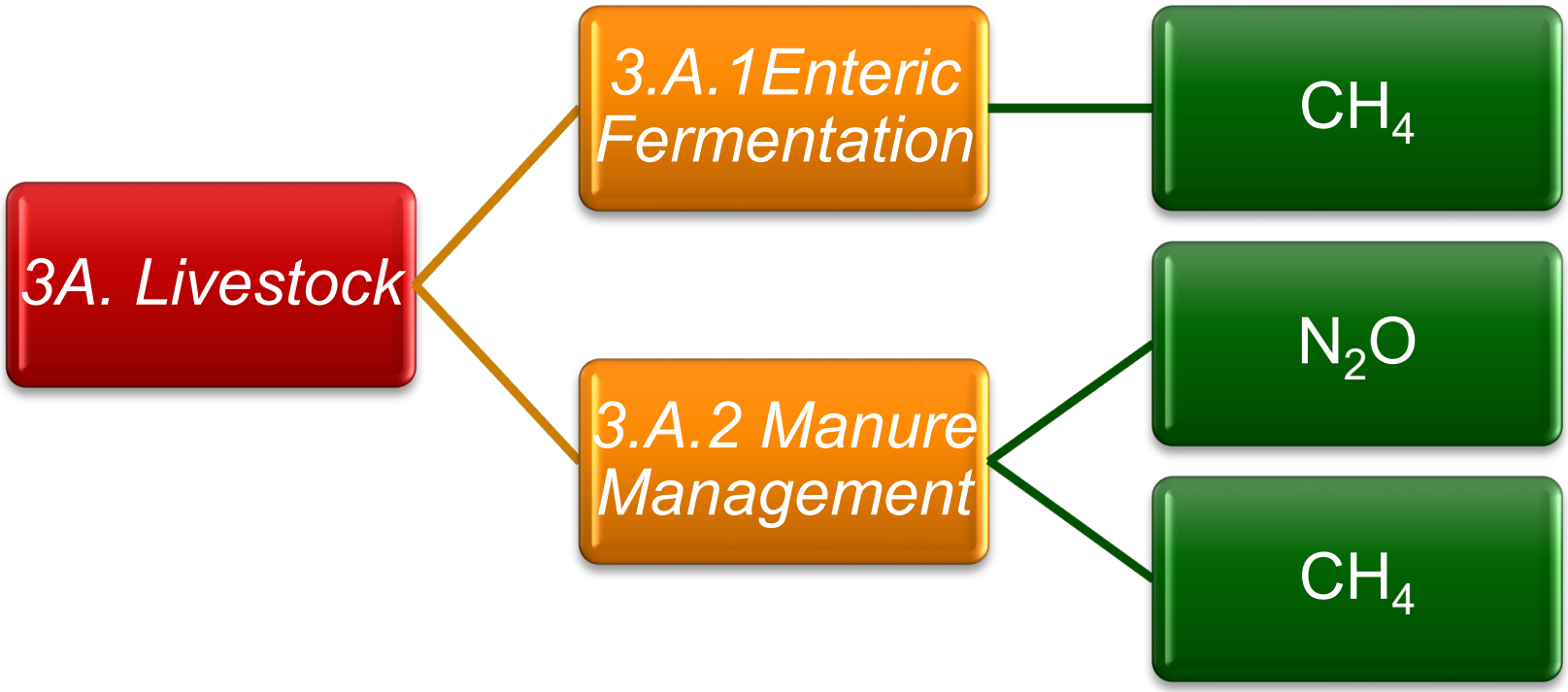
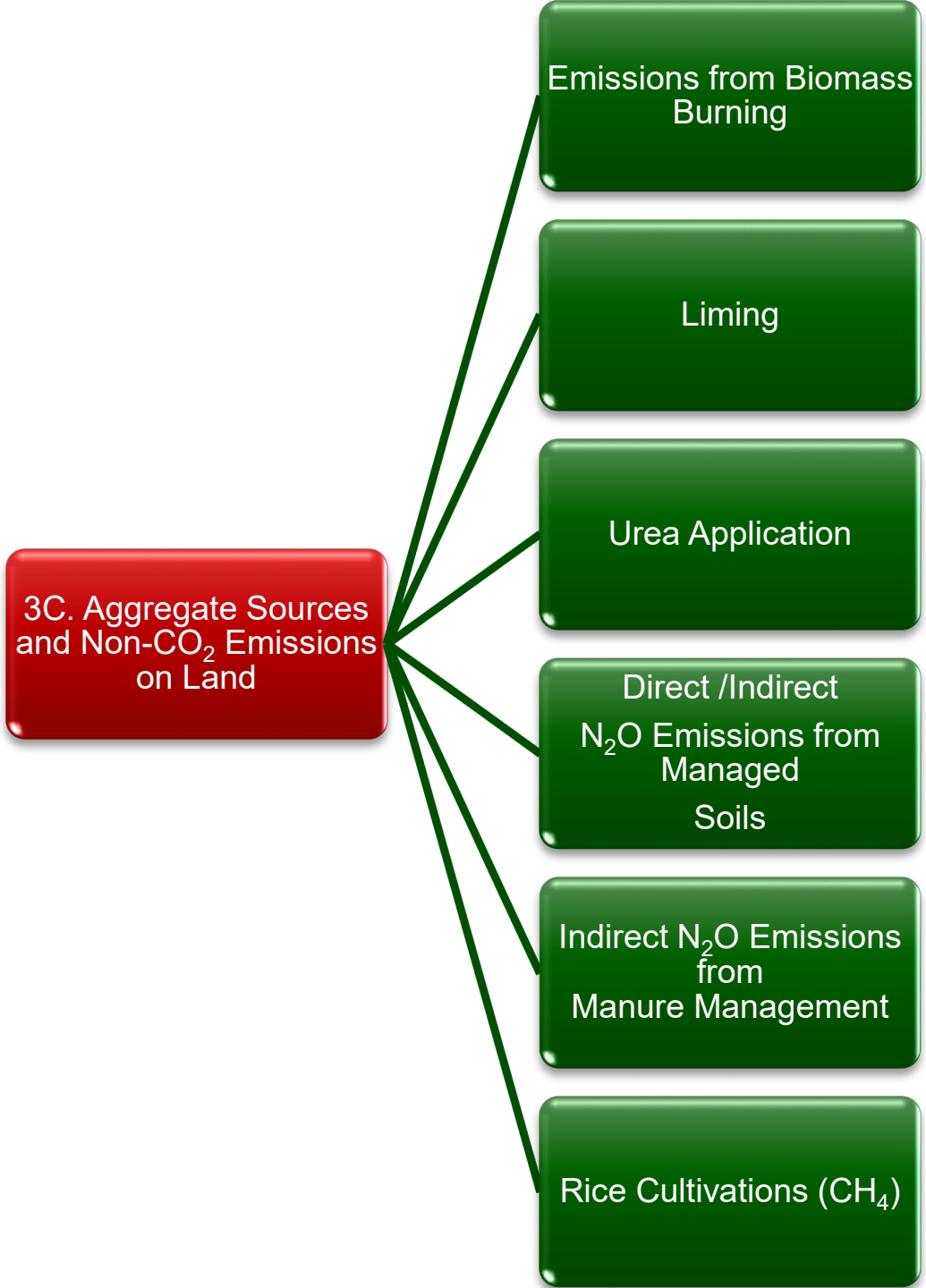
AFOLU Sector in the 2006 IPCC Guidelines

The 2006 Guidelines integrates Land Use, Land Use Change and Forestry (LULUCF) and the Agriculture sectors into a single Sector: Agriculture, Forestry and Other land-use (AFOLU) sector:



3A. Livestock emissions




3C. Aggregate Sources and Non-CO_2 Emissions on Land
Emissions from Biomass Burning
Liming
Urea Application
Direct /Indirect N_2O Emissions from Managed Soils
Indirect N_2O Emissions from Manure Management
Rice Cultivations (CH_4)

Why integrate Agriculture & LULUCF?

- The emissions from both sectors have been integrated into this new framework in order to resolve inconsistencies and avoid double counting:

- ✓ Removes the somewhat arbitrary distinction between these categories in the previous guidance, and promotes consistent use of data between them, especially for more detailed methods.

- ✓ Makes consistent the treatment of gases in the Agriculture and LULUCF Sectors and so allows for more consistent treatment of land conversions;

Methodological approaches used in the estimation of emissions/removals in AFOLU sector

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General Method

- There are large uncertainties in estimating fluxes of CO_2.
- Direct measurements are extremely difficult (small differences of large numbers) and inherent heterogeneity.
- A practical first order approach is to make assumptions about effects of land use change/management on carbon stocks and their impacts on carbon stocks and the biological response to a given land use at various points in time.

Flux of C assumed = changes in carbon stocks in existing biomass and soils.

Methodological Approach in the 2006 Guidelines – AFOLU Sector

- Defined “anthropogenic” GHG emissions as those occurring on managed land, managed land is used as a proxy for anthropogenic emissions/removals
- Managed land is land where human interventions and practices have been applied to perform production, ecological or social functions’
- Managed land has to be nationally defined and classified transparently and consistently over time
- Land category based approach covering 6 IPCC land use categories: forest land, cropland, grassland, wetland, settlement and others
- Land categories are further subdivided into:
- ✓ land remaining in the same use category
- ✓ other land converted to this land category
- Three-tier structure presented for choice of methods, AD and EF
- Estimation of biomass increment and losses in each land category.
- Linking of biomass and soil carbon for each land use category
- Methods given for all carbon pools: AGB, BGB, dead organic matter and soil carbon and all non-CO_2 gases
- Key source/sink category analysis provided for selecting significant land categories sub-land categories, C-pools and CO_2 and non-CO_2 gases

Definition of Concepts:

- **The land sector is made of:**
- ✓ **Emissions to the atmosphere** GHG caused by losses of organic matter from terrestrial ecosystems…
- ✓ and of carbon dioxide (CO_2) **removals from the atmosphere** as uptake by vegetation and stored in the organic matter
- ✓ Organic matter is composed of organic compounds that are part of organisms such as plants and their remains. It is essentially composed of the four elements below; their weight in organic matter is also provided.

Carbon (C) 40-55% Oxygen (O) 35-45%	Hydrogen (H) 3-5% Nitrogen (N)1-4% %

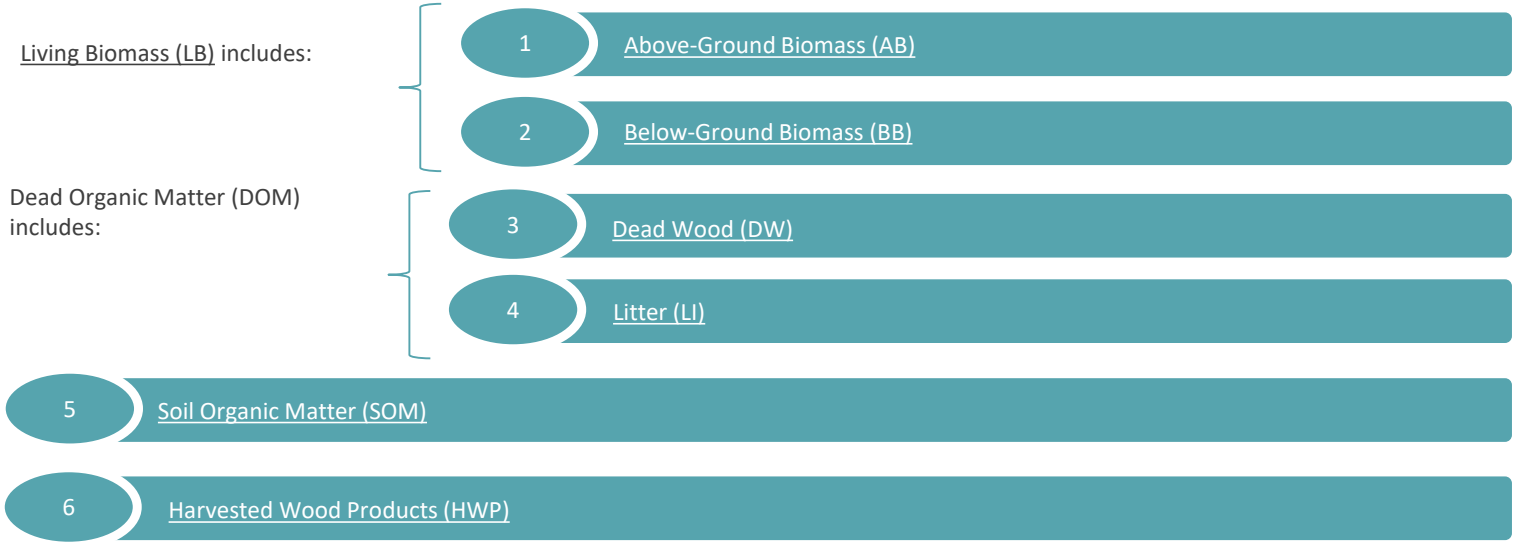
- ✓ These elements are constituents of the three important GHGs, that are reported in the land use sector, namely:

i. Carbon Dioxide (CO_2),
ii. Methane (CH_4)
iii. Nitrous Oxide (N_2O)

Stratification of organic matter within 6 carbon pools

Carbon Pools

- Since C is the most relevant component of the organic matter. The amount of organic matter in an ecosystem is regarded as a carbon stock (C Stock) that can be stratified into six so-called carbon pools present in the image below.
- Carbon Pool: is a a reservoir, that is component of the climate system where a GHG or a precursor of a GHG is stored. In particular carbon pools have the capacity to accumulate and release carbon dioxide.



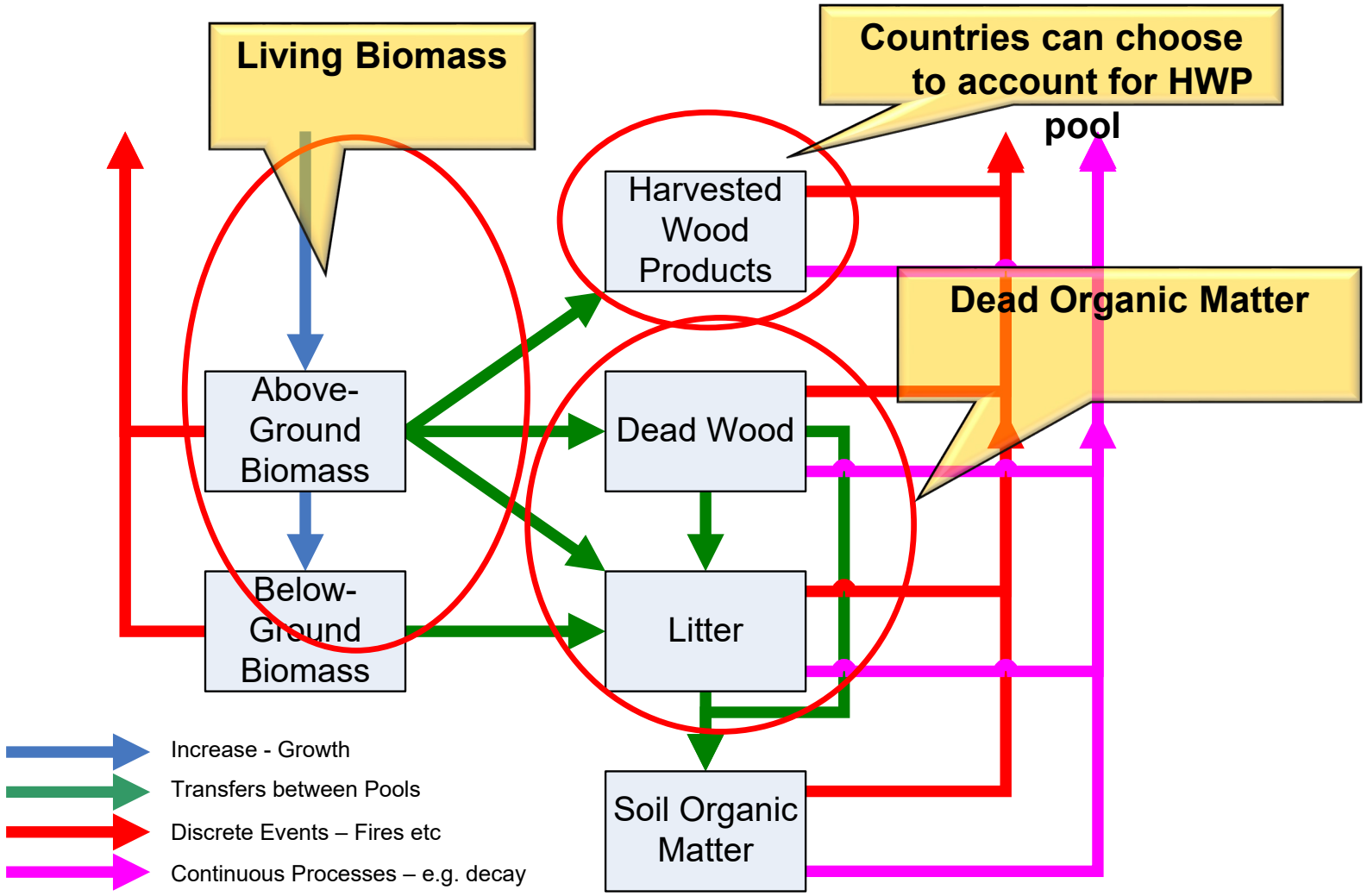
C stocks in C pools

- C pools exchanges GHG as removals from the atmosphere through photosynthesis and as emissions to the atmosphere through biochemical processes (decay of C stocks) and physiochemical process (fires).

- Emissions occur as C stock losses from C pools while removals occur as C stock gains. Consequently C stock changes are a proxy for estimating GHG emissions/removals for land categories.
- Both, C stock gains (positive sign) and C stock losses (negative sign) are multiplied by -44/12 to convert them in CO_2 removals and emissions respectively. Where 44 is the molecular weight of CO_2 and 12 is the atomic weight of C.

- Further, transfers (as gains or losses) of organic matter among C pools occur as a consequence of mortality (natural and man-made) and decay, so determining C stock losses in the C pools from which the stock is transferred and C stock gains in the pools in which the C stock is transferred
- Biomass is the only sink among C pools

Carbon cycle processes : showing carbon stock flows into and out of carbon pools

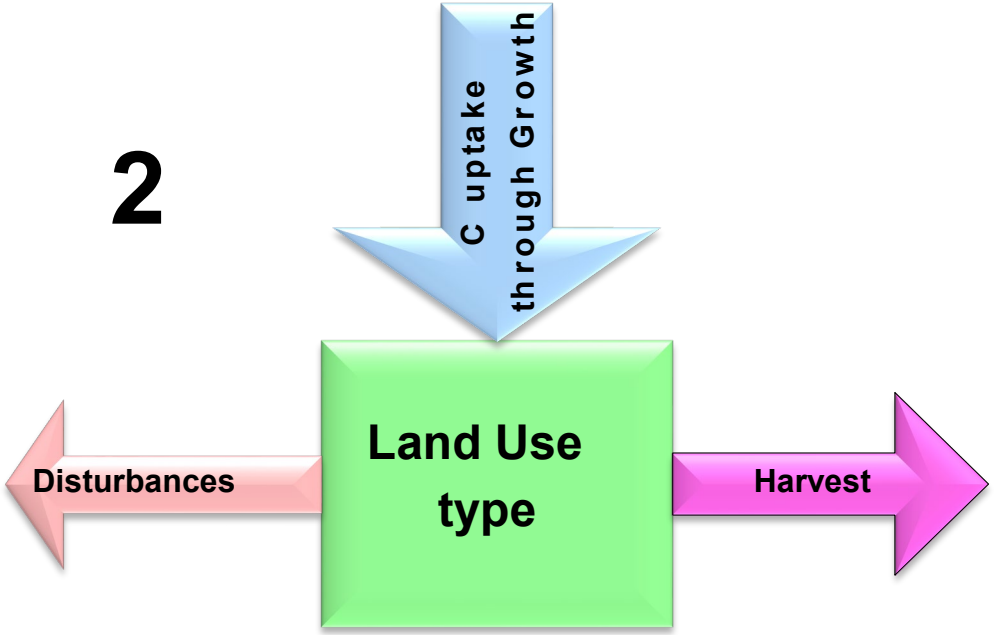


Generic approaches when estimating C stock changes

1

Difference between carbon stocks (Stock-Difference Method)

2



Sum of gains and losses (Gain-Loss Method)

Generic approaches for estimation are the same in 1996 Guidelines, through the GPG LULUCF to the 2006 Guidelines & AFOLU

Why use Managed Land as a Proxy?

- The preponderance of anthropogenic effects occurs on managed lands and, from a practical standpoint, the information needed for inventory estimation is largely confined to managed lands.

- By definition, all direct human-induced effects on greenhouse gas emissions and removals occur on managed lands only.

- While local and short-term variability in emissions and removals due to natural causes can be substantial the natural 'background' of greenhouse gas emissions and removals by sinks tends to average out over time and space. This leaves the greenhouse gas emissions and removals from managed lands as the dominant result of human activity.
- In practice this means that countries designate areas of land as "managed" and "unmanaged", and that only those emissions and removals that occur on land designated as "managed" for which IPCC Guidelines provides a methodology are included in the estimation of GHG inventories and counted as anthropogenic.

Data Needs

- ➢ Guidelines use “Tiers” and “Key Categories” to focus resources
- ✓ **Key Categories** are the largest categories that cumulatively account for 95% of the total.

– **Tiers** are levels of complexity and detail.

- ✓ Tier 1: Defaults given in the Guidelines
- ✓ Tier 2: Same method as Tire 1 but use nationally specific data. May have more stratification and can account for abatement
- ➢ Tier 3: More sophisticated and detailed modeling approaches – results compatible with Tier 1 & 2.
- ✓ In general GPG inventories need Tier 2 or 3 for key categories NOT Tier 1
- ➢ IPCC Guidelines focus on Tier 1
- ➢ National data:
- ✓ May need to be local surveys - e.g. fuel wood is often an informal sector. Management practices can vary…
- ✓ Significant data requirement in areas of each land use and areas of transitions.

Land Representation

- In the 2006 GL **Land representation** is the analysis undertaken to identify and quantify human activities on land, as well as to track their changes over time.
- This includes analysis of information, on land classification, land area data, and sampling that represents various land-use categories, this information is needed to estimate the carbon stocks, and the emission and removal of greenhouse gases associated with Forestry and Other Land Use (FOLU) activities.
- The land representation results in a stratification of the total area of the country into strata (units of land) homogeneous for a number of variables, that explain the current level and dynamic of C stocks within the stratum, with the purpose of making the GHG inventory compilation practicable while enhancing accuracy of GHG estimates.
- Land is characterized by bio-physical variables and various human activities. The variables for land stratification are listed below:

✓ *Biophysical characteristics*

✓ *Land Use*

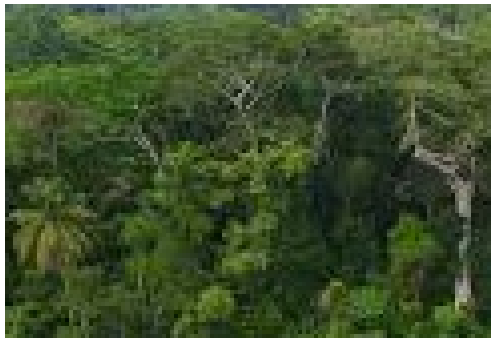
✓ *Management practices and disturbances*

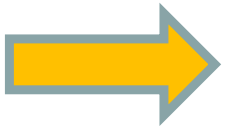
✓ *Other category specific variables*

✓ *Stratum: Unit of Land*

Land Representation: Why we need Land Stratification

- When estimating GHG emissions and removals, land areas are used as activity data (AD). As activity data, they represent the magnitude of a human activity that generates GHG emissions and/or removals during a given period of time.
- This is why the stratification of land is a paramount tool to achieve accuracy of GHG estimates.
- ✓ *Example of a land representation and associated C stock changes below*. This illustration below is an example of how land stratification correlates with the amount of C stocks found in a unit of land and their dynamic.





Forest Land

Cropland

- As you can see the conversion of land from forest land to cropland determines a negative C dynamic of C stocks (i.e. the amount of C stocks in this unit of land decreases across time).

Representing Land Areas in 2006 GL

- **Approach 1** identifies the total area for each individual land-use category,
- ✓ but does not provide detailed information on changes of area between categories
- ✓ and is not spatially explicit other than at the national or regional level.
- **Approach 2** introduces tracking of land-use changes between categories.
- ✓ National land use change matrix
- **Approach 3** extends Approach 2 by allowing land-use changes

to be tracked on a spatial basis.

Future developments of the IPCC 2006 Guidelines

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New Methodology Reports (1)

- The TFI has developed two additional methodology reports in response to the invitations from UNFCCC:
  - 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (***Wetlands Supplement***)
    - To fill gaps in the coverage of wetlands and organic soils in the 2006 IPCC Guidelines
  - 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (***KP Supplement)***
    - To update and augment the existing Chapter 4 of the GPG- LULUCF
- The ***Wetlands Supplement*** and ***KP Supplement*** were adopted/accepted by the IPCC Plenary at its 37th Session (IPCC 37) in Batumi, Georgia, 14-18 October 2013, and published on the TFI website in February 2014.
- ***Wetlands Supplement***

http://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html

- ***KP Supplement***

http://www.ipcc-nggip.iges.or.jp/public/kpsg/index.html

2019 Refinement to the 2006 IPCC Guidelines (2)

- **TFB at its 26th Meeting in Ottawa (28-29 August 2014) concluded that:**
- ✓ **2006 IPCC Guidelines provide a technically sound methodological basis of national greenhouse gas inventories; however,**
- ✓ **to maintain their scientific validity, certain refinements may be required, taking into account scientific and other technical advances that have matured sufficiently since 2006.**
- **The 2019 Refinement was developed by approximately 200 authors from all over the world.**
- **Three review stages:**
  - Expert Review of First Order Draft: Dec 2017 – Feb 2018
  - Government/Expert Review of Second Order Draft: Jul – Sep 2018
  - Government Review of Final Draft: Jan – Mar 2019
- **Scope and outline approved by the IPCC at its 44th Session (Oct 2016, Bangkok, Thailand) are included in Decision IPCC/XLIV-5.** http://www.ipcc.ch/meetings/session44/p44_decisions.pdf
- Other relevant documents:
  - Report of the Scoping Meeting (Aug 2016, Minsk, Belarus) http://www.ipcc-nggip.iges.or.jp/meeting/meeting.html
  - Overall schedule of production of IPCC Reports including 2019 Refinement http://www.ipcc.ch/activities/pdf/ar6_schedule.pdf#page=2

Summary

- 2006 Guidelines represent the best available scientific information for estimating and reporting GHG emissions and removals from all land based and agricultural sources
- 2006 Guidelines have removed inconsistencies and double counting issues by integration of agriculture and land use categories
- IPCC Guidance has progressively included better estimation methods, default parameters and new and improved guidance on more source/sink categories while maintaining consistency and similarity of approach throughout
- 2019 Refinement did not to revise the 2006 IPCC Guidelines, but updated, supplemented and/or provided new guidance in the 2006 IPCC Guidelines where gaps or out-of-date science have been identified.
- Future Developments - “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories” was adopted on 12 May 2019 in Kyoto)

Thank you

https://www.ipcc-nggip.iges.or.jp/index.html

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