ANNEX 3

SUMMARY OF THE REVISED 1996 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES

A3.1 Background

This Annex summarises additions and revisions to the 1995 IPCC Guidelines for National Greenhouse Gas Inventories (1995 IPCC Guidelines). It also describes efforts made by the IPCC to harmonise methods with others. The additions and revisions were accepted by the IPCC at its Twelfth Session held in Mexico City (11-13 September 1996) after acceptance by Working Group I at its Sixth Session held in Mexico City (10 September 1996) in accordance with IPCC procedures. They are called the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Within this Annex, a revision of an existing methodology or default data is referred to as a ‘revision’, ‘revised method’ or ‘revised data’. Additional methods and default data are defined as ‘new’ methods or ‘new data’.

A3.2 Energy

The Energy Chapter contains the following improvements and additions:

- Harmonisation of international (IPCC and CORINAIR) emission estimation methodologies and allocating of emissions from autoproducers\(^1\) to the sector where they are generated and not to the transformation\(^2\) sector (revision);

- Development of a new Tier 1 method for estimating non-CO\(_2\) Greenhouse Gas (GHG) and SO\(_2\) emissions based on fuel consumption;

- Development of a new Tier 2 method for estimating emissions from aircraft;

- Inclusion of new default values for various types of traditional biomass fuels;

- Clarification of the definition of National Navigation (the definition of International Marine Bunkers remains unchanged).

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\(^1\) An autoproducer is defined as an entity which produces electricity and/or heat for sale in addition to its primary activities.

\(^2\) The transformation sector comprises the conversion of primary forms of energy to secondary and further transformation (e.g. coking coal to coke, heavy fuel oil to electricity)
A3.3 Industrial Processes

The Industrial Process Chapter contains a broad range of new estimation methodologies for the so-called "new gases", that is perfluorocarbons, PFCs (e.g. CF₄ and C₂F₆), HFCs (e.g. HFC-125 and HFC-134a), sulphur hexafluoride (SF₆), the direct GHG (CO₂, CH₄, and N₂O), and ozone and aerosol precursors (SO₂, NOₓ, CO, NMVOC) from industrial, non-energy, processes.

**Direct GHG**: The new methodologies cover CO₂, CH₄, and N₂O emissions from the production of mineral compounds, chemical industries and metal manufacture. The estimation of CO₂ emissions from cement production remains unchanged, but the methodologies for N₂O emissions from nitric and adipic acid production have been revised.

**Aerosol and ozone precursors**: For SO₂, NOₓ, CO, NMVOC, new methodologies are presented, which draw upon and improve existing international methodologies. The sectors covered are: mineral compounds production, chemical industries and metal manufacture.

**Fluorocarbons and SF₆**: For HFCs and PFCs, and SF₆, methodologies are provided to estimate by-product and fugitive emissions from aluminium (Al) and magnesium (Mg) manufacturing processes, as well as emissions from their production and consumption. Two approaches are given: Tier 1 (a, b) for potential emissions, and Tier 2, for actual emissions. Potential emissions of PFCs, HFCs, and SF₆, are equal to the amount of a chemical consumed in a country, minus the amount of a chemical recovered for destruction or export in the year of consideration. Actual emissions estimates take into account the time lag between consumption and emissions. The Tier 2 methodology is, therefore, the more accurate estimation approach.

A3.4 Land-use Change and Forestry

Several revisions to the methods for the Land-use Change and Forestry Chapter are provided. One such revision is to the method for estimating CO₂ fluxes from soils, as described below.

The revisions to the Land-use Change and Forestry Chapter greatly extend and improve the range and quality of default data, particularly for the tropics, where national forestry statistics are sometimes less accessible than in the temperate or boreal regions. The revisions can be summarised by changes in (a) default data and in (b) methods, as follows:

**Default data**

**Classification system for land cover types**: A revised system more consistent with sources of national, regional and international data, such as forest conversion rates and forest inventories was developed. The revised classification system better reflects the diversity of forest types. For the tropics, three classes of forests have been replaced with six, based on differences in rainfall amount, seasonality, and altitude.

**Rates of forest conversion**: New FAO default data are provided for each country and forest type according to the proposed land-cover classification.
system. These data have been compiled for the tropics for the 1980-90 period. Such revisions were incorporated because country-level data are often difficult to obtain for many tropical countries; the 1995 IPCC Guidelines contain no such data.

**Aboveground biomass for native tropical forests:** Emissions estimates from land-use change and forestry can be highly sensitive to such input data and therefore a priority was given to improving aboveground biomass data. Since publication of the 1995 IPCC Guidelines, better datasets have become available drawing upon larger regional studies. The revisions now include a large database of default values for Africa, America, and Asia for the revised land-cover classification system. Additional data based on individual forest inventories (suitable for converting to biomass) for many tropical countries are also included. None of the default values are separated into primary and secondary forests (as in 1995 IPCC Guidelines) because it was felt by experts that this was not a practical classification, given the variability of definitions in different regions.

**Rates of tropical forest regrowth:** Revised default data are given for forest regrowth; the data are related to the biomass data and are reported for the three tropical regions by forest type, according to the revised classification system.

**Methods**

**Estimation of net CO₂ emissions from soil carbon:** In the 1995 IPCC Guidelines, CO₂ estimates are based upon the product of the rate of change in area of a given land-use and the rate of change of soil carbon. The revised method estimates changes in soil carbon pools associated with altered land-use or land management practices. Thus, all categories of agriculturally-impacted lands, including conversions of forest or other vegetation to agriculture, land abandonment, shifting cultivation and permanent agriculture, are included in the methodology. A default stock method is employed to estimate CO₂ fluxes associated with agricultural activities for a 20-year inventory period. This area of the IPCC Methodology has been much improved because better scientific data is now available. The revised method is more compatible with potential policy analysis.

**A3.5 Agriculture**

Three sections of this Chapter have been revised, that are, (1) methane emissions from rice cultivation, (2) nitrous oxide emissions from agricultural soils and (3) manure management. For the estimation of N₂O emissions, the default methods and data are new.

**Methane Emissions from Rice Cultivation**

In the 1995 IPCC Guidelines, the estimation of CH₄ emissions from wetland rice cultivation is a function of the CH₄ emission factor, area of rice cultivated and the season length. One critical default parameter is the CH₄ emission factor, which is based upon temperature. It was determined that the relationship between CH₄ emissions and soil temperature as assumed in
the 1995 IPCC Guidelines was no longer appropriate because new data suggest that the seasonally integrated CH$_4$ flux depends much more on the input of organic carbon, water regime, time and duration of drainage and soil type than on local temperature. The revised methodology is a function of the emission factor integrated over a cropping season for particular rice water regime, for a given organic amendment, and of the annual harvested area cultivated under these conditions. The latter is given by the cultivated area times the number of cropping seasons per year.

The revisions to the method use internationally-agreed definitions for rice eco-systems classified according to the water regime and a range of CH$_4$ emission scaling factors relative to continuously flooded rice eco-systems and for soils without organic amendment. A default seasonally integrated emission factor is also provided for the continuously-flooded regime, without-organic amendment.

**Nitrous Oxide Emissions from Agricultural Soils and Manure Management**

A new default method for calculating national emissions of N$_2$O from agriculture is provided. The new N$_2$O method is a revision of the method in the 1995 IPCC Guidelines. It includes more sources of N$_2$O from agricultural activities and makes explicit recommendations on N$_2$O emission factors. The new method accounts for the application of N-fertilisers to the soil and N uptake in crops and subsequently tracks the flow of N as it moves through the (anthropogenic) animal and human food chain. Three categories of N$_2$O sources are distinguished in the new methodology, (1) direct emissions from agricultural soils, (2) emissions from animal production, and (3) N$_2$O emissions indirectly induced by agricultural activities. Because a larger number of sources and pathways are considered, the new N$_2$O methodology affects several source sectors. Emissions are reported in several sections of the 1995 IPCC Guidelines, namely, Manure Management (Section 4.2, 1995 IPCC Guidelines), Agricultural Soils (Section 4.5, 1995 IPCC Guidelines), and Waste (Section 6.3, 1995 IPCC Guidelines). The input data required can be obtained from FAO databases.

The new method provides a comprehensive description of N$_2$O emissions from agriculturally-related activities by accounting for previously omitted N$_2$O sources. Using this method, global N$_2$O emission estimates imply that atmospheric N$_2$O input from agricultural production as a whole has apparently been previously underestimated by at least 70%. Nitrous oxide emissions resulting from atmospheric deposition are assigned to the NO$_x$ or NH$_3$ emitting country.

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3 It is however recognised that there are other sources of anthropogenic atmospheric inputs of N-compounds to soils e.g., NO$_x$ from fuel combustion. Only compounds directly applied to agricultural soils are considered.

4 In some countries and regions, other conventions related to long range transboundary air pollution are addressing the issue of atmospheric transport and deposition in greater detail.
A3.6 Waste

The Chapter on Waste addresses various topics, including: improved waste disposal data, evaluation of the methodologies for solid waste and wastewater, definitions of activities and uncertainties of CH$_4$ emission estimates. The main improvements to the methods and default data are as follows:

**Solid Waste**

**Site classification:** A new term - solid waste disposal site - has been proposed to refer to all sites and to replace the terminology in 1995 IPCC Guidelines for ‘landfills’ and ‘open dumps’. The new term was proposed because experience suggests that the existing categories do not adequately include the entire range of waste disposal sites that exists in all countries. Solid waste disposal sites include all sites where waste is deposited and is likely to generate some methane. Sites are further classified according to the level of site management and depth.

**Methane correction factor:** The new site classification is used to derive a methane correction factor (MCF) to account for the methane generation potential of the site. The amount of methane produced depends in part upon the available oxygen and the level of compaction of the waste. In general, waste in managed sites potentially generates more methane than waste in unmanaged sites. Furthermore, the deeper the site, the greater the methane generation potential. The methane correction factor for each type of site reflects these differences in methane generation potential. The site classification recognises that some developing countries, or countries with-economies-in-transition, may have a majority of less-well managed or unmanaged sites, often with a lower methane-producing potential than well managed sites.

**Waste data:** A wide range of revised and new default data on waste generation, composition and disposal data in many additional developed and developing countries is provided. A definition for Municipal Solid Waste and a method for calculating the Degradable Organic Carbon content of various waste streams are now included in the revised Chapter.

**Methodology:** The default methodology was evaluated and retained. The methodology uses a zero-order equation requiring data on population, waste landfills, and waste composition as proposed by Bingemar and Crutzen (1987).

**Wastewater**

A revised method and default data for calculating emissions from wastewater and sludge is included. The amount of CH$_4$ produced from these systems depends upon several factors, including the characteristics of the wastewater and the management system, and temperature. These factors are highly dependent upon the waste treatment system used. The revised methodology allows countries to tailor the estimation approaches more precisely to their wastewater management systems. This is accomplished by the MCF that accounts for the differing CH$_4$ generating potential of
different wastewater management systems. In addition, the revised methodology uses data that is commonly available from most countries, or which can be estimated by wastewater experts.

**Human sewage**

A new methodology and default data are provided for the estimation of N₂O nitrous oxide emissions from human sewage disposed to land, and in subsequent run-off to rivers and estuaries. There is no such methodology in 1995 IPCC Guidelines.

### A3.7 Harmonisation of International Emission Estimation Methodologies

Progress has been made in the harmonisation of the IPCC and EMEP/CORINAIR methodologies to allow more direct comparison of the two approaches. These changes are mainly in the Energy Chapter, but harmonisation was a theme in all other chapters, including Industrial Processes. Examples of harmonisation are given below from the Energy Chapter:

- Biomass fuels are allocated to the various source categories (new). As in 1995 IPCC Guidelines, CO₂ from biomass will not be reported in national totals as this is captured in the Land-use Change and Forestry Chapter.

- Emissions from fuel used for electricity and heat production by autoproducers will be included in the sector where it is generated and not with the transformation industries.

- Treatment of evaporative emissions (NMVOCs) from road transport in the Tier 2 method of IPCC is made consistent with CORINAIR. Combustion and evaporative emissions are to be reported separately. However, in the new Tier I IPCC method, all emissions from road transport are included together under fuel combustion.

- Development of a new Tier 2 method for estimating emissions from aircraft.

### References

- 1995 IPCC Guidelines for National Greenhouse Gas Inventories, Reporting Instructions (Volume 1); Workbook (Volume 2); Reference Manual (Volume 3).
### Table 1. Additions/revisions to the 1995 IPCC Guidelines for National Greenhouse Gas Inventories

<table>
<thead>
<tr>
<th>Sector</th>
<th>Volume</th>
<th>Chapter/Section</th>
<th>Summary of additions/revisions²</th>
</tr>
</thead>
</table>
| 1. Energy | Reference Manual (Volume 3) | Chapter 1, Energy | Main changes are:  
- assignment of GHG emissions from autoproducers to the sector where they were generated and not to the transformation sector (revision);  
- development of a Tier 1 method for estimating non- CO₂ GHG and SO₂ emissions based on fuel consumption (new);  
- development of a Tier 2 method for estimating emissions from aircraft (new);  
- inclusion of default values for various types of traditional biomass fuels (new);  
- clarification of the definition of National Navigation (the definition of International Marine Bunkers remains unchanged) |
|        | Workbook (Volume 2) | Module 1, Energy | |
| 2. Industrial Processes | Reference Manual (Volume 3) | Chapter 2, Industrial Processes | New methods and default data for the estimation of emissions of:  
- direct greenhouse gases (CO₂, CH₄, and N₂O) and SO₂ from:  
  - mineral production;  
  - chemical industries;  
  - metal manufacture;  
- ozone precursors (NOₓ, CO, NMVOC) from:  
  - chemical industries;  
  - metal manufacture;  
- halocarbons (PFCs, HFCs) and sulphur hexafluoride (SF₆) from metal manufacture, use and production.  
  - Tier 1 (a): for bulk chemicals;  
  - Tier 1 (b): for bulk chemicals and chemicals stored in products;  
  - Tier 2 : product (containing PFCs, HFCs, SF₆) lifetimes are taken into account. |
|        | Workbook (Volume 2) | Module 2, Industrial Processes | |

¹ Chapter 3, “Solvents and other product use” has not been revised.  
² A revision of an existing methodology or default data is referred to as a ‘revision’. In cases where an additional method has been developed and default data provided, this is defined as ‘new’.
### Table 1. Additions/revisions to the 1995 IPCC Guidelines for National Greenhouse Gas Inventories (continued)

<table>
<thead>
<tr>
<th>Sector 1</th>
<th>Volume</th>
<th>Chapter/Section</th>
<th>Summary of additions/revisions 2</th>
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<tbody>
<tr>
<td><strong>4. Agriculture</strong></td>
<td>Reference Manual (Volume 3)</td>
<td>Chapter 4: Agriculture, Methane Emissions from Rice Cultivation</td>
<td>Revised method and new default data for the estimation of Methane Emissions from Rice Cultivation uses: - internationally-agreed definitions of rice ecosystems (revision); - default data (e.g. seasonally integrated CH₄ emission factors) (new); - scaling factors for CH₄ emissions factors relative to continuously flooded fields (without-organic amendment) (new).</td>
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<td>Reference Manual (Volume 3)</td>
<td>Chapter 4: Agriculture, Agricultural Soils and Manure Management</td>
<td>Additions and revisions include: - default method for the estimation of nitrous oxide emissions from Manure Management and Agricultural soils (new); - revised default emission factors for the estimation of direct emissions of N₂O from soils (revision); - default data (e.g. N₂O emission factors for animal waste and for indirect emissions) (new).</td>
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<td></td>
<td>Workbook (Volume 2)</td>
<td>Module 4: Agriculture Agricultural Soils, Manure Management, and Methane Emissions from Rice Cultivation</td>
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<tr>
<td><strong>5. Land-use Change &amp; Forestry</strong></td>
<td>Reference Manual (Volume 3)</td>
<td>Chapter 5, Land-use Change &amp; Forestry</td>
<td>Revised/new default data and classification are suggested for: - land-cover types (revision); - rates of forest conversion (new); - aboveground biomass for native tropical forests (revision); - rates of tropical forest regrowth (revision)</td>
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<td></td>
<td>Workbook (Volume 2)</td>
<td>Module 5, Land-use Change &amp; Forestry</td>
<td>Method for the estimation of CO₂ fluxes from agricultural soils (revision) and default data (new).</td>
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</tbody>
</table>

1. Chapter 3, “Solvents and other product use” has not been revised.
2. A revision of an existing methodology or default data is referred to as a ‘revision’. In cases where an additional method has been developed and default data provided, this is defined as ‘new’.
Table 1. Additions/revisions to the 1995 IPCC Guidelines for National Greenhouse Gas Inventories (continued)

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<td>Revised/new data and classification are listed below for:</td>
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<td>- solid waste disposal site classification: definition encompasses all sites classified in the current Guidelines (revision);</td>
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<td>- methane correction factor to account for the methane generation potential of the site (new);</td>
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<td>- wider range of default data for waste generation, composition and disposal data (revision).</td>
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<td></td>
<td>Workbook (Volume 2)</td>
<td>Module 6, Waste</td>
<td>• Wastewater</td>
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<td>- revised approach and default data for calculating $\text{CH}_4$ emissions (revision).</td>
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<td>• Human sewage</td>
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<td>- method and default data for the estimation of $\text{N}_2\text{O}$ emissions (new).</td>
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</table>

1 Chapter 3, “Solvents and other product use” has not been revised.
2 A revision of an existing methodology or default data is referred to as a ‘revision’. In cases where an additional method has been developed and default data provided, this is defined as ‘new’.