Climate MRV for Africa – Phase 2
Development of National GHG Inventory Uncertainty Assessment

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Content

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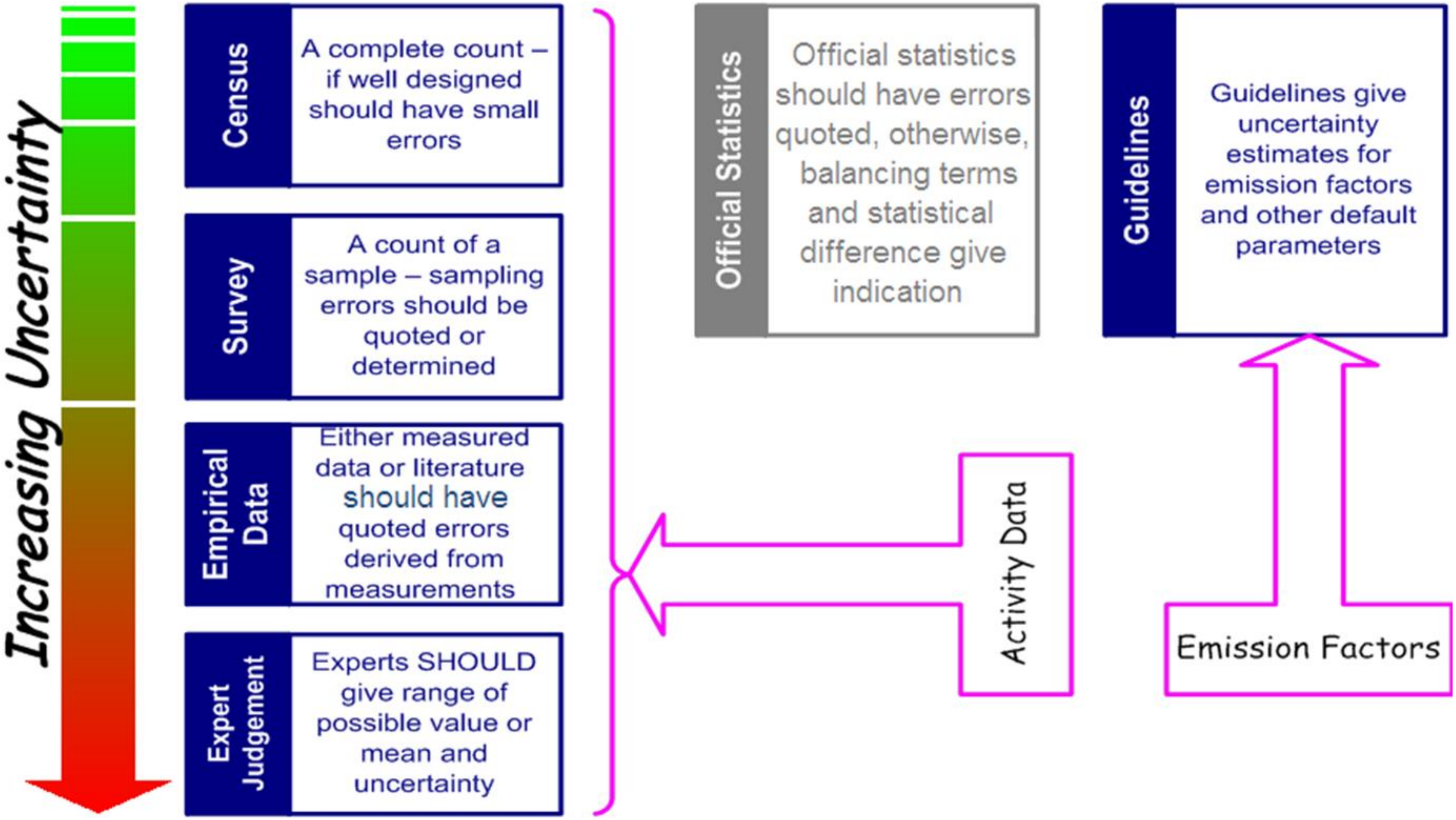
Uncertainty Assessment
General

Reasons for Uncertainty in Input Data

- Lack of data (missing data or extrapolation)
- Measurement error
- Data not truly representative
- Statistical random sampling error
- Misreporting/misclassification

Levels of Uncertainty



Source: consultative group of expert (CGE) training material on uncertainty analysis

Benefits of Uncertainty Analysis

Credibility

Inventories are estimates – uncertainty analysis gives a clear statement of what we do and do not know

Utility

Users of the inventory need to know how reliable the numbers are – especially if they are input into policy or inventory improvement actions

Requirement

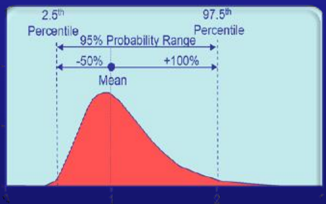
Uncertainty analysis is a requirement of all good practice inventories

Scientific

All scientific analysis should include an uncertainty assessment

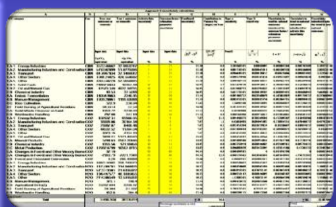
Source: consultative group of expert (CGE) training material on uncertainty analysis

Uncertainty Estimation



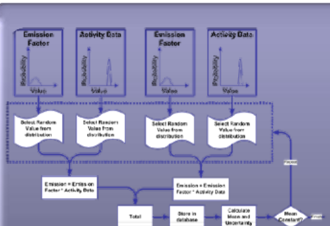
Gather Information

- Collect uncertainty information on activity data and emission factors



Decide approach to use

- Error Propagation
- Monte Carlo



Perform Inventory Analysis

- Spreadsheet
- Software tool

Source: consultative group of expert (CGE) training material on uncertainty analysis

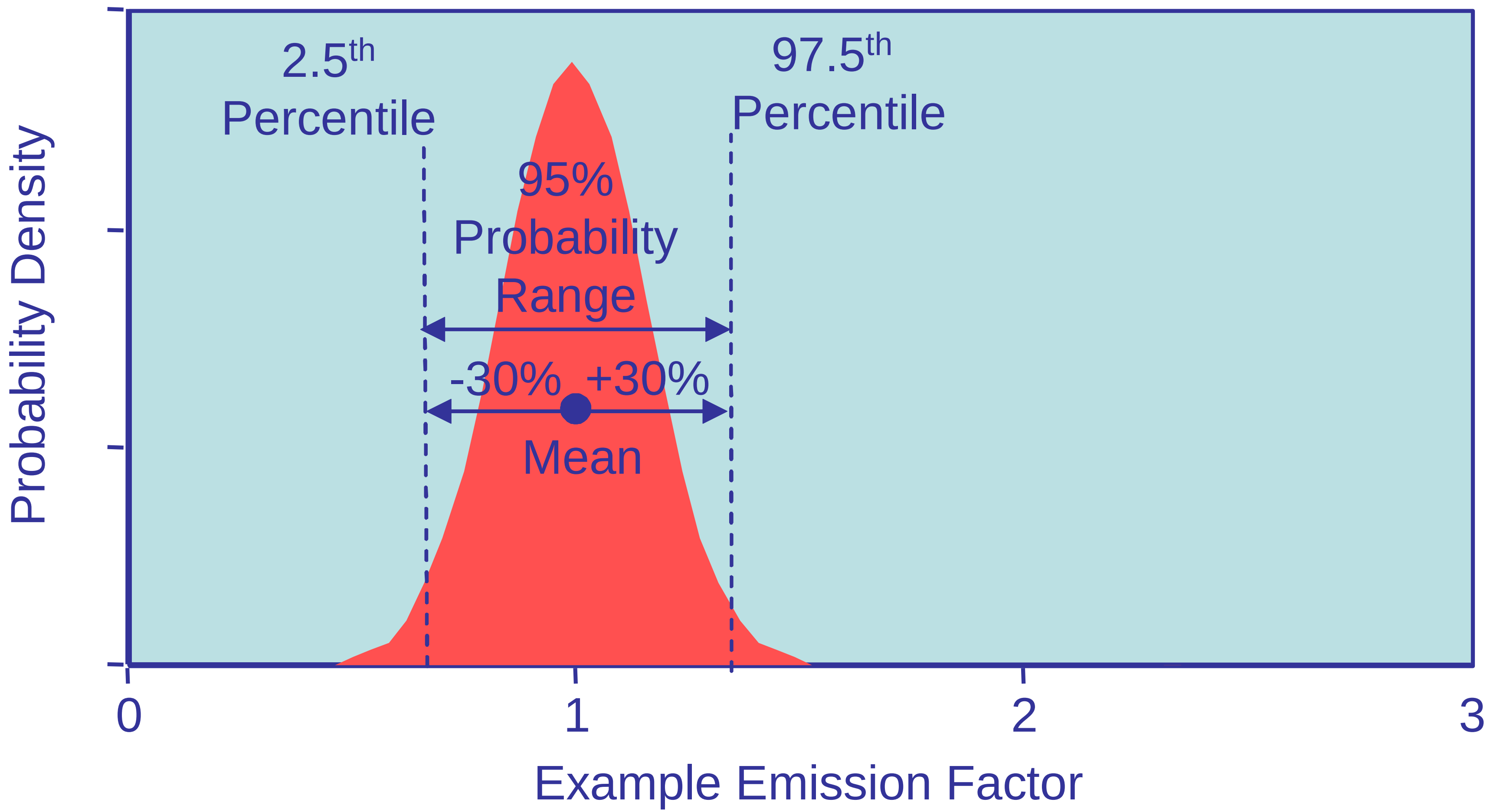
Specifying Uncertainty

- **Uncertainty** is quoted as the 2.5 and 97.5 percentile i.e. bounds around a 95% confidence interval.

- This **can be expressed as**:
  - 234 ± 23%
  - 26,400 (- 50%, + 100%)
  - 2,000 (a factor of 2) (i.e. - 50%, + 100%)
  - An order of magnitude (i.e. 1 to 100)

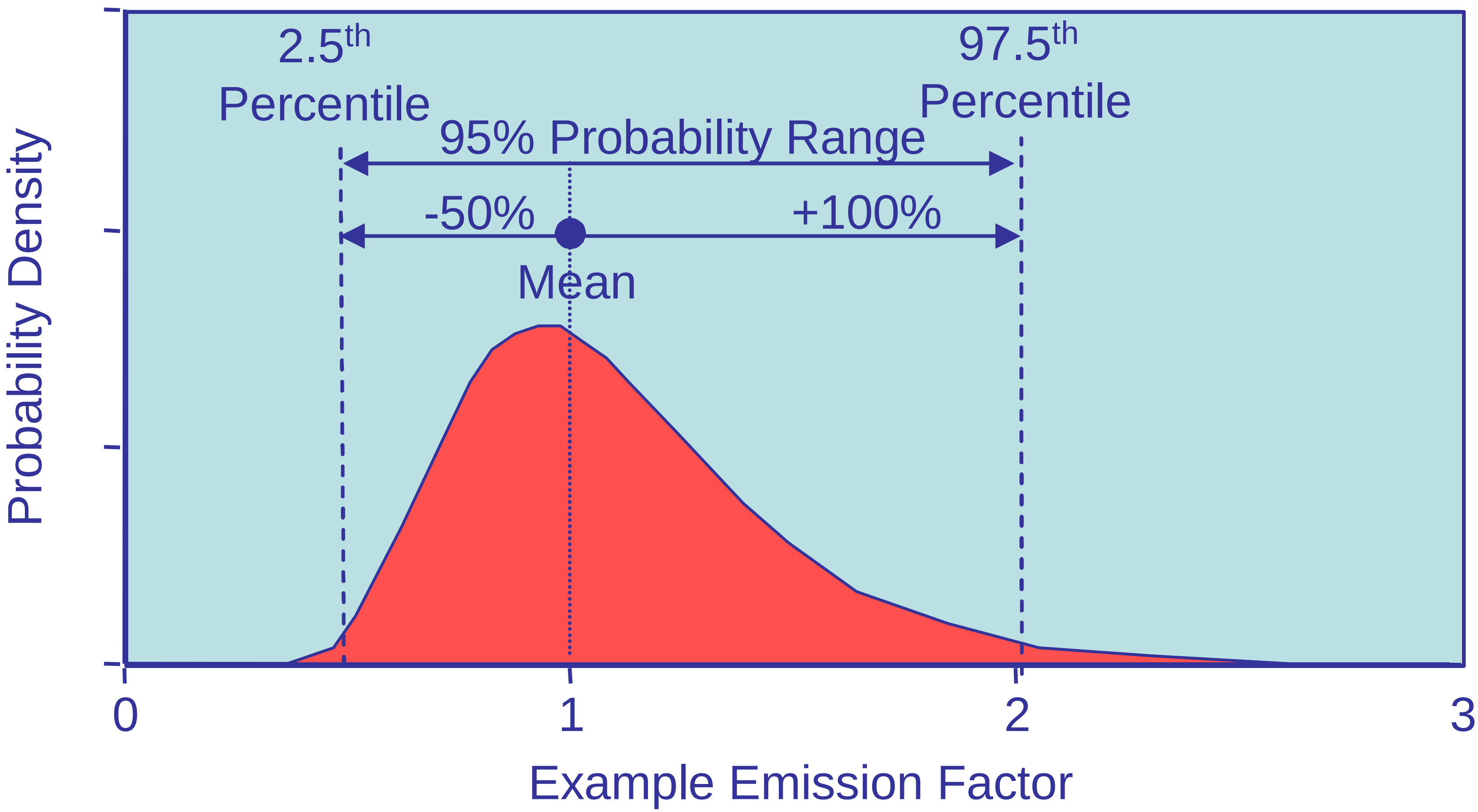
Source: consultative group of expert (CGE) training material on uncertainty analysis

Probability Density – Normal



Source: consultative group of expert (CGE) training material on uncertainty analysis

Probability Density – Asymmetric



Source: consultative group of expert (CGE) training material on uncertainty analysis

Methods to Combine Uncertainty

Error propagation

- Uncertainty in individual categories, in the inventory as a whole, and in trends between a year
- Simple - standard spread sheet can be used
  - IPCC Guidelines give explanation and equations
- Difficult to deal with correlations
- Strictly (standard deviation/mean) < 0.3
  - A simple solution is provided

Monte-Carlo Simulation

- More complex - Use specialized software
- Suitable where uncertainties are large, non-Gaussian, complex algorithms, correlations exist and uncertainties vary with time

Uncertainty of Annual Estimate

Example error propagation equation for multiplication

$$U_{SG} = \sqrt{U_{EF}^2 + U_{AD}^2}$$

- U_{SG} = percentage uncertainty in emissions of source category
- U_{EF} = percentage uncertainty in Emission Factor
- U_{AD} = percentage uncertainty in Activity Data

Source: consultative group of expert (CGE) training material on uncertainty analysis version 2 April 2012

Uncertainty of Annual Estimate

Example error propagation equation for addition & subtraction

$$U_{total} = \frac{\sqrt{(U_{SG1} * x_{SG1})^2 + (U_{SG2} * x_{SG2})^2 + \ldots + (U_{SGn} * x_{SGn})^2}}{|x_1 + x_2 + \ldots xn|}$$

- U_{total} = percentage uncertainty in total emissions
- U_{SGn} = percentage uncertainty in emissions of source category
- X_{SGn} = Emissions from SGn

Source: consultative group of expert (CGE) training material on uncertainty analysis version 2 April 2012

Uncertainty in Trend

- Overall uncertainty in Trend is estimated based on:
  - Type A: Change in difference in overall emissions between base year and inventory year as a result of 1% change in both base year and inventory year (systematic uncertainty)
  - Type B: Change in difference in overall emissions between base year and inventory year as a result of 1% change in inventory year only (random error)

Source: consultative group of expert (CGE) training material on uncertainty analysis version 2 April 2012

Uncertainty in the estimate of CH_4 emissions from SWDS

There are two areas of uncertainty:

- **the uncertainty attributable to the method**
  - Decay of carbon compounds to CH_4 involves a series of complex chemical reactions and may not always follow a first-order decay reaction;
  - SWDS are heterogeneous: temperature, moisture, waste composition and compaction vary considerably even within a single site;
  - Use of the FOD method introduces additional uncertainty associated with decay rates (half-lives) and historical waste disposal amounts.
- **the uncertainty attributable to the activity data**
  - The uncertainty in waste disposal data depends on how the data is obtained. Uncertainty can be reduced when the amounts of waste in the SWDS are weighed.

Uncertainty from SWDS

TABLE 3.5 ESTIMATES OF UNCERTAINTIES ASSOCIATED WITH THE DEFAULT ACTIVITY DATA AND PARAMETERS IN THE FOD METHOD FOR CH_4 EMISSIONS FROM SWDS	
Activity data and emission factors	**Uncertainty Range**
Total Municipal Solid Waste (MSW_T)	**Country-specific:** 30% is a typical value for countries which collect waste generation data on regular basis. ±10% for countries with high quality data (e.g., weighing at all SWDS and other treatment facilities). For countries with poor quality data: more than a factor of two.
Fraction of MSW_T sent to SWDS (MSW_F)	±10% for countries with high quality data (e.g., weighing at all SWDS). ±30% for countries collecting data on disposal at SWDS. For countries with poor quality data: more than a factor of two.
Total uncertainty of Waste composition	±10% for countries with high quality data (e.g., regular sampling at representative SWDS). ±30% for countries with country-specific data based on studies including periodic sampling. For countries with poor quality data: more than a factor of two.
Degradable Organic Carbon (DOC)[7]	**For IPCC default values** : ±20% **For country-specific values**: Based on representative sampling and analyses: ±10%

Uncertainty from SWDS (Table 3.5. Continued...)

Fraction of Degradable Organic Carbon Decomposed (DOC_f)	**For IPCC default value (0.5):** ± 20% **For country-specific value** ± 10% for countries based on the experimental data over longer time periods.
Methane Correction Factor (MCF) = 1.0 = 0.8 = 0.5 = 0.4 = 0.6	**For IPCC default value:** –10%, +0% ±20% ±20% ±30% –50%, +60%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	**For IPCC default value:** ±5%
Methane Recovery (R)	The uncertainty range will depend on how the amounts of CH_4 recovered and flared or utilised are estimated: ± 10% if metering is in place. ± 50% if metering is not in place.
Oxidation Factor (OX)	Include OX in the uncertainty analysis if a value other than zero has been used for OX itself. In this case the justification for a non-zero value should include consideration of uncertainties.
half-life ($t_{1/2}$)	Ranges for the IPCC default values are provided in Table 3.4. Country-specific values should include consideration of uncertainties.
Source: Expert judgement by Lead Authors of the Chapter.	

Incineration and Open Burning of Waste

Emission Factor Uncertainty:

- Uncertainties associated with CO_2 emission factors for open burning are ± 40 % and related to:
  - fraction of dry matter in waste open-burned,
  - fraction of carbon in the dry matter,
  - fraction of fossil carbon in the total carbon,
  - combustion efficiency,
  - and fraction of carbon oxidised and emitted as CO_2.
- Direct measurement or monitoring of emissions of N_2O and CH_4 has less uncertainty. (± 10)

Incineration and Open Burning of Waste

Activity data uncertainties:

- When waste incinerated is based on waste statistics or plant specific data ± 5 % percent on a wet weight basis;
- The conversion of waste amounts from wet weight to dry weight adds additional uncertainty.

Uncertainty from Waste Water Treatment

Following parameters are typically very uncertain:

- The degrees to which wastewater in developing countries is treated in latrines, septic tanks, or removed by sewer, for urban high, urban low income groups and rural population (Ti,,j).
- The fraction of sewers that are 'open', as well as the degree to which open sewers in developing countries are anaerobic and will emit CH4 (subject to retention time and temperature).
- The amount of industrial TOW that is discharged into open or closed domestic sewers for each country is very difficult to quantify.

Emission Factor Uncertainty

TABLE 6.7 DEFAULT UNCERTAINTY RANGES FOR DOMESTIC WASTEWATER	
Parameter	**Uncertainty Range**
Emission Factor	
Maximum CH_4 producing capacity (B_o)	± 30%
Fraction treated anaerobically (MCF)	The MCF is technology dependent. See Table 6.3. Thus the uncertainty range is also technology dependent. The uncertainty range should be determined by expert judgement, bearing in mind that MCF is a fraction and must be between 0 and 1. Suggested ranges are provided below. Untreated systems and latrines, ± 50% Lagoons, poorly managed treatment plants± 30% Centralized well managed plant, digester, reactor, ± 10%

Activity Data Uncertainty (Table 6.7 continued)

Activity Data	
Human population (P)	± 5%
BOD per person	± 30%
Fraction of population income group (U)	Good data on urbanization are available, however, the distinction between urban high income and urban low income may have to be based on expert judgment. ± 15%
Degree of utilization of treatment/ discharge pathway or system for each income group ($T_{i,j}$)	Can be as low as ± 3% for countries that have good records and only one or two systems. Can be ± 50% for an individual method/pathway. Verify that total $T_{i,j}$ = 100%
Correction factor for additional industrial BOD discharged into sewers (I)	For uncollected, the uncertainty is zero %. For collected the uncertainty is ± 20%
Source*:* Judgement by Expert Group (Authors of this section).	

Thank you!

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