INTERIM METHODOLOGY

Air Pollution Model

Technical Manual

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1 Introduction

1.1 Document purpose

1. This document is the Interim Air Pollution Model Technical Manual, which provides a description of the Interim Air Pollution Model's structure and functionality, input data, and assumptions. It aims to help readers better understand and expand the model that informs the Interim Air Pollution Topic Methodology. The Model Technical Manuals aim to improve transparency and confidence in the Global Value Factors Database (GVFD), and support companies' use of the GVFD for decision-making and sensitivity analysis.

2. The Interim Air Pollution Methodology is part of a series of four interim environmental methodologies released by IFVI, as complements to the impact accounting methodologies produced by IFVI in partnership with the Value Balancing Alliance. All four methodologies are designed with similar structures and resources, outlined below.

3. For general implementation and understanding of the Interim Methodologies, the following primary resources should be utilized:

    a. **Global Value Factors Database:** An Excel file compilation of all value factors of all methodologies. Companies should use the outputs shown here in estimating their impact values.

    b. **Methodologies:** These documents describe the methodology of each environmental impact topic, including key assumptions and conceptual underpinnings and the data requirements of entities in using them.

4. These resources are underpinned by supplemental resources, including the following:

    a. **Models:** Excel files for each methodology. All calculations that form the output value factors for each impact topic can be viewed and understood in detail here.

    b. **Technical Manuals:** These documents provide a high-level description of the structure and functionality of each environmental impact valuation model.

    c. **Central Input Data Workbook:** Upon request, users can access a single Excel file of input data that links the models across all methodologies through PowerQuery.

5. These supplemental resources are provided for three main reasons:

a. *Transparency:* along with the methodology documents for each model, the models are made available so each step in the calculation pathway can be examined by interested users.

b. *Sensitivity analysis or bespoke analysis for decision making:* if users want to understand the sensitivity of the value factors to different parameters or data points in the models, then having the full models allows for this. If more geographically specific analysis of impacts under different scenarios is required for business decision making, then the models can be used as a basis for this.

c. *Creation of value factors for additional decision-making contexts:* value factors for all countries are provided in the GVFD but if users want to produce additional value factors for particular decision-making purposes, such as for more granular geographic locations, then the models and technical manuals are provided to allow this.

6. Review of the models and technical manuals should be done in coordination with the other resources available to ensure thorough understanding of the contents.

1.2 Model input data versus impact driver measurements

7. A distinction should be made between impact driver measurements of an entity (i.e. kg of each air pollutant) and input data used to create the value factors of the methodology. Companies using the GVFD and the Interim Air Pollution Methodology will need impact driver measurements (i.e.kg of each pollutant which they are responsible for using or converting), whereas the input data used in the GVFD is contained within the Model (the full list of input data is outlined in Appendix A). The relationship between these types of data is depicted in Figure 1.

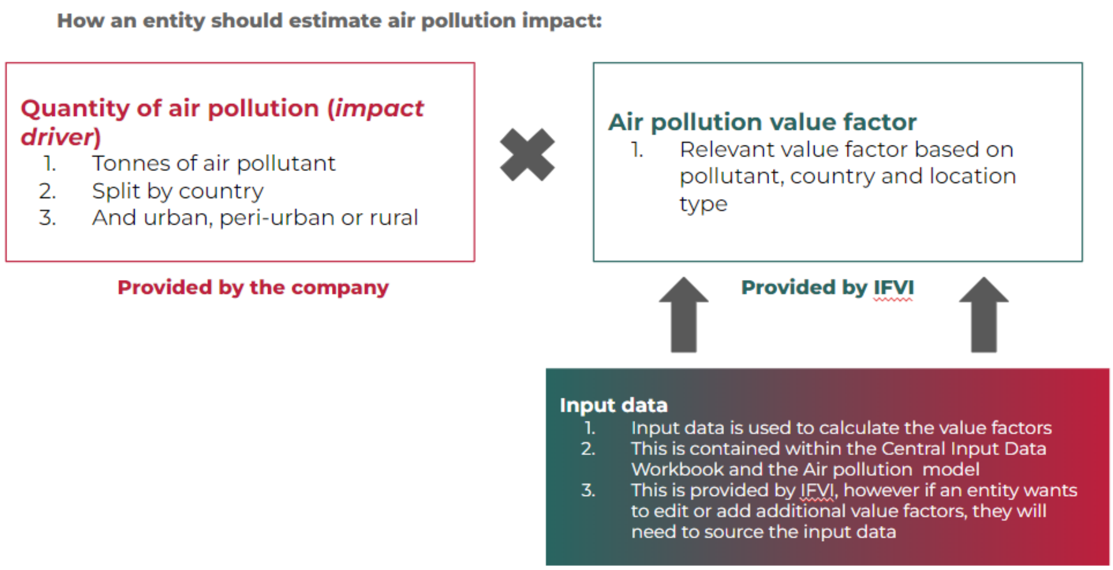

Figure 1: Difference between impact driver measurements and model input data

8. This manual focuses on model input data, rather than impact driver measurements. More detail on impact driver measurements is available in the Interim Air Pollution Methodology.

2 Model structure and functionality

2.1 High-level data architecture

9. There are three core elements to the data that informs each Interim Methodology: the Global Value Factors Database (GVFD), the models themselves, and the Central Input Data Workbook (CIDW). The models and the GVFD are both publicly available, while the Central Input Data Workbook is available upon request.

10. The Central Input Data Workbook is a central repository for all the input data sources used in all the models including the links to the sources, units and year. It also contains all key assumptions and parameters used in the models. Given the complexity of the data architecture and the importance of consistent and comparable applications of impact accounting this workbook is only available upon request.

11. The individual models then combine the relevant input data sources and calculate the value factors for each country and impact area.

12. The final value factors are then collated in the Global Value Factors Database. For most users looking to use the value factors to value environmental impacts, this will be the most important resource and can be used independently of the models and CIDW.

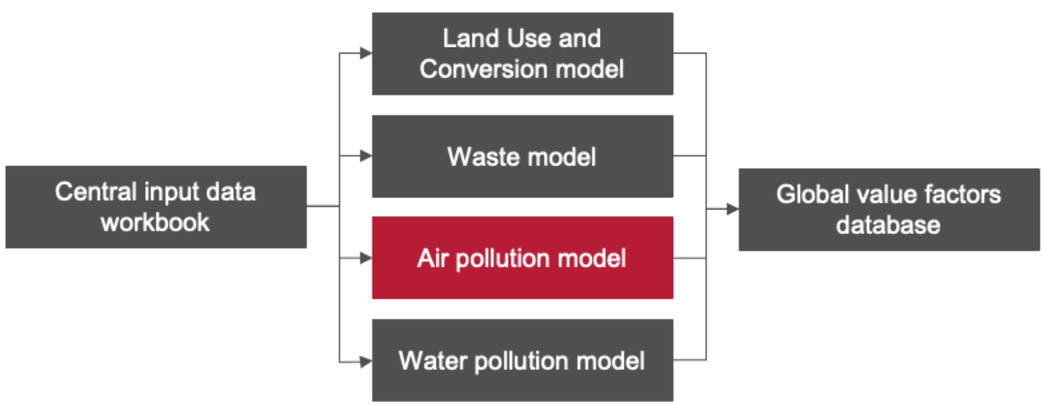

Figure 2: High-level diagram of the model architecture

2.2 Understanding and opening the Model

13. Each model contains a cover sheet that provides an overview of each tab and the appropriate way to navigate them.

14. The Model is organized, and color coded to indicate which sheets represent data inputs, calculations, or value factors. Any updates or changes to the underlying data within the

Model should be applied to the data inputs, which will then be carried through the calculation sheets to produce updated value factors.

15. Any modifications to these models may produce distinct value factors distinct from those produced by IFVI and should not be considered endorsed or approved by or a representation of the IFVI methodology.

16. When opening the Excel model for the first time, a banner may appear signifying the file is in protected view. Select 'Enable editing.' A 'Security Warning' banner may then appear as the file has external data connections. Select 'Enable Content.'

2.3 Model structure

17. The Interim Air Pollution Model is structured through three modules and seven supporting sheets:

    a. **Value Factors** displays the final value factors for the impact of Air Pollution

    b. **Module 1** calculates primary pollutant health impacts.

    c. **Module 2** calculates secondary pollutant health impacts, visibility and agriculture impacts.

    d. **Module 3** combines NOx impacts from primary and secondary pollutant impact calculations

    e. **Supporting sheets:** Several sheets are used for supporting data storage and calculation.

18. The main model calculations for each module are colored in dark green. Any supplementary model data/information are shown in the gray and lighter blue color. All input data tabs are colored in light red.

Value Factors

19. This section is comprised of one sheet that displays the final value factors for the Interim Air Pollution Model.

    a. **Sheet: Air Pollution Value Factors**
    This sheet provides the final value factors for the impact of air pollution. The value factors as presented are the same values in the Global Value Factors

Database, but if a user adjusts the data in the Model they may change and should not be considered endorsed or approved by or a representation of the IFVI methodology.

Module 1: Primary Health Impacts

20. The primary health module structure is shown in Figure 3 below.

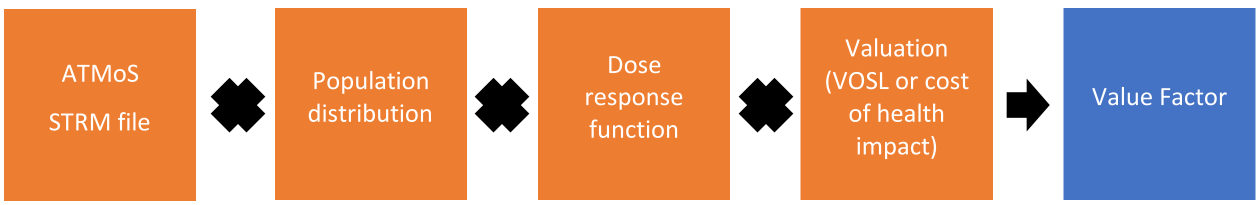

Figure 3: Module 1 structure

21. **Module 1** is comprised of seven sheets, which along with input data and other supporting sheets, calculate the primary health impact value factors:

    a. **Sheet: 1a. STRM Processing**
    This sheet consists of the macros to read and extract the ATMoS output files. The first macro is "Module1.SelectFolder" which allows the user to select the folder where the ATMoS outputs have been saved. The next macro "PrintSubFolders" reads the folders structure, note this must be named as "LOCATIONCODE_COUNTRY_CITY" (e.g. AUS_Australia_Canberra). The final macros is "RUNAirPolMatrixCalcs" which runs the matrix multiplication of the ATMoS output matrices and the emissions source vectors (see worksheet "Source vector"). These macro buttons have been removed for the external version of the Model, as they require ATMoS files to properly run.

    b. **Sheet: 1b. Pollution Dispersion Matrices**
    Contains the interim results of the macro. Each row represents one SRTM file (for a city / pollutant combination) multiplied by one pollutant source vector.

    c. **Sheet: 1c. Grid Population Distribution**
    Creates a gridded population distribution for each city, based on city type and country level inputs. The resulting grids are found in 1d. Custom population editor and 1e. Population grid output.

    d. **Sheet: 1d. Custom Population Editor**

This sheet shows the population distribution for each country, for an urban and rural type, in a visual manner, and through the population editor contains the potential to create custom population grids for cities where the population density is well understood.

e. **Sheet: 1e. Population Grid Output**
This sheet contains automatically generated population grids for each city separated by urban and rural city type. If a custom population grid was created in module 1.d, it will be used here instead of the urban grid.

f. **Sheet: 1f. Primary Health Impacts**
This sheet calculates the primary health impacts from air pollution. It takes the pollutant dispersion matrices (produced earlier by the macro), and overlays (multiplies) this with the population grid to estimate the number of people affected. This is then multiplied by effect/capita values for different pollutants to calculate the final primary health impact per pollutant.

g. **Sheet: 1g. Primary Health VFs**
This sheet pulls out country-level primary health impact coefficients. For transport, a weighted average of urban and rural transport city level coefficients is taken. Morbidity and Mortality impacts are then aggregated for city types and pollutants. Extreme values are addressed by population distribution statistics and data gaps are removed by regional averages.

Module 2: Secondary Health, Visibility and Agricultural Impacts

22. The secondary health, visibility and agriculture module structure is shown in Figure 4.

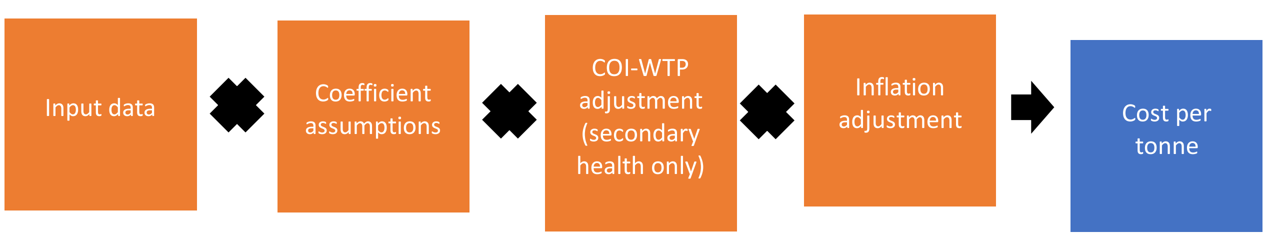

Figure 4: Module 2 structure

23. Secondary health, visibility and agriculture impacts are calculated in sub-module sections within a single sheet. Input data — a different combination of variables 1-6 for each impact — are applied to coefficient assumptions calculated from data provided by

Muller and Mendleson (2007)[1]. It multiplies the outcome of these calculations and applies an inflator to produce a cost per metric ton of pollutant in 2023 USD$. The secondary health impact calculation has an additional step applied alongside the inflator where the social costs from the Muller and Mendleson paper are adjusted from a cost of illness measurement (COI) to a willingness to pay measurement (WTP). This is done to align with the approach used in the primary health module (Module 1).

24. **Module 2** is comprised of three sheets, which along with input data and other supporting sheets, calculate a combined social cost per metric ton of pollutant. This cost is inclusive of the secondary health, visibility and agricultural impacts:

    a. **Sheet: 2a. Secondary Assumptions**
    This sheet contains the constants used through the module. The constants can be grouped in terms of the regression coefficients and the cost of illness to willingness to pay ratio.

    b. **Sheet: 2b. Secondary Impacts**
    This sheet calculates the secondary health, visibility and agricultural impacts from air pollution. Each sub-module takes input data, a combination of variables 1-6, and applies coefficient assumptions. It also calculates a coefficient. It multiplies the outcome of these calculations and applies an inflator in order to produce a cost per metric ton of pollutant.

    c. **Sheet: 2c. Secondary VFs**

    This sheet uses a regional average approach to fill gaps in secondary pollutant health impacts, visibility and agriculture impacts. Where a regional average approach is not possible, income-based averages are calculated as a secondary approach to fill data gaps. To avoid over-weighting US coefficients within the North American region, US State data has been removed from regional and income-based average calculations. There are no gaps in US State coefficients, however, they are included in the final summary table at the end of this sheet to provide a complete table of coefficients.

Module 3: output value factors

a. **Sheet: 3a. NOx VFs**

[1] Muller and Mendleson (2007)

This module consists of one sheet which sums the primary and secondary pollutant health associated with NOx.

25. There are six supporting calculations sheets within the Model, these contain:

    a. **Sheet: Air Pollution General Data**: This sheet refers to general data at the country level relevant to the Interim Air Pollution Model.

    b. **Sheet: Assumptions and Parameters**: This sheet details basic assumptions and parameters used throughout the Interim Air Pollution Model.

    c. **Sheet: i. Population Data Processing**: This sheet prepares country population data for model calculations.

    d. **Sheet: ii. Emissions Grids Setup**: This sheet prepares pollution emission grids. These grids represent how pollutants are emitted in different environments and are later multiplied with the SRTM files to give final pollutant distributions.

3 Adapting the Models for Bespoke Analysis

3.1 Updates to input data, assumptions, and parameters

26. The intent of the impact accounting methodology is to provide consistent and comparable impact accounting methodologies that can be applied across entities. As such, the methodologies are intended to be used as is. IFVI will update the input data variables, assumptions, and parameters as necessary and on a regular basis, without the need for model users to make their own updates.

27. However, if any sensitivity or bespoke analysis is desired, the input data can be updated in the models.

28. Should an entity wish to add new countries, regions or geographical areas specifically to the Interim Air Pollution Model, this can be done by amending the Air Pollution General Data Sheet and the Central Inputs Data Workbook.

29. There are 66 different input data points that make up the variables in the Model. Data will need to be gathered for all variables for each country, region or geographical area to be added.

30. The ATMOs model may need to be run in order to generate additional VFs related to human health.

31. A full list of the data points are listed in Appendix A.

32. Some data inputs to the models apply across multiple models or may only exist in the Central Input Data Workbook. For users wishing to conduct bespoke analysis across multiple models with consistent and efficient data, this can be done by making adjustments to the underlying Central Input Data Workbook. This workbook and a set of models that are directly linked to it via PowerQuery are available upon request.

Appendix A: Full List of Input Data

Data point	Unit
Population	Number
Population density	People / miles2
Rural population	%
GNI PPP per capita	2021 international dollars
GNI PPP per capita relative to USA	2021 GNI PPP index relative to USD
GNI PPP	2021 international dollars
Land area	Km2
Urban land area	Km2
Population concentration	% of people in cities over 1 million
Urbanization	% living in cities
Median income	2022 USD$
Mortality	Deaths per 1000
Oxygen	PPM
Average high temperature	Fahrenheit
Annual rainfall	Inches
Capital city population	Number
Rural land	Km2
Urban population split	%
Rural population split	%
City population density	People / km2

Bibliography

Muller N.Z. and Mendelssohn, R., (2007). Measuring the Damages of Air Pollution in the United States. Journal of Environmental Economics and Management, Vol. 54 (1), pp. 1-14.

Please note: this bibliography only refers to sources referenced in this user guide. For a bibliography that includes the theoretical and empirical basis of the Methodology, please refer to the separate methodology document.

INTERIM METHODOLOGY

Land Use and Conversion Model

Technical Manual

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2.3 MODEL STRUCTURE 1

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3.1 UPDATES TO INPUT DATA, ASSUMPTIONS, AND PARAMETERS 0

APPENDIX A: FULL LIST OF INPUT DATA 1

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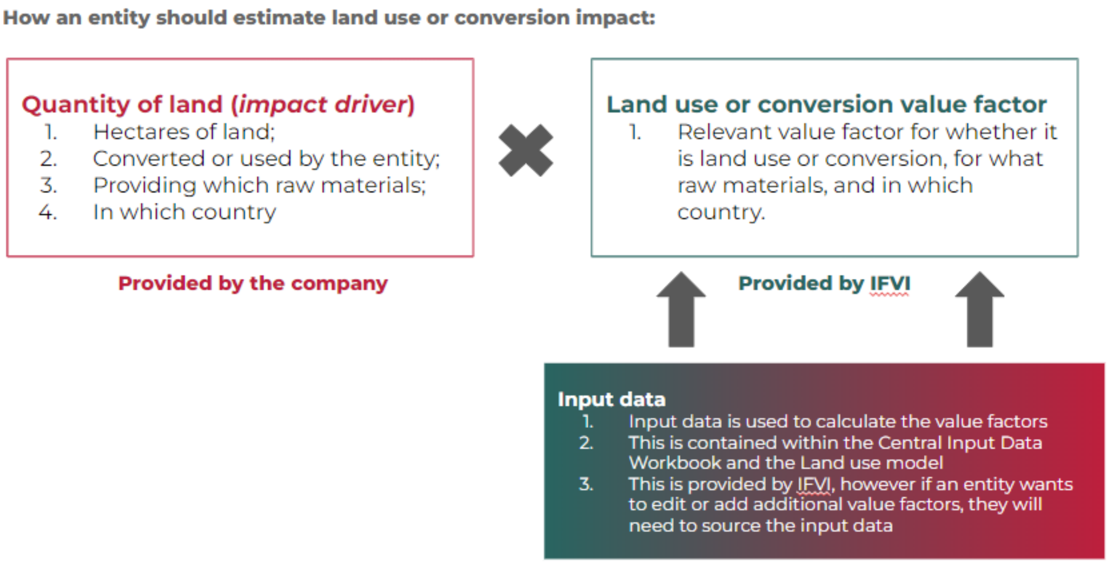

Figure 1: Difference between impact driver measurements and model input data

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2 Model Structure and Functionality

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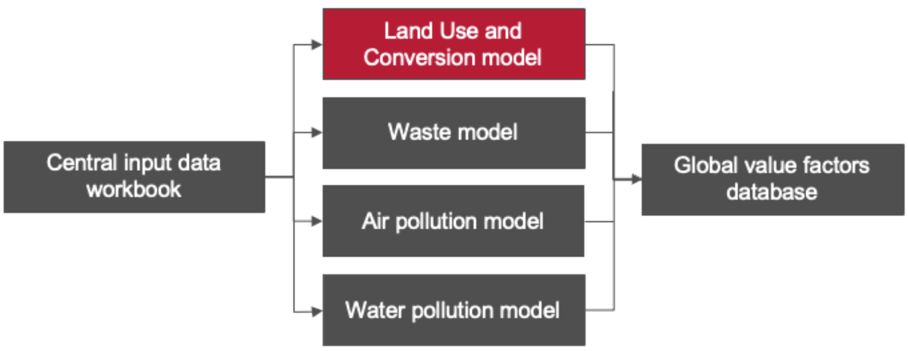

Figure 2: High-level diagram of the model architecture

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13. Each model contains a cover sheet that provides an overview of each tab and the appropriate way to navigate them.

14. The Model is organized, and color coded to indicate which sheets represent data inputs, calculations, or value factors. Any updates or changes to the underlying data within the Model should be applied to the data inputs, which will then be carried through the calculation sheets to produce updated value factors.

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2.3 Model structure

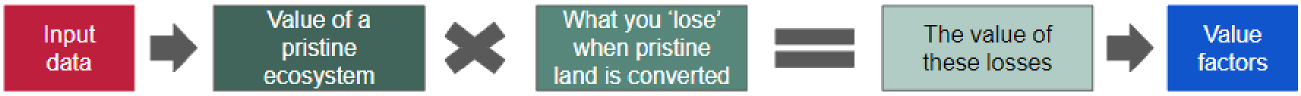

Figure 3: Land use model structure

17. The Interim Land Use Model follows the format of Figure 3.

18. The paragraphs below provide an overview of the functionality of each sheet in the Model. The sheets colored in dark green are calculating the value of a pristine or natural ecosystem. The medium green sheets then calculate what is 'lost' when a pristine land is converted into managed land. The light green sheets calculate the percentage loses when this land is converted and then multiplies this by the value of a pristine ecosystem to get the value of the lost ecosystem.

    a) **Sheet: 1a. ESVD Cleaned**

    This sheet gets the average ecosystem service value per ESVD biome from the ESVD studies and maps it onto the biome list used in the model by weighting the values by number of studies.

    b) **Sheet: 1b. Rescaling**

    This sheet calculates an adjustment factor based on country population density and rural population, applied to ESVD studies to reflect countries that have higher population density or more rural communities value ecosystem services higher. To ensure scaling factors are all positive (e.g., Greenland), bounds can be set in depending on how the user would like the scope of the distribution to fall.

c) **Sheet: 1c. Pristine ES Value**
This sheet calculates the value of each ecosystem services for a hectare of pristine land in each country. Where ecosystem services are local, the raw ESVD pristine values are multiplied by the adjustment factor for each country. Where global, the average value is taken as is.

d) **Sheet: 1d. ES Recalibration**
This sheet applies the actual GIS biome split to countries ES value (i.e. if 0% of country X is Tropical Forest, 0% of ESVD Tropical Forests value is applied), and then, as the average ESVD value per biome has been affected by the adjustment factor and biome split, values are recalibrated to ensure the average ES value for each biome is in line with ESVD original values.

e) **Sheet: 2a. Country Climate**
This sheet uses Koppen-Geiger climate zone input data to determine the dominant climate zone in each country, which are then used to estimate pristine biomass and species in the following sheets.

f) **Sheet: 2b. Biomass**
This sheet takes the biomass lost with changes from pristine land to converted land per climate zone and applies the results to individual countries.

g) **Sheet: 2c. Species**
This sheet takes plant species data for each climate zone for pristine and converted lands, which is used to estimate the species loss associated with change from pristine land to converted land.

h) **Sheet: 2d. SOC**
This sheet calculates the percentage of soil organic carbon (SOC) remaining per biome and country based on each land use change. The sheet uses International Panel on Climate Change soil organic carbon (SOC) factors.

i) **Sheet 3b. Loss Combinations**
This sheet calculates the percentage loss of biomass, species and SOC, based on the loss combinations assigned to the land use types in the assumptions input.

j) **Sheet 3b. Valued Loss**
This sheet combines the percentage losses with the pristine ecosystem services values to get the US$ values of lost ecosystem services.

k) **Sheet: 4a. Interim Land Use Calculations**

This sheet adds ecosystem services losses per "pristine biome type -> converted land type" combination. This is then multiplied by the actual biome % in that country (e.g. if country X has 0% tropical forests, the resulting "tropical forest -> wheat" loss value is $0). Regional averages are calculated to gap fill where data is missing.

l) **Sheet: Interim Land Conversion Calculations**
This sheet uses a macro to populate the Land Conversion Value Factors tab. The land use value factors for each land type are multiplied by 2 to obtain the marginal value per hectare of land, projected over 100 years and discounted at 2% p.a. to a net present value. This represents the present value of 100 years of lost ecosystem service value.

m) **Sheet: Land Use Value Factors**

a) This sheet provides the final value factors for the impact of land use. These value factors are the same values in the Global Value Factors Database. The sheet divides the valued losses by 2 to account for the marginal versus average effect of land use changes. Where country values are missing, regional averages are used. The value factors as presented are the same values in the Global Value Factors Database, but if a user adjusts the data in the model they may change and should not be considered endorsed or approved by or a representation of the IFVI methodology.

n) **Sheet: Land Conversion Value Factors**

b) This sheet provides the final value factors for the land conversion pathway. The value factors as presented are the same values in the Global Value Factors Database, but if a user adjusts the data in the model they may change and should not be considered endorsed or approved by or a representation of the IFVI methodology. This sheet compiles the final conversion value factors from the macro.

o) **Input Data Sheets**

- **Sheet: Land Use General Data**: This sheet refers to general data at the country level relevant to the land use model.
- **Sheet: Ecosystem Service Valuation Database (ESVD) Averages**: This sheet represents the ecosystem service values (in 2020 USD) downloaded from the ESVD on July 3, 2024.
- **ESVD Mappings**: This sheet converts biome classifications used in the ESVD to biomes used in the model. It also classifies all ecosystem services into categories and areas affected.

- **Species and Richness**: This sheet provides the number of species and species richness across biomes and land use types.

- **Biomass**: This sheet provides biomass data across biomes and land use types.

- **Forest Aboveground Biomass**: This sheet consolidates forest aboveground biomass data from the Biomass sheet.

- **Soil Organic Carbon**: This sheet provides soil organic carbon (SOC) change factors across biomes and land use types.

- **SOC Factors**: This sheet represents the factor selection for the IPCC SOC factors. The SOC methodology calculates the change in SOC based on land use, management and input practices as well as the climate. This sheet shows which factors should be used for reach land use by weighting them.

- **Country Biomes**: This sheet estimates the proportion of each country classified as each biome type.

- **Climate Classifications**: This sheet estimates the proportion of each country in each Koppen-Geiger Climate Classification zone.

- **Countries & Annual Growth**: This sheet classifies each country to the associated region based on World Bank classifications. Additionally, it estimates the annual growth rate from 2005 – 2022 from the OECD.

- **Assumptions and Mapping**: This sheet details basic assumptions used in the model along with mappings of land use, climate, and biomes.

3 Adapting the models for bespoke analysis

3.1 Updates to input data, assumptions, and parameters

19. The intent of the impact accounting methodology is to provide consistent and comparable impact accounting methodologies that can be applied across entities. As such, the methodologies are intended to be used as is. IFVI will update the input data variables, assumptions, and parameters as necessary and on a regular basis, without the need for model users to make their own updates.

20. However, if any sensitivity or bespoke analysis is desired, the input data can be updated in the models.

21. If the input data is changed by the model user, the land conversion value factors will need to be re-run. This will not happen automatically in the model and the Excel macro will need to be manually run by the user.

22. Should an entity wish to add new countries, regions or geographical areas specifically to the Interim Land Use Model, this can be done by amending the Land Use General Data, Country Biomes, and Climate Classifications sheets.

23. This will involve collecting the following data:

    a) Percentage split between WWF Wildfinder biomes

    b) Percentage split between Koppen-Geiger climate zones

    c) Population

    d) Population density

    e) Rural population

    f) Purchasing power per capita

    g) Land area

    h) Above-ground forest biomass

24. A full list of the data points are listed in Appendix A.

25. Some data inputs to the models apply across multiple models. For users wishing to conduct bespoke analysis across multiple models with consistent and efficient data, this can be done by making adjustments to the underlying Central Input Data Workbook. This workbook and a set of models that are directly linked to it via PowerQuery are made available upon request.

Appendix A: Full List of Input Data

Country variable data:

Data point, per country / region / geographic area	Unit
Split between WWF Wildfinder biomes	%
Split between Koppen-Geiger climate zones	%
Population	Number
Population density	Population / land area
Rural population	%
Purchasing power per capita	2023 US$
Land area	Km2
Above-ground forest biomass	Metric tons / hectare

Global data points:

Data point	Unit
Average plant species per pristine biome	Number / hectare
Average biomass per pristine biome	Metric tons / hectare
Average plant species per managed land	Number / hectare
Average biomass per managed land	Metric tons / hectare
Soil organic carbon change factors	%

Bibliography

Greenhouse Gas Protocol (2022) Land Sector and Removals Guidance Part 2: Calculation Guidance, Supplement to the GHG Protocol Corporate Standard and Scope 3 Standard.

IPCC (2019) IPCC National Greenhouse Gas Inventories Program, Good practice guidance for Land-Use, Land-Use Change and Forestry.

Please note: this bibliography only refers to sources referenced in this user guide. For a bibliography that includes the theoretical and empirical basis of the methodology, please refer to the separate methodology document.

INTERIM METHODOLOGY

Waste Model

Technical Manual

The International Foundation for Valuing Impacts, Inc. (IFVI) is a section 501(c)(3) public charity dedicated to building and scaling the practice of impact accounting to promote decision-making based on risk, return, and impact.

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1 Introduction

1.1 Document purpose

1. This document is the Interim Waste Model Technical Manual, which provides a description of the Interim Waste Model's structure and functionality, input data, and assumptions. It aims to help readers better understand and expand the model that informs the Interim Waste Methodology. The Model Technical Manuals aim to improve transparency and confidence in the Global Value Factors Database (GVFD), and support companies' use of the GVFD for decision-making and sensitivity analysis.

2. The Interim Waste Methodology is part of a series of four interim environmental methodologies released by IFVI, as complements to the impact accounting methodologies produced by IFVI in partnership with the Value Balancing Alliance. All four methodologies are designed with similar structures and resources, outlined below.

3. For general implementation and understanding of the Interim Methodologies, the following primary resources should be utilized:

    a) **Global Value Factors Database:** An Excel file compilation of all value factors of all methodologies. Companies should use the outputs shown here in estimating their impact values.

    b) **Methodologies:** These documents describe the Methodology of each environmental impact topic, including key assumptions and conceptual underpinnings and the data requirements of entities in using them.

4. These resources are underpinned by supplemental resources, including the following:

    a) **Models:** Excel files for each methodology. All calculations that form the output value factors for each impact topic can be viewed and understood in detail here.

    b) **Technical Manuals:** These documents provide a high-level description of the structure and functionality of each environmental impact valuation model.

    c) **Central Input Data Workbook:** Upon request, users can access a single Excel file of input data that links the models across all methodologies through PowerQuery.

5. These supplemental resources are provided for three main reasons:

    a) *Transparency:* along with the methodology documents for each model, the models are made available so each step in the calculation pathway can be examined by interested users.

b) *Sensitivity analysis or bespoke analysis for decision making:* if users want to understand the sensitivity of the value factors to different parameters or data points in the models, then having the full models allows for this. If more geographically specific analysis of impacts under different scenarios is required for business decision making, then the models can be used as a basis for this.

c) *Creation of value factors for additional decision-making contexts:* value factors for all countries are provided in the GVFD but if users want to produce additional value factors for particular decision-making purposes, such as for more granular geographic locations, then the models and technical manuals are provided to allow this.

6. Review of the models and technical manuals should be done in coordination with the other resources available to ensure thorough understanding of the contents.

1.2 Model input data versus impact driver measurements

7. A distinction should be made between impact driver measurements of an entity (i.e. metric tons of waste) and input data used to create the value factors of the Methodology. Companies using the GVFD and the Interim Waste Methodology will need impact driver measurements (i.e. the metric tons of waste for which they are responsible), whereas the input data used in the GVFD is contained within the Model (the full list of input data is outlined in Appendix A). The relationship between these types of data is depicted in Figure 1.

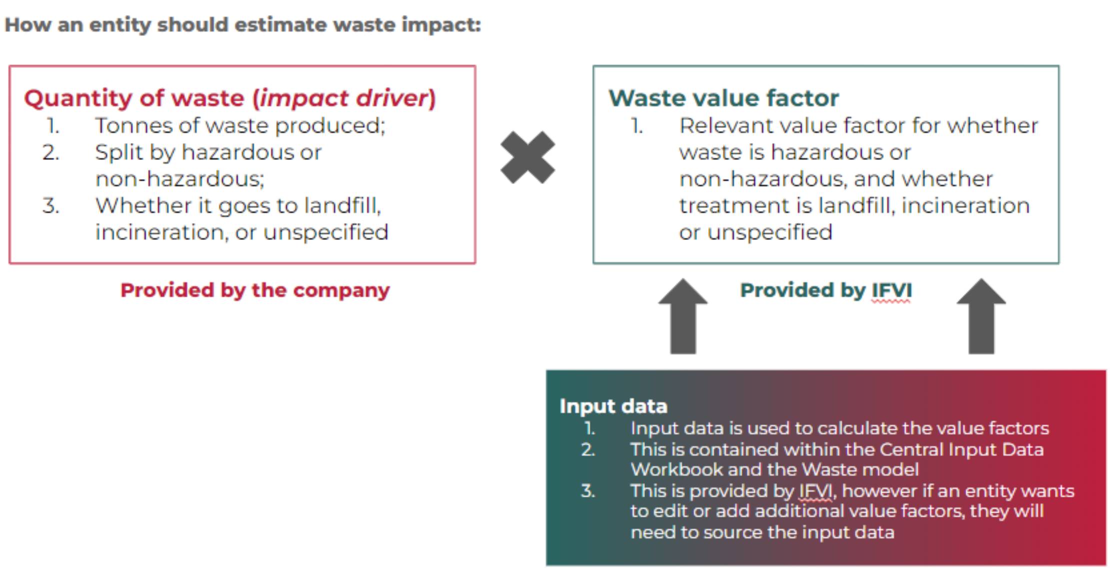

Figure 1: Difference between impact driver measurements and model input data

8. This manual focuses on model input data, rather than impact driver measurements. More detail on impact driver measurements is available in the Interim Waste Methodology.

2 Model Structure and Functionality

2.1 High-level data architecture

9. There are three core elements to the data that informs each Interim Methodology: the Global Value Factors Database (GVFD), the models themselves, and the Central Input Data Workbook (CIDW). The models and the Global Value Factors Database are both publicly available, while the Central Input Data Workbook is available upon request.

10. The Central Input Data Workbook is a central repository for all the input data sources used in all models including the links to the sources, units and year. It also contains all key assumptions and parameters used in the models. Given the complexity of the data architecture and the importance of consistent and comparable applications of impact accounting, this workbook is only available upon request.

11. The individual models then combine the relevant input data sources and calculate the value factors for each country and impact area.

12. The final value factors are then collated in the Global Value Factors Database. For most users looking to use the value factors to value environmental impacts, this will be the most important resource and can be used independently of the models and CIDW.

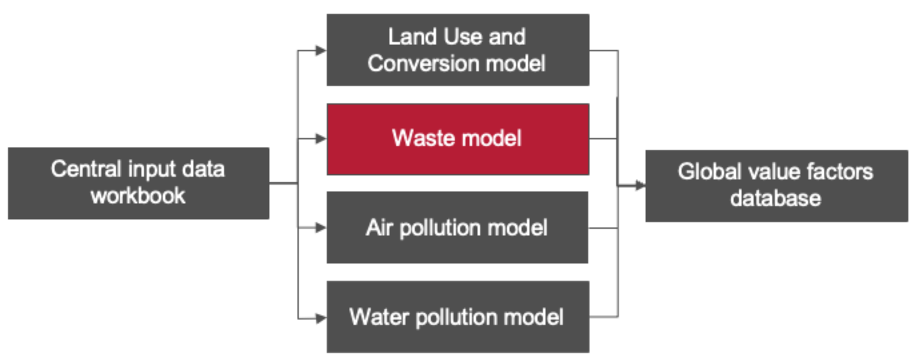

Figure 2: high-level diagram of the model architecture

2.2 Understanding and opening the model

13. Each model contains a cover sheet that provides an overview of each tab and the appropriate way to navigate them.

14. The model is organized, and color coded to indicate which sheets represent data inputs, calculations, or value factors. Any updates or changes to the underlying data within the

model should be applied to the data inputs, which will then be carried through the calculation sheets to produce updated value factors.

15. Any modifications to these models may produce distinct value factors distinct from those produced by IFVI and should not be considered endorsed or approved by or a representation of the IFVI methodology.

16. When opening the Excel model for the first time, a banner may appear signifying the file is in protected view. Select 'Enable editing.' A Security Warning' banner may then appear as the file has external data connections. Select 'Enable Content.'

2.3 Model structure

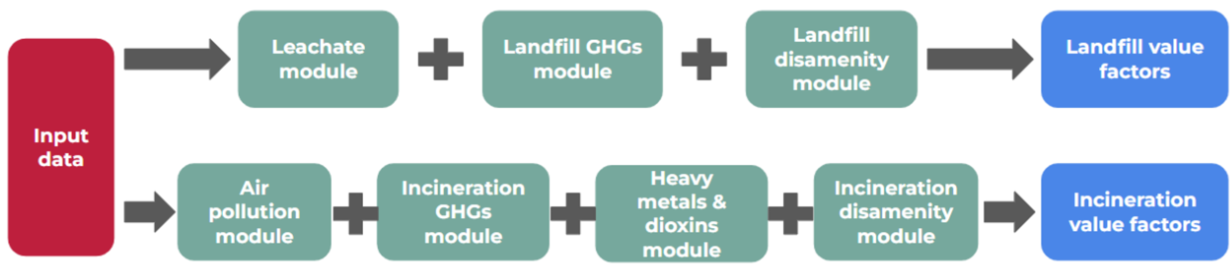

Figure 3: Interim Waste Model Structure

17. The Model is made up of seven modules (which form the calculations for four impact pathways outlined in the Methodology). Three of these modules form the landfill value factors and four form the incineration value factors. This is illustrated in Figure 3. Note that in the Interim Waste Model, disamenity impact is calculated for both landfill and incineration in one sheet, hence why there are only six sheets described below.

18. The main model calculations for each module are colored in dark green. Any supplementary models or calculations are shown in the lighter green color. The module that they relate to is given by the module number.

    a) **Sheet: 1. Leachate**
    The Leachate module calculates value factors of leachate from landfills for hazardous and non-hazardous waste. HARAs scores are used to assign likelihood of impact based on soil permeability, population density and % of lined landfills within the country. ERQ scores are used as proxy where % of lined landfills is not known.

    b) **Sheet: 2. Air Pollution**
    The air pollution module calculates value factors for NOx, SOx, PM10 and PM2.5

from waste incineration. Avoided emissions from energy recovery within countries is removed from the gross emissions of the pollutants.

c) **Sheet: 3. Heavy Metals & Dioxins**

The heavy metals & dioxins module values health impacts from incineration. Dioxin impacts are valued through cost of fatal (VSL) and non-fatal (WTP) cancers. Cost of lead and mercury are valued through lost IQ (WTP).

d) **Sheet: 4. Disamenity**

The disamenity module values impacts of living near a landfill or incineration site. Discounted waste flows from both sites are calculated in the LF DWF and IN DWF tabs and combined with country housing factors to value disamenity impact.

e) **Sheet: 4a. LF DWF**

This sheet shows the landfill discounted waste flow. The calculations discount waste flow from landfills over their remaining lifetime. This feeds into the disamenity module.

f) **Sheet: 4b. IN DWF**
This sheet shows the Incineration discounted waste flow. The calculations discount waste flow from incinerators over their remaining lifetime. This feeds into the disamenity module.

g) **Sheet: 4c. Hedonic Pricing**
This sheet shows the calculations that form the hedonic pricing transfer function that forms part of the final disamenity calculations.

h) **Sheet: 5. Landfill GHGs**
This sheet shows the outputs of the IPCC Landfill Greenhouse Gas model. Users can change the type of waste being sent to landfill under the Waste Type Input drop down. Clicking 'Update coefficients' runs a macro for the IPCC model for all countries. Hazardous and non-hazardous coefficients are shown.

i) **Sheet: 5a. IPCC Model**
Forms the calculations for the landfill GHGs module. Uses IPCC Model to determine methane generation rates, which are then transformed to carbon and valued with the social cost of carbon.

j) **Sheet: 6. Incineration GHGs**

The incineration GHGs module values greenhouse gas impacts from incineration. Avoided emissions from energy recovery are removed from the gross emissions emitted.

k) **Sheet: 7. Interim Value Factors**
These interim coefficients combine all value factors in the model for the modified list of countries. Regional and income averages are calculated and used to gap-fill for all other countries where primary data is not available

l) **Sheet: Waste Value Factors**
Final value factors (VFs) for the solid waste impact pathways. The value factors as presented are the same values in the Global Value Factors Database, but if a user adjusts the data in the model they may change and should not be considered endorsed or approved by or a representation of the IFVI methodology.

m) **Input Data Sheets**

- **Waste Assumptions Sheet**: contains all assumptions for the Waste model.
- **Waste Data Sheet**: contains all country-specific data for the Waste model.
- **Country Mappings**: contains the modified country list that is used in the waste model.
- **Inflation Calculations**: Inflation data used to convert all values to 2023 USD.
- **Waste HARAS ERQ**: contains HARAS and ERQ data that is used in the leachate module.
- **Waste MGR**: contains IPCC Methane Generation data that forms the IPCC model in the Landfill GHG module.

3 Adapting the models for bespoke analysis

3.1 Updates to input data, assumptions, and parameters

19. The intent of the impact accounting methodology is to provide consistent and comparable impact accounting methodologies that can be applied across entities. As such, the methodologies are intended to be used as is. IFVI will update the input data variables, assumptions, and parameters as necessary and on a regular basis, without the need for model users to make their own updates.

20. However, if any sensitivity or bespoke analysis is desired, the input data can be updated in the Models.

21. If the input data is changed by the model user, the landfill GHGs module will need to be re-run. This will not happen automatically in the model and the Excel macro will need to be manually run by the user.

22. Should an entity wish to add new countries, regions or geographical areas specifically to the Interim Waste Model, this can be done by amending the Waste Data Sheet in the model.

23. There are 32 different data points that make up the variables in the Interim Waste Model. Data will need to be gathered for all 32 for each specific country, region or geographical area that is being added.

24. A full list of the data points are listed in Appendix A.

25. Some data inputs to the models apply across multiple models. For users wishing to conduct bespoke analysis across multiple models with consistent and efficient data, this can be done by making adjustments to the underlying Central Input Data Workbook. This workbook and a set of models that are directly linked to it via PowerQuery are available upon request.

Appendix A: Full List of Input Data

Data point per country / region / geographic area	Unit
ERQ score	Number
SOx intensity of national grid	Metric tons / kwh
NOx intensity of national grid	Metric tons / kwh
PM2.5 intensity of national grid	Metric tons / kwh
PM10 intensity of national grid	Metric tons / kwh
Average CO2e grid factor	Metric tons / kwh
Household size	People / house
Total waste generated	Metric tons
Landfill waste flow	%
Total landfill waste	Metric tons
Incineration waste flow	%
Total incineration waste flow	Metric tons
Number of landfills	Number
Number of incineration plants	Number
Incineration with energy recovery	%
Lined landfills	%
Waste collection	%
Average property price	2023 USD
Fraction of methane captured from landfill - Hazardous	%
Fraction of methane captured from landfill – Non-hazardous	%

Fraction of methane captured, then burned - Hazardous	%
Fraction of methane captured, then burned – Non-hazardous	%
GNI PPP per capita	2023 USD
Soil permeability	Classification below
Climate zone	Temperate Wet, Temperate Dry, Tropical Wet or Tropical Dry
Population density	People / km2
Hazardous waste incinerated	Metric tons
Non-hazardous waste incinerated	Metric tons
NOx Value Factor	2023 USD, from Air Pollution model
SOx Value Factor	2023 USD, from Air Pollution model
PM2.5 Value Factor	2023 USD, from Air Pollution model
PM10 Value Factor	2023 USD, from Air Pollution model

Soil permeability ranking:

Soil permeability is used as an indicator of how readily leachate will infiltrate water and soil systems. The Model uses country permeability rankings from Gleeson et al (2011). To assign countries a score of Best, Medium and Worst, these definitions are used:

- Best: 10(-15) to 10(-17) logk m2
- Medium: 10(-12) to 10(-15) logk m2
- Worst: 10(-10) to 10(-12) logk m2

Where no data is available, we assume medium case. Should an entity wish to update the soil permeability or add a new country / region / geographic area, these definitions should be used.

Bibliography

Gleeson, T. et al (2011), Mapping Permeability over the Surface of the Earth, Geophysical Research Letters, Vol.38(2), pp.1-6

Please note: This bibliography only refers to sources referenced in this user guide. For a bibliography that includes the theoretical and empirical basis of the methodology, please refer to the separate methodology document.

INTERIM METHODOLOGY

Water Pollution Model

Technical Manual

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1 Introduction

1.1 Document purpose

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2. The Interim Water Pollution Topic Methodology is part of a series of four interim environmental methodologies released by IFVI, as complements to the impact accounting methodologies produced by IFVI in partnership with the Value Balancing Alliance. All four methodologies are designed with similar structures and resources, outlined below.

3. For general implementation and understanding of the Interim Methodologies, the following primary resources should be utilized:

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4. These resources are underpinned by supplemental resources, including the following:

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1.2 Model input data versus impact driver measurements

7. A distinction should be made between impact driver measurements of an entity (i.e. kg of each pollutant released to water) and input data used to create the value factors of the methodology. Companies using the GVFD and the Interim Water Pollution Methodology will need impact driver measurements (i.e. kg of each pollutant for which they are responsible), whereas the input data used in the GVFD is contained within the Interim Water Pollution Model (the full list of input data is outlined in Appendix A). The relationship between these types of data is depicted in Figure 1.

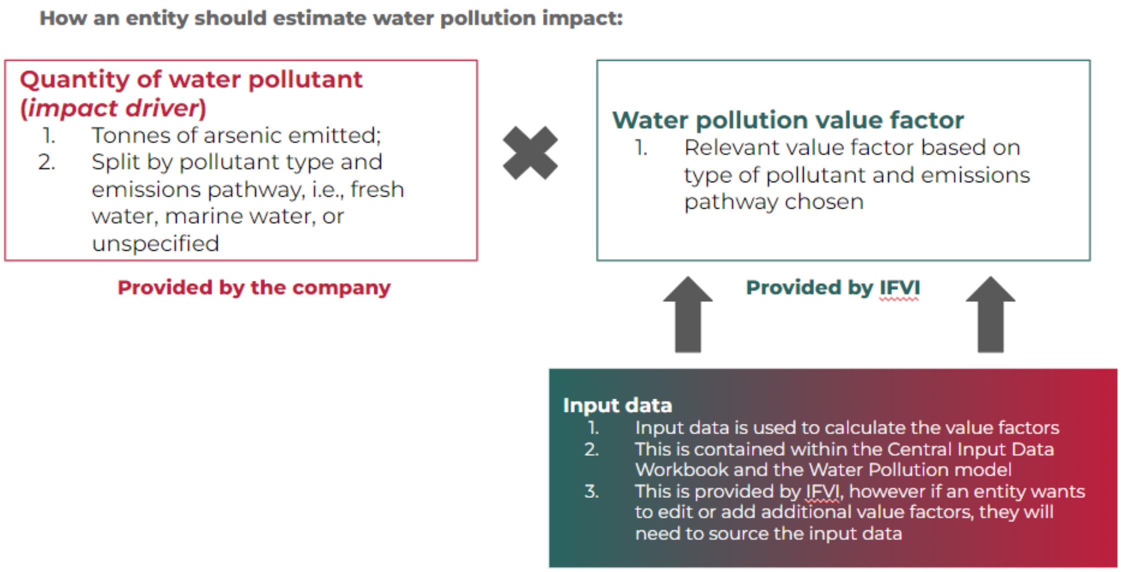

Figure 1: Difference between impact driver measurements and model input data

8. This manual focuses on model input data, rather than impact driver measurements. More detail on impact driver measurements is available in the Interim Water Pollution Methodology.

2 Model Structure and Functionality

2.1 High-level data architecture

9. There are three core elements to the data that informs each Interim Methodology: the Global Value Factors Database (GVFD), the models themselves, and the Central Input Data Workbook (CIDW). The models and the Global Value Factors Database are both publicly available, while the Central Input Data Workbook is available upon request.

10. The Central Input Data Workbook is a central repository for all the input data sources used in all the models including the links to the sources, units and year. It also contains all key assumptions and parameters used in the models. Given the complexity of the data architecture and the importance of consistent and comparable applications of impact accounting this workbook is only available upon request.

11. The individual models then combine the relevant input data sources and calculate the value factors for each country and impact area.

12. The final value factors are then collated in the Global Value Factors Database. For most users looking to use the value factors to value environmental impacts, this will be the most important resource and can be used independently of the models and CIDW.

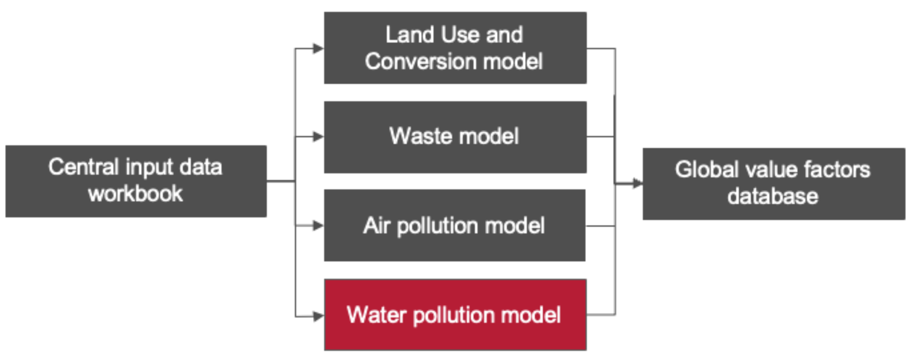

Figure 2: high-level diagram of the model architecture

2.2 Understanding and opening the Model

13. The Model is split into two files, one containing the data for health impacts and the other containing the data for eutrophication. Each contains a cover sheet that provides an overview of each tab and the appropriate way to navigate them.

14. The Model is organized, and color coded to indicate which sheets represent data inputs, calculations, or value factors. Any updates or changes to the underlying data within the Model should be applied to the data inputs, which will then be carried through the calculation sheets to produce updated value factors.

15. Any modifications to these models may produce value factors distinct from those produced by IFVI and should not be considered endorsed or approved by or a representation of the IFVI methodology.

16. When opening the Excel model for the first time, a banner may appear signifying the file is in protected view. Select 'Enable editing'. A 'Security Warning' banner may then appear as the file has external data connections. Select 'Enable Content.'

2.3 Model structure

17. The Water Pollution Model is made up of 2 modules contained in separate files: the Eutrophication module and Health module. The Eutrophication module structure is illustrated in Figure 3.

Figure 3: Eutrophication module structure

18. The Eutrophication Model calculates the Eutrophication potential for one kg of phosphorus (P) released into fresh water and 1 kg each of phosphorous (P) and nitrogen (N) released into marine water.

19. The valuation method measures the economic cost that people are willing to incur (in other words, willingness to pay) to avoid the negative impacts of eutrophication associated with each kilogram of P and N emitted into water.

20. The paragraphs below provide an overview the functionality of each sheet in the Model. The main model calculations for the Eutrophication module are colored in dark green. Any supplementary model data/information are shown in the gray and lighter blue color. All input data tabs are colored in light red.

a) **Eutrophication General Data**
This sheet stores all the data used in the Eutrophication Model. It is linked via formulas to the Water Pollution General data.

b) **Eutrophication Assumptions and Parameters**
This sheet details all assumptions and parameters used in the Eutrophication Model.

c) **Water Pollution Assumptions and Parameters**
This sheet provides additional assumptions and parameters, including assumptions related to USEtox and GLOBACK.

d) **Water Pollution General Data**
This sheet acts as an intermediary between the Central Input Data Workbook and the Eutrophication General Data Sheet, which compiles all data used in the Eutrophication Model.

e) **Coastal Population Information**
This sheet provides additional information for determining coastal population percentages required within the Eutrophication General Data Sheet.

f) **Calculations**
This sheet calculates the Valuation Factors using the WTP values (adjusted to 2023$) for P in Fresh Water and P and N in Marine Water, the Relative Characterization Factors and Relative GNI PPP.

g) **Value Factors Pre-Gap Filling**
This sheet calculates final country-specific and regionally-averaged value factors for the combined impact to Recreation, Property values, and fish stock. Regional averages are filled in where countries are missing data within the sheet called 'Water Pollution Eutrophication Value Factors.'

h) **Water Pollution Eutrophication Value Factors**
This sheet compiles final gap-filled value factors for the combined impact to recreation, property values, and fish stock. The value factors as presented are the same values in the Global Value Factors Database, but if a user adjusts the data in the Model they may change and should not be considered endorsed or approved by or a representation of the IFVI methodology.

21. The Health module structure is shown in Figure 4 below.

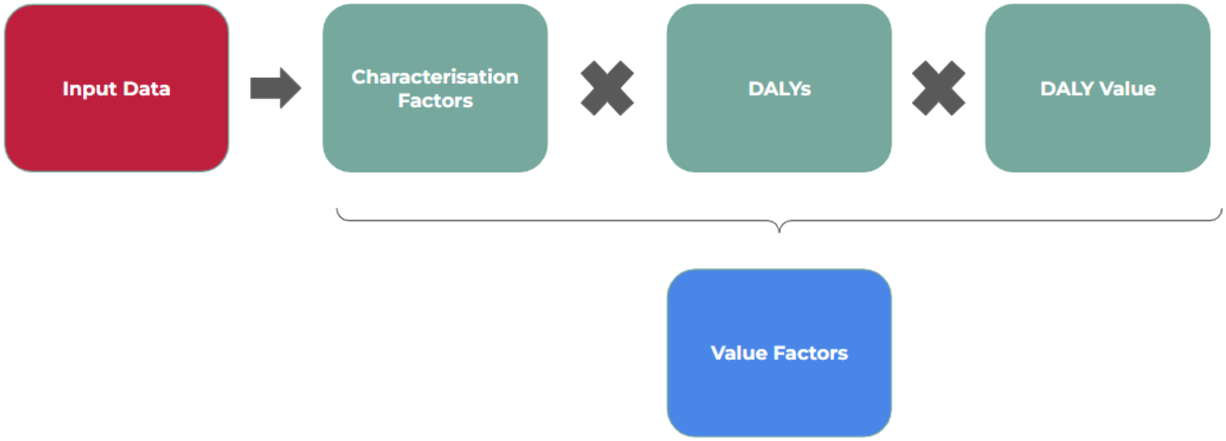

Figure 4: Health module structure

22. To estimate the societal impact of toxic pollutants on human health, the Interim Water Pollution Model identifies specific pollutants that cause health issues, such as heavy metals, pesticides, and industrial chemicals. Next, the incidence of health conditions attributable to these pollutants, including cancer, neurological disorders, and respiratory issues, is estimated. The output of this model is the pollutant-specific '**characterizations factor'** which gives the number of health harms per unit of pollutant emitted. The preferred model for the calculation of characterization factors is **USEtox (Rosenbaum et al, 2008)**. It was specifically designed to determine the fate, exposure, and effects of toxic substances.

23. Health cases per kg of pollutant emitted are then multiplied against the respective DALYs for cancer and non-cancer effects to determine the DALYs per kg emitted, for both in-country and global impacts.

24. Economic studies on the value of statistical life (VSL) are then applied to estimate the financial burden of these health conditions. The societal cost is calculated by multiplying the incidence of health conditions by the associated medical and economic costs, thereby providing a monetary value representing the societal impact of toxic pollutants on human health.

25. The paragraphs below provide an overview the functionality of each sheet in the Model. The main health model calculations for each module are colored in dark green. Any

supplementary model data/information are shown in the gray and lighter blue color. All input data tabs are colored in light red.

a) **Health Assumptions and Parameters**
This sheet details major *assumptions* and parameters used in the Water Pollution Health Model. It is linked back via Power Query to the Central Input Data Workbook. Any changes to these datasets should be made in that workbook.

b) **Health Core Inputs**
This sheet provides two core inputs related to the Water Pollution Health Model, (1) World Population, and (2) World Average Cost of DALYs.

c) **Additional Named Ranges**
This sheet provides all named ranges added to the USEtox model.

d) **Additional Pollutant Proxies**
This sheet provides additional pollutant proxies for organic pollutants.

e) **Composites**
This sheet provides abundance percentages that feed into the sheet titled "Value Factors – Weighted'

f) **Health General Data**
This sheet stores all the data used in the Water Pollution Health Model. It is linked back via Power Query to the Central Input Data Workbook. Any changes to these datasets should be made in that workbook.

g) **In-country and Global USEtox results**
This sheet stores all the characterisation factor results from the USEtox In-Country and Global impact runs. It includes formulas linked to macros in the 'Calculate VFs' tab to automatically determine the Value Factors based on DALY value.

h) **1. Calculate Value Factors**
This sheet is the main calculation tab of the Model and contains list of selected pollutants, countries, and include macro buttons to clear results, calculate VFs and compile VFs in a format that matches the Global Value Factors Database (GVFD).

i) **2. Full USEtox Results**

This sheet stores results from pressing the second macro of the '1. Calculate Value Factors' sheet, which compiles USEtox Global and In-Country results.

j) **3. Value Factors – Raw**
This sheet contains the initial calculated Value Factors and is populated after pressing the third macro located in sheet '1. Calculate Value Factors.'

k) **4. Value Factors – Weighted**
This sheet contains Value Factors that are weighted based on the modeled abundance value for some of the pollutants.

l) **Value Factors – Gap Filled, Value Factors – Composites**
These two sheets store the final health related Water Pollution value factors. 'Value Factors – Gap Filled' includes Value Factors with all missing data filled in. 'Value Factors – Composites' are composite Value Factors derived from multiple sources. The value factors as presented are the same values in the Global Value Factors Database, but if a user adjusts the data in the Model they may change and should not be considered endorsed or approved by or a representation of the IFVI methodology.

3 Adapting the Models for Bespoke Analysis

3.1 Updates input data, assumptions, and parameters

26. The intent of the impact accounting methodology is to provide consistent and comparable impact accounting methodologies that can be applied across entities. As such, the methodologies are intended to be used as is. IFVI will update the input data variables, assumptions, and parameters as necessary and on a regular basis, without the need for model users to make their own updates.

27. However, if any sensitivity or bespoke analysis is desired, the input data can be updated in the Models.

28. Should an entity wish to add new countries, regions or geographical areas specifically to the Interim Water Pollution Model, most of this data is only available in the Central Input Data Workbook, available upon request. Some is available in the Health General Data sheet.

29. There are 66 different input data points that make up the variables in the Water Pollution model. Data will need to be gathered for all variables for each country, region or geographical area to be added. The full list of input data is outlined in Appendix A.

30. To add an additional country, region or geographical area, the contextual data requirements include geophysical data, such as land, freshwater and coastal area; temperature, and wind speed; and exposure data such as exposed population, water and food consumption rates. Most of the country-level geophysical data in the Interim Water Pollution Model is sourced from GLOBACK, a dataset that contains spatially differentiated parameters. The USEtox model may need to be run to generate any new characterization factors that are required.

31. Individual pollutant data in the Water Pollution Methodology is obtained from USEtox, which includes over 3,000 organic and inorganic chemicals. If a substance is not present in the USEtox database, this can be manually added into the USEtox model, provided an entity has the relevant parameters of the substance or its proxy.

32. This will require substance-specific input parameters to model pollutant behavior and can be categorized as:

    a) The physical characteristics of pollutants, e.g. molecular weight, partitioning coefficients, degradation rates and bioaccumulation factors, and

b) The human health characteristics of pollutant, e.g. dose response and critical effect values.

33. The UseTox model may need to be run in order to generate additional VFs related to human health

34. For the Eutrophication module, refreshing the links in the relevant data input tab after changes in the Central Input Data Workbook would be sufficient to ensure changes are incorporated into the model calculations.

35. It is not recommended that users re-run USEtox to generate new or further characterization factors.

36. Some data inputs to the models apply across multiple models or, as mentioned above, only exists in the Central Input Data Workbook. For users wishing to conduct bespoke analysis across multiple models with consistent and efficient data, this can be done by making adjustments to the underlying Central Input Data Workbook. This workbook and a set of models that are directly linked to it via PowerQuery are available upon request.

Appendix A: Full List of Input Data

Health module:

Data point	Unit
Advanced economy	Yes / No
Cost of a DALY	2023 USD
Birthrate	Per 1000
National water access	%
Coastal population	%
Continental scale land area	Km2
Continental scale sea area	Km2
Continental scale freshwater	%
Continental scale natural soil	%
Continental scale agricultural soil	%
Continental scale other soil	%
Continental scale temperature	oC
Continental scale wind speed	m.s-1
Continental scale mixing height wind speed	m.s-1
Continental scale rain rate	Mm/year
Continental scale freshwater depth	Meter
Continental scale irrigation	Km3
Continental human population	Number
Exposure human breathing rate	M3 / (person*day)
Exposure water ingestion rate	L / (person*day)
Above-ground produce	kg/(day*capita)
Below-ground produce	kg/(day*capita)
Meat intake	kg/(day*capita)
Dairy products intake	kg/(day*capita)
Freshwater fish intake	kg/(day*capita)
Coastal fish intake	kg/(day*capita)

Eutrophication module:

Data point	Unit
Population	Number
Population density	People / km2
Rural population	%
GNI PPP per capita	2021 USD
Land area	Km2
Helme's Fate Factors	Days

Characterization factor for phosphorus emissions	PDFyr/kg
Characterization factor for nitrogen emissions	PDFyr/kg
Coastal population	%

Bibliography

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Please note: This bibliography only refers to sources referenced in this user guide. For a bibliography that includes the theoretical and empirical basis of the methodology, please refer to the separate methodology document.