INTERIM METHODOLOGY

Water Pollution Model

Technical Manual

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1 Introduction

1.1 Document purpose

1. This document is the Interim Water Pollution Model Technical Manual, which provides a description of the Interim Water 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 Water Pollution 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 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:

   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 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.

How an entity should estimate water pollution impact:

Quantity of water pollutant (*impact driver*)
1. Tonnes of arsenic emitted;
2. Split by pollutant type and emissions pathway, i.e., fresh water, marine water, or unspecified

Provided by the company

✖

Water pollution value factor
1. Relevant value factor based on type of pollutant and emissions pathway chosen

Provided by IFVI

Input data
1. Input data is used to calculate the value factors
2. This is contained within the Central Input Data Workbook and the Water Pollution model
3. This is provided by IFVI, however if an entity wants to edit or add additional value factors, they will need to source the input data
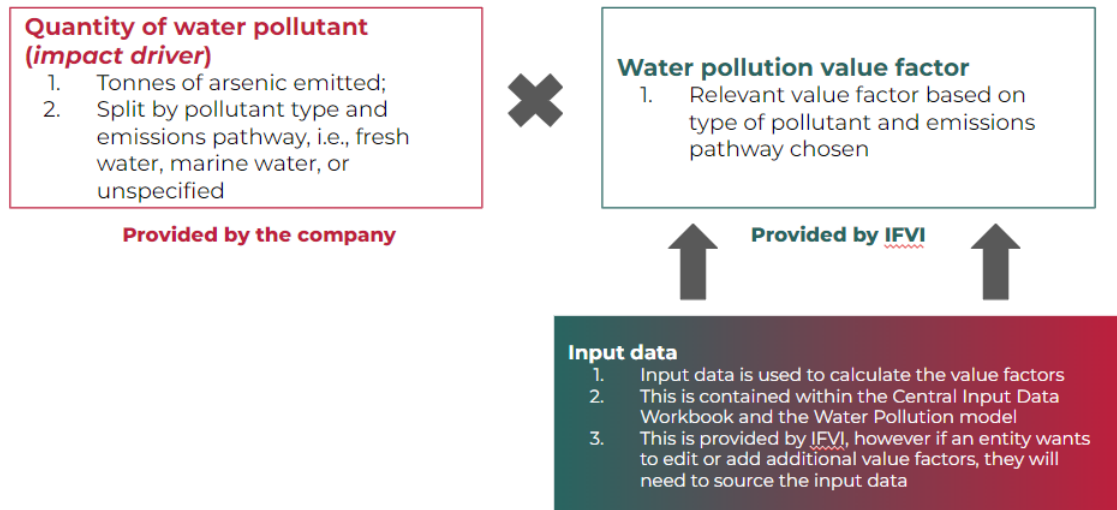
Figure 1: Difference between impact driver measurements and model input data

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.
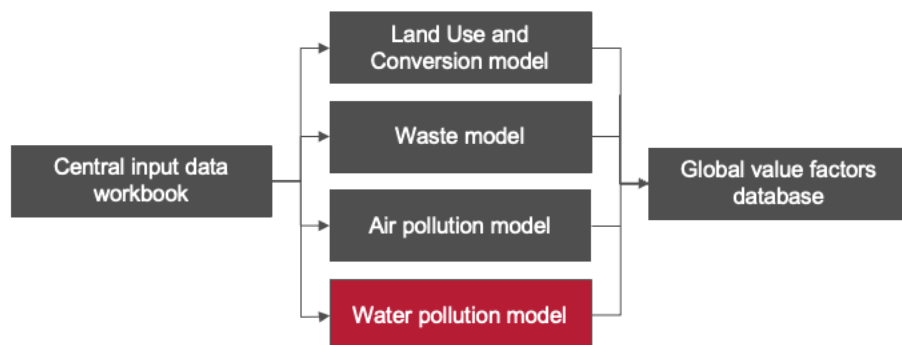

Figure 2: high-level diagram of the model architecture

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.

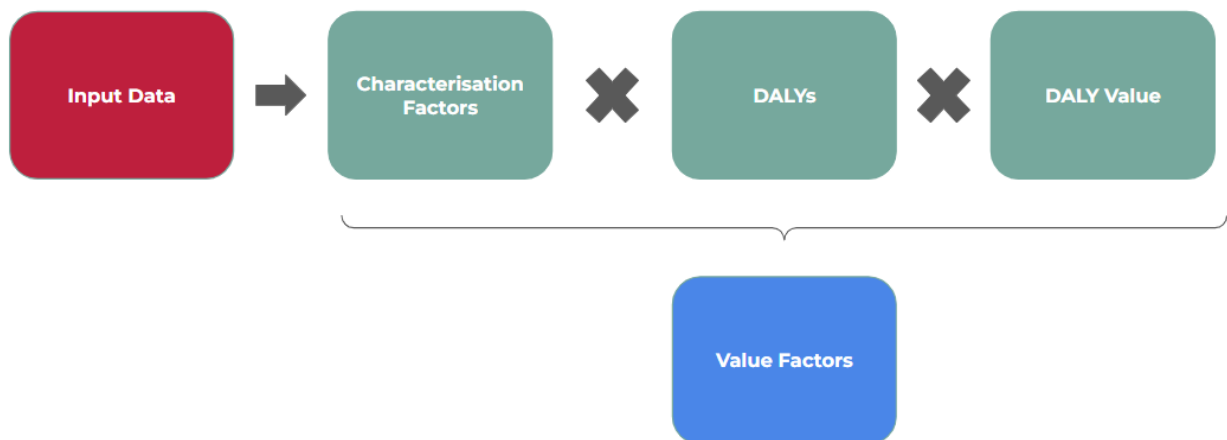21. The Health module structure is shown in Figure 4 below.

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

Rosenbaum, R.K., Bachmann, T.M., Gold, L.S., Huijbregts, M.A.J., Jolliet, O., Juraske, R., Koehler, A., Larsen, H.F., MacLeod, M., Margni, M.D., McKone, T.E., Payet, J., Schuhmacher, M., van de Meent, D., Hauschild, M.Z., (2008). USEtox - The UNEP-SETAC toxicity model: Recommended characterisation factors for human toxicity and freshwater ecotoxicity in life cycle impact assessment. The International Journal of Life Cycle Assessment 13, pp.532-546.

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.