Metadata: Water Consumption Footprint

1. Definition, concepts, and classifications

1.a. Definition

Water Consumption Footprint (WF) is the attribution of global freshwater consumption to the domestic final demand of a country.

Freshwater consumption is the portion of abstracted water from surface water bodies (e.g. rivers or lakes) or groundwater bodies that does not return to inland water resources because it is evapotranspired, incorporated into products.

1.b. Indicator concepts

Freshwater consumption is defined in the SEEA-Water [10] as water incorporated in products plus evapotranspiration. Or:

Water consumption = Total water abstraction – Total water returns to the environment

In water statistics [12] and accounts, the concept of water consumption gives an indication of the amount of water that is lost by the economy during use in the sense that it has entered the economy but has not returned either to water resources or to the sea. This happens because during use, part of the water is incorporated into products, evaporated, transpired by plants or simply consumed by households or livestock. It can be computed for each economic unit and for the whole economy.

WF reports freshwater consumption across the whole supply chain to service final demand.

1.c. Unit of measure

Million cubic meters.

2. Methodological considerations

2.a. Methodology concept

The Global Footprint Tool combines two main types of information to calculate a country's freshwater consumption footprint. First, it uses national water use and withdrawal data provided by users to represent total freshwater consumption across the entire economy in a given year. Second, the tool uses a global economic model (the GLORIA multi-regional input-output (MRIO) tables) to describe how goods and services are produced and traded across countries and sectors. Together, these components allow the tool to attribute both direct and supply-chain-related freshwater use to national final demand.

2.b. Description of the footprint calculation methodology

The Water Consumption Footprint (WF) measures freshwater consumption directly and indirectly associated as a result of economic activities of final demanders, including households, the government and the capital sector. WF includes freshwater consumption from the entire upstream supply chains underlying a national economy. It is derived from input-output data[1] according to:

$$WF = DW + \mathbf{my},$$

where DW are freshwater consumption by the final demanders themselves during the reporting period (e.g., household energy use, private transport, government operations), $\mathbf{m}$ is a $1\times N$ vector of freshwater consumption *multipliers* for a range of economic sectors, and $\mathbf{y}$ is an $N\times 1$ vector of final demand of products made by these sectors.

2.c. National users' inputs

Freshwater consumption categories are aligned with the definitions for water flow accounts of the System of Environmental-Economic Accounting Central Framework (SEEA CF) [11].

To calculate WF using the Global Footprint Tool, the template requests country data on freshwater consumption by agriculture, forestry and fishing (ISIC Section A), freshwater consumption by other economic activities (ISIC Sections B-U), as well as freshwater consumption by households (i.e. *DW* in the above equation).

The user-provided national data represent total freshwater consumption across the entire economy in the reporting year, with household consumption explicitly reported as a separate category. Because household freshwater consumption is directly provided by the user, no internal splitting of national totals based on the GLORIA MRIO model is required.

Within the Global Footprint Tool, freshwater consumption by economic activities (ISIC Sections A–U) is used as the production-related component and enters the MRIO framework to calculate freshwater use embodied in domestic and international supply chains. Freshwater consumption by households is treated as direct final demand and is added directly to the footprint results. By combining these two components, the tool preserves the full national freshwater consumption total provided by the user while ensuring a consistent attribution of direct and supply-chain-related freshwater use to national final demand.

2.d. Multi-regional input-output (MRIO) framework

The MRIO data used in the Global Footprint Tool are taken from the GLORIA MRIO database, which provides globally consistent multi-regional Supply–Use / Input–Output tables and associated environmental satellite accounts. The GLORIA structure enables attribution of upstream emissions

[1] Representing the economy as *N* intermediate sectors (e.g. agriculture, forestry, fishing, mining, manufacturing, utilities, construction, trade, transport, services), and *M* final demanders (households, the government and the capital sector).

across regions and sectors to national final demand, consistent with international statistical standards (SNA and SEEA).

The System of National Accounts ([1], §28.37) states the fundamental input-output relationship as:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\,\mathbf{y},$$

where $\mathbf{x} = \mathbf{T}\mathbf{1}^{\mathbf{T}} + \mathbf{y}\mathbf{1}^{\mathbf{y}}$ denotes a vector of sectoral *total output*, $\mathbf{T}$ is an $N\times N$ *intermediate demand* matrix, $\mathbf{y}$ is an $N\times M$ *final demand* matrix, $\mathbf{1}^{\mathbf{T}} = \{\underbrace{(1,\ldots,1)}_{N}\}$ and $\mathbf{1}^{\mathbf{y}} = \{\underbrace{(1,\ldots,1)}_{M}\}$ are summation operators, $\mathbf{I}$ is an $N\times N$ identity matrix, and $\mathbf{A} = \mathbf{T}\hat{\mathbf{x}}^{-1}$ holds $N\times N$ intermediate *input coefficients*. The $N\times N$ matrix $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ is called the *Leontief inverse* (see §28.38 in [1] and §20.F in [2]), which facilitates the analytical power of input-output analysis for the purpose of enumerating footprints. $\mathbf{T}$, $\mathbf{y}$ and $\mathbf{x}$ are standard components of any official national or global input-output database, and $\mathbf{A}$ and $\mathbf{L}$ are derived from these. The Global Footprint Tool makes use of global, multi-regional input-output (MRIO) data (see [3] and §17 in [2]).

In compliance with the System of Environmental-Economic Accounting (see §29.105 in [1] and §13 in [2]), blue water consumption data distinguishing K blue water consumption types are arranged into a so-called *satellite account* $\mathbf{Q}$, sized $K\times N$. The combination of blue water consumption and monetary input-output data enables the calculation of embodied blue water consumption footprints [4]. Pre-multiplying the fundamental input-output relationship with land use *intensities* $\mathbf{q} = \mathbf{Q}\hat{\mathbf{x}}^{-1}$ yields blue water consumption footprints *WF* as:

$$\mathbf{q}\mathbf{x} = \mathbf{q}(\mathbf{I} - \mathbf{A})^{-1}\,\mathbf{y} =: \mathbf{m}\mathbf{y} = WF.$$

The blue water consumption *multipliers* are $\mathbf{m} = \mathbf{q}(\mathbf{I} - \mathbf{A})^{-1} = \mathbf{q}\mathbf{L}$, and – as with the Leontief inverse $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ – incorporate the entire supply-chain network underpinning the production of goods and services ultimately consumed by final demanders (§20.K in [2]).

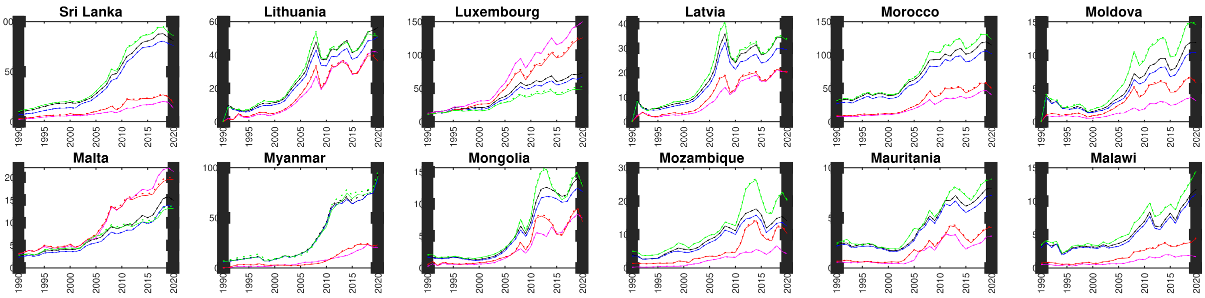
For the attribution of the Water Consumption Footprint of final demand in the Global Footprint Tool, global multi-regional input-output (MRIO) analysis and data are employed (§17 in [2]). The MRIO data are taken from the GLORIA MRIO database [5]. The primary data underlying this database are described in the GLORIA Release Notes. These notes also contain explanations of GLORIA's multi-region Supply-Use structure (see §17.B in [2]), detailed descriptions of compilation procedures, a visualisation of Water Footprint trends for 159 countries (see Annex 1), as well as a plain-English short philosophy of MRIO-building and a plain-English explanation of MRIO-based footprinting.

2.e. Description of the data forecast methodology

Most primary data underlying the GLORIA MRIO database are up-to-date until 2023. The forecast of all monetary tables starting 2024 until 2028 is based on GDP projections by the International Monetary Fund [6] and the World Bank [7]. Satellite entries are forecast by extrapolating a linear fit of the 1990-2023 data.

2.f. Validation

The GLORIA Release Notes contain a number of validation visualisations, for example through a country-by-country comparison of GLORIA aggregates (GDP, value added, imports, exports, labour wages) with corresponding values in the United Nations SNA Main Aggregates database [8] and the ILO labour database [9]. These comparisons illustrate the adherence of GLORIA data and national accounts aggregates.



Excerpt from the GLORIA – UN Main Aggregates comparison.
UN Main Aggregates solid lines, GLORIA dashed lines.

2.g. Quality assurance

The compilation of the GLORIA MRIO database includes a series of Quality Assurance (QA) diagnostics tests. These tests are offered alongside the data download [5] and as excerpts in the Release Notes. These diagnostics tests assure that GLORIA data:

- adhere as much as possible to primary data such as from the United Nations Statistics Division (UNSD), the OECD, the International Labour Organisation (ILO), the United Nations Food and Agriculture organisation (FAO), and the United Nations Industrial Development Organisation (UNIDO);
- yield realistic relationships with physical data; for example (a) dividing GLORIA's monetary wages and salaries data by ILO's employment statistics should yield realistic per-worker wages across various sectors and regions, and (b) dividing GLORIA's monetary household consumption data by FAOSTAT's food balances should yield realistic per-capita energy and macronutrient intakes across various sectors and regions.

3. Data sources

Countries are encouraged to use statistics from the national physical flow accounts for water resources or, if the country does not develop physical flow accounts for water resources, data provided to the UNSD through the UNSD/UNEP Questionnaire on Environment Statistics (water section) or any other similar questionnaire at the regional level.

4. Data availability and disaggregation

4.a. Data availability

The Global Footprint Tool allows to calculate the Water Consumption Footprint indicator for 159 countries (see Annex 1).

4.b. Time series

The Water Consumption Footprint indicator can be calculated since 1990.

4.c. Disaggregation

The Water Consumption Footprint indicator is disaggregated according to the International Standard Industrial Classification of All Economic Activities (ISIC) for agriculture, forestry and fishing (ISIC Section A), other economic activities (ISIC Sections B-U) and household consumption.

5. Comparability / deviation from international standards

The Water Consumption Footprint is calculated in accordance with international standards, recommendations and classifications such as the System of National Accounts 2008, the System of Environmental-Economic Accounting – Central Framework 2012, the System of Environmental-Economic Accounting for Water (SEEA-Water), the International Recommendations for Water Statistics, the International Standard Industrial Classification of All Economic Activities (ISIC).

6. References

[1] UN, System of National Accounts 2008, United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, World Bank, New York, USA, 2009.
[2] UNSD, Handbook on Supply, Use and Input-Output Tables with Extensions and Applications, United Nations Statistics Division, New York, USA, 2018.
[3] W.W. Leontief, A.A. Strout, Multiregional input-output analysis, in: T. Barna (Ed.), Structural Interdependence and Economic Development, Macmillan, London, UK, 1963, pp. 119-149.
[4] W. Leontief, D. Ford, Environmental repercussions and the economic structure: an input-output approach, Review of Economics and Statistics 52(3) (1970) 262-271.
[5] M. Lenzen, M. Li, The GLORIA MRIO database, The University of Sydney, Sydney, Australia, 2023.
[6] IMF, Gross domestic product, current prices, 2020-2028, International Monetary Fund, Washington, D.C., USA, 2023.
[7] World Bank, Global Economic Prospects, World Bank,, Washington DC, USA, 2023.
[8] UNSD, National Accounts Main Aggregates Database, United Nations Statistics Division, New York, USA, 2022.
[9] ILO, ILOSTAT - Statistics on employment, International Labour Organization, Genève, Switzerland, 2022.
[10] UNSD, System of Environmental-Economic Accounting for Water (SEEA-Water). New York, USA, 2012.
[11] UN, System of Environmental-Economic Accounting Central Framework (SEEA CF) 2012. United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development, the World Bank. New York, USA, 2014.
[12] UNSD, International Recommendations for Water Statistics. New York, USA, 2012.

Annex 1: List of countries for which the Material Footprint indicator can be calculated using the Global Footprint Tool

#	Country acronyms	Country names
1	AFG	Afghanistan
2	AGO	Angola
3	ALB	Albania
4	ARE	United Arab Emirates
5	ARG	Argentina
6	ARM	Armenia
7	AUS	Australia
8	AUT	Austria
9	AZE	Azerbaijan
10	BDI	Burundi
11	BEL	Belgium
12	BEN	Benin
13	BFA	Burkina Faso
14	BGD	Bangladesh
15	BGR	Bulgaria
16	BHR	Bahrain
17	BHS	Bahamas
18	BIH	Bosnia and Herzegovina
19	BLR	Belarus
20	BLZ	Belize
21	BOL	Bolivia
22	BRA	Brazil
23	BRN	Brunei Darussalam
24	BTN	Bhutan
25	BWA	Botswana
26	CAF	Central African Republic
27	CAN	Canada
28	CHE	Switzerland
29	CHL	Chile
30	CHN	China
31	CIV	Cote d'Ivoire
32	CMR	Cameroon
33	COD	DR Congo
34	COG	Rep Congo
35	COL	Colombia
36	CRI	Costa Rica
37	CUB	Cuba
38	CYP	Cyprus
39	CZE	Czech Republic
40	DEU	Germany

41	DJI	Djibouti
42	DNK	Denmark
43	DOM	Dominican Republic
44	DZA	Algeria
45	ECU	Ecuador
46	EGY	Egypt
47	ERI	Eritrea
48	ESP	Spain
49	EST	Estonia
50	ETH	Ethiopia
51	FIN	Finland
52	FRA	France
53	GAB	Gabon
54	GBR	United Kingdom
55	GEO	Georgia
56	GHA	Ghana
57	GIN	Guinea
58	GMB	Gambia
59	GNQ	Equatorial Guinea
60	GRC	Greece
61	GTM	Guatemala
62	HND	Honduras
63	HKG	Hong Kong
64	HRV	Croatia
65	HTI	Haiti
66	HUN	Hungary
67	IDN	Indonesia
68	IND	India
69	IRL	Ireland
70	IRN	Iran
71	IRQ	Iraq
72	ISL	Iceland
73	ISR	Israel
74	ITA	Italy
75	JAM	Jamaica
76	JOR	Jordan
77	JPN	Japan
78	KAZ	Kazakhstan
79	KEN	Kenya
80	KGZ	Kyrgyzstan
81	KHM	Cambodia
82	KOR	South Korea
83	KWT	Kuwait
84	LAO	Laos
85	LBN	Lebanon

86	LBR	Liberia
87	LBY	Libya
88	LKA	Sri Lanka
89	LTU	Lithuania
90	LUX	Luxembourg
91	LVA	Latvia
92	MAR	Morocco
93	MDA	Moldova
94	MDG	Madagascar
95	MEX	Mexico
96	MKD	Macedonia
97	MLI	Mali
98	MLT	Malta
99	MMR	Myanmar
100	MNG	Mongolia
101	MOZ	Mozambique
102	MRT	Mauritania
103	MWI	Malawi
104	MYS	Malaysia
105	NAM	Namibia
106	NER	Niger
107	NGA	Nigeria
108	NIC	Nicaragua
109	NLD	Netherlands
110	NOR	Norway
111	NPL	Nepal
112	NZL	New Zealand
113	OMN	Oman
114	PAK	Pakistan
115	PSE	Palestine
116	PAN	Panama
117	PER	Peru
118	PHL	Philippines
119	PNG	Papua New Guinea
120	POL	Poland
121	PRK	North Korea
122	PRT	Portugal
123	PRY	Paraguay
124	QAT	Qatar
125	ROU	Romania
126	RUS	Russian Federation
127	RWA	Rwanda
128	SAU	Saudi Arabia
129	SDS	South Sudan
130	SEN	Senegal

131	SGP	Singapore
132	SLE	Sierra Leone
133	SLV	El Salvador
134	SOM	Somalia
135	SRB	Serbia
136	SDN	Sudan/North Sudan (2010/2011)
137	SVK	Slovakia
138	SVN	Slovenia
139	SWE	Sweden
140	SYR	Syria
141	TCD	Chad
142	TGO	Togo
143	THA	Thailand
144	TJK	Tajikistan
145	TKM	Turkmenistan
146	TUN	Tunisia
147	TUR	Turkey
148	TZA	Tanzania
149	UGA	Uganda
150	UKR	Ukraine
151	URY	Uruguay
152	USA	United States of America
153	UZB	Uzbekistan
154	VEN	Venezuela
155	VNM	Viet Nam
156	YEM	Yemen
157	ZAF	South Africa
158	ZMB	Zambia
159	ZWE	Zimbabwe