
Environmental management — Water footprint — Illustrative examples on how to apply ISO 14046

Management environnemental — Empreinte eau — Exemples illustrant l'application de l'ISO 14046



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 207, *Environmental management*, Subcommittee SC 5, *Life cycle assessment*.

This second edition cancels and replaces the first edition (ISO/TR 14073:2016), of which this constitutes a minor revision incorporating minor editorial corrections and improved figures.

Introduction

Principles, requirements and guidelines for the quantification and reporting of a water footprint are given in ISO 14046. The water footprint assessment according to ISO 14046 can be conducted as a stand-alone assessment, where only impacts related to water are assessed, or as part of a life cycle assessment. In addition, a variety of modelling choices and approaches are possible depending on the goal and scope of the assessment. The water footprint can be reported as a single value or as a profile of impact category indicator results.

This document provides illustrative examples on the application of ISO 14046 to further enhance understanding of ISO 14046 and to facilitate its widespread application.

At the time of the publication of this document, water footprint assessment methods are developing rapidly. Practitioners are encouraged to be aware of the latest developments when undertaking water footprint studies.

These examples are for illustrative purposes only and some of the data used are fictitious. The data are not intended to be used outside of the context of this document.

The Bibliography might contain references to methods that are not fully compliant with ISO 14046:2014.

Environmental management — Water footprint — Illustrative examples on how to apply ISO 14046

1 Scope

This document provides illustrative examples of how to apply ISO 14046, in order to assess the water footprint of products, processes and organizations based on life cycle assessment.

The examples are presented to demonstrate particular aspects of the application of ISO 14046 and therefore do not present all of the details of an entire water footprint study report as required by ISO 14046.

NOTE The examples are presented as different ways of applying ISO 14046 and do not preclude alternative ways of calculating the water footprint, provided they are in accordance with ISO 14046.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14046:2014, *Environmental management — Water footprint — Principles, requirements and guidelines*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14046:2014 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <http://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Symbols and abbreviated terms

4.1 Symbols

α	characterization factor
C	Concentration
E	Emission
F	Footprint
R	Rainfall
V	Volume

4.2 Abbreviated terms

1,4-DB	1,4-Dichlorobenzene
2,4-D	2,4-Dichlorophenoxyacetic acid
APSIM	Agricultural Production Systems sIMulator
BOD	Biological Oxygen Demand (BOD ₅ means “measured during 5 days”)
CF	Characterization Factor
COD	Chemical Oxygen Demand
CTU	Comparative Toxic Unit
	NOTE 1 “CTU _e ” for ecosystems; “CTU _h ” for humans; “CTU _c ” for cancer; “CTU _{n-c} ” for non-cancer.
CWU	Consumptive Water Use
CWV	Critical Water Volume
DALY	Disability Adjusted Life Years
DWU	Degradative Water Use
DWCM-AgWU	Distributed Water Circulation Model Incorporating Agricultural Water Use
ET	Evapotranspiration
FU	Functional Unit
H ₂ O-eq	Water “equivalent”
	NOTE 2 Typical unit to express the impact score associated with water scarcity. Sometimes the term H ₂ O-eq is written H ₂ O eq, or H ₂ Oe.
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
OEF	Organization Environmental Footprint
PEF	Product Environmental Footprint
PDF	Potentially Disappeared Fraction of species
PAF	Potentially Affected Fraction of species
RU	Reporting Unit
TOC	Total Organic Carbon
WSI	Water Scarcity Index

NOTE 3 Sometimes the term water stress index (also abbreviated as WSI) is used in the literature for what is termed a water scarcity index in this document.

WSF Water Scarcity Footprint

WULCA Water Use in LCA

5 Selection of the type of water footprint assessment

5.1 General

The water footprint assessment conducted according to ISO 14046 can be:

- a stand-alone assessment where only impacts related to water are assessed;
- a part of a life cycle assessment (LCA) where consideration is given to a comprehensive set of environmental impacts, which are not only impacts related to water.

[Table 1](#) lists the illustrative examples in this document and the different topics that are highlighted in each example.

Table 1 — Types of water footprint assessment shown in the examples

Example	Product/ process or organization focus	Topic highlight- ed ^a	Case study used in the example	Type of footprint ^a	System boundary	Impact assessment method ^a
A (6.1)	Product/ Process	Water footprint inventory	Power plant	n/a (Water foot- print inventory only)	Gate-to-gate	n/a (inventory only)
B (6.2)	Product/ Process	Water footprint inventory using a baseline	Rice cultiva- tion	n/a (Water foot- print inventory only)	Gate-to-gate	n/a (inventory only)
C (6.3)	Product/ Process	Option com- parison using scarcity	Municipal water manage- ment	Water scarcity footprint	Gate-to-gate	Boulay et al. (2016) (WU LCA)[5]
D (6.4)	Product/ Process	Application of water scarcity footprint method	Rice	Water scarcity footprint	Gate-to-gate	Ridoutt and Pfister (2010) [6]
E (6.5)	Product/ Process	Influence of im- pact assessment method chosen for scarcity	Textile	Water scarcity footprint	Cradle-to- grave	Boulay et al. (2016) (WULCA) [5]; Pfister et al. (2009)[7]; Frischknecht et al. (2009) [8]; EU (2013) (PEF/OEF) [9]; Boulay et al. (2011)[10]; Hoekstra et al. (2012) (Water Footprint Net- work - WFN) [11]; Berger et al. (2014)[12]
^a All examples explicitly or implicitly contain a water footprint inventory.						

Table 1 (continued)

Example	Product/ process or organization focus	Topic highlight- ed ^a	Case study used in the example	Type of footprint ^a	System boundary	Impact assessment method ^a
F (6.6)	Product/ Process	Seasonality	Reservoir operation	Water scarcity footprint	Gate-to-gate	Pfister and Bayer (2014) [13]
G (6.7)	Product/ Process	Scarcity vs avail- ability	Packaging production	Water scarcity footprint; water availability foot- print	Gate-to-gate	Boulay et al. (2011)[10]
H (6.8)	Product/ Process	Influence of water sources	Wheat cultiva- tion	Water scarcity footprint	Gate-to-gate	Yano et al. (2015)[14]
I (6.9)	Product/ Process	Influence of for- est management / land use change	Beer produc- tion	Water scarcity footprint	Gate-to-gate	Yano et al. (2015)[14]
J (6.10)	Product/ Process	Number of indi- cators per type of impact	Maize	Water eutrophica- tion footprint	Cradle-to- gate	EU (2013) (PEF/OEF)[9]; Jolliet et al. (2003) (IM- PACT 2002+) [15]
K (6.11)	Product/ Process	Comprehensive water footprint	Packaging product	Water footprint (comprehensive profile)	Cradle-to- gate	Bulle et al. (2017) (IMPACT World+)[16]; Rosenbaum et al. (2008) (USEtox)[17]; Guinée et al. 2001[19]; EU (2013) (PEF/OEF) [9]; Verones et al. (2010) [19]; Boulay et al. (2016) (WULCA)[5]; Boulay et al. (2011)[10]; Hannafiah et al. (2011)[20]
L (6.12)	Product/ Process	Applying weight- ing to obtain a single value	Cereal cultiva- tion	Non-comprehen- sive weighted water footprint	Gate-to-gate	Goedkoop et al. (2013) (ReCiPe)[21]; Ridoutt and Pfister (2010) [6]; Ridoutt and Pfister (2013)[22]

^a All examples explicitly or implicitly contain a water footprint inventory.

Table 1 (continued)

Example	Product/ process or organization focus	Topic highlight- ed ^a	Case study used in the example	Type of footprint ^a	System boundary	Impact assessment method ^a
M (6.13)	Product/ Process	Water footprint as part of an LCA	Packaging product	Water footprint as part of an LCA	Cradle-to- gate	Boulay et al. (2016) (WULCA)[5] (Water degradation footprint profile already present)
N (6.14)	Product/ Process	Seasonality	Textile product	Non-compre- hensive water footprint	Cradle-to- gate	Hoekstra et al. (2012); (Water Foot- print Network - WFN)[11]
O (6.15)	Product/ Process	Applying weight- ing to obtain to single value	Municipal water manage- ment	Non-comprehen- sive weighted water footprint	Cradle-to- grave	Pfister et al. (2009)[7]; Ridoutt and Pfister (2013) [22]; Goedkoop et al., (2013) (ReCiPe) [21]; Jolliet et al. (2003) (IMPACT 2002+)[15]; Rosenbaum et al. (2008) (USEtox)[17]
P (6.16)	Organization	Applying water footprint to dif- ferent sites	Chemical pro- duction	Non-compre- hensive water footprint	Gate-to-gate	Berger et al. (2014)[12]; Saling et al. (2002)[23]
Q (6.17)	Organization	Applying water footprint to supply chain of a company	Aluminium production	Water scarcity footprint	Cradle-to- gate	Pfister et al. (2009)[7]
R (6.18)	Organization	Applying water footprint to a ser- vice company	Hotel opera- tion	Non-compre- hensive water footprint	Gate-to-gate	Boulay et al. (2016) (WULCA)[5] at the monthly approach; Goedkoop et al. (2013) (ReCiPe)[21]
^a All examples explicitly or implicitly contain a water footprint inventory.						

NOTE 1 Guidance about application of LCA to organizations is given in ISO/TS 14072. In addition, ISO 14046:2014, Annex A, provides guidelines for water footprint assessment of organizations.

NOTE 2 The principles of comprehensiveness for an LCA study and for a water footprint assessment are different (see ISO 14040:2006, 4.1.7, and ISO 14046:2014, 4.13).

NOTE 3 The term “partial” is sometimes used as a synonym for “non-comprehensive”. However, “partial” is avoided in this document as it is also used with a different meaning, such as in ISO/TS 14067

5.2 Choice of the type of water footprint study

The different types of water footprint are defined in ISO 14046:2014, 5.4.5 to 5.4.7. The choice of a particular type of water footprint to be assessed in a stand-alone water footprint study is determined in the goal and scope definition phase.

In addition to the goal of the study (see ISO 14046:2014, 5.2.1) the choice of type of water footprint may be influenced by consideration of an appropriate system boundary, the type(s) of water resource used and affected water resources, the associated changes in water quantity and quality and determination of relevant impact assessment categories and methodologies.

[Figure 1](#) illustrates a procedure for choosing the type of water footprint for a stand-alone water footprint study.

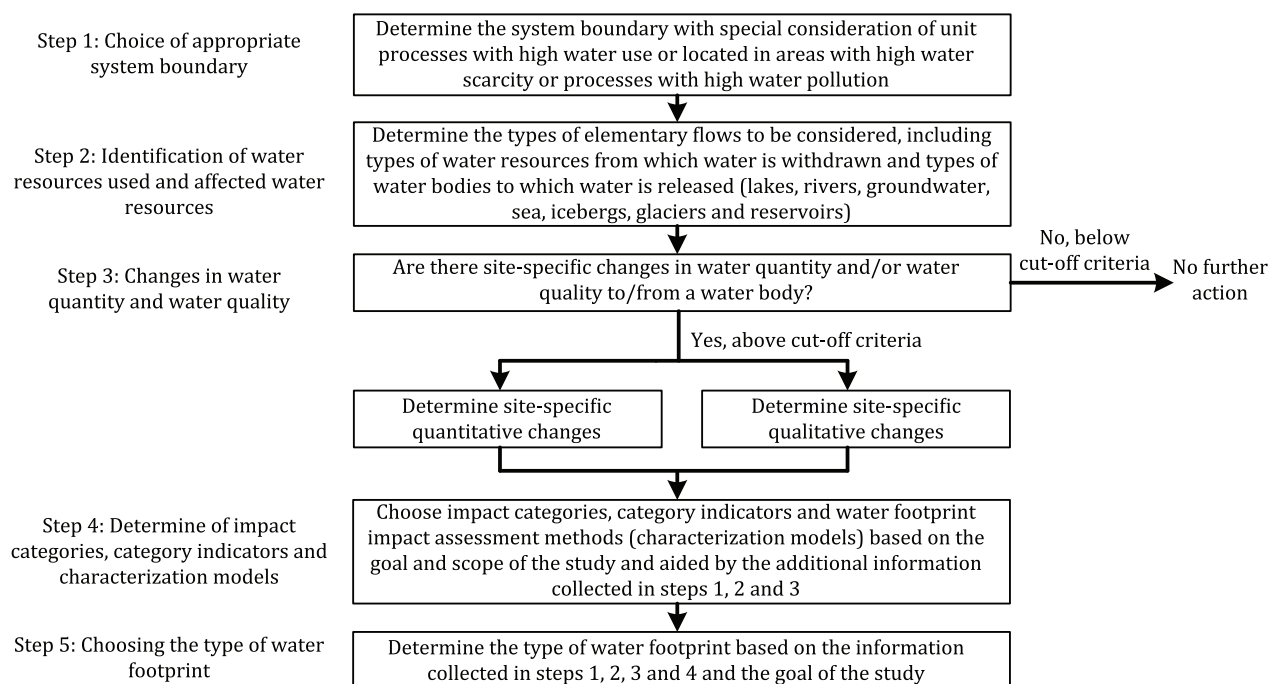


Figure 1 — Procedure for choosing the type of a water footprint assessment for a stand-alone water footprint study

The procedure for choosing an appropriate system boundary in a water footprint study as defined in ISO 14046:2014, 3.3.8, can be supported by collation of additional information such as:

- developing a map showing the geographical location of each unit process;
- identification of the unit processes that are located in areas of critical water availability (taking into account relevant seasonal and temporal variability);
- identification of the unit processes with air, water and soil emissions that can potentially affect ecologically vulnerable water bodies.

All water inputs and outputs relevant to the system (see examples in [Figure 2](#)) are considered for relevant changes in water quantity (volume) and water quality parameters and/or characteristics, including emissions to air, water and soil that affect water quality. Estimates may be based on readily available data or models.

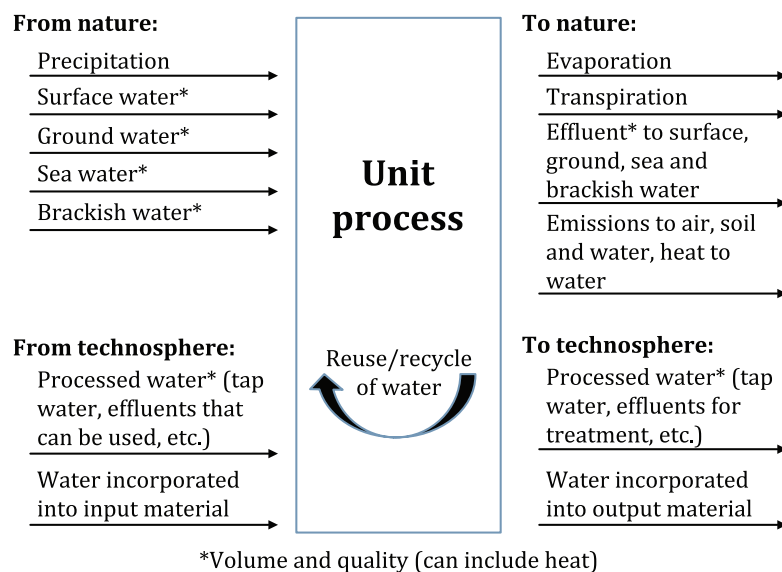


Figure 2 — Examples of water inputs (left) and outputs (right) for a unit process under study

In addition to the goal of the water footprint study, the information collected in order to define the system boundary, the type(s) of water resource used and affected water resources, and the associated (quantitative and/or qualitative) changes in water, can assist in determining the appropriate impact categories, category indicators and the characterization models to be considered for the water footprint study – and therefore choice of a type of water footprint. Based on the information collected, it is possible to:

- estimate the degree of likely significance (i.e. potential contribution to the water footprint) of each unit process for the study, and therefore which unit processes should become the focus for more detailed data collection;
- specify the data requirements (e.g. primary data, secondary data, estimated data) based on the likely significance of each unit process for the water footprint;
- define the initial cut-off criteria for the study (which are revisited throughout the study following ISO 14046:2014, 4.5).

Based on this information and general information related to the goal of the study (see ISO 14046:2014, 5.2.1) the type of water footprint that will be a result of the water footprint study can be chosen.

6 Presentation of the examples

6.1 Example A – Water footprint inventory of two power plants

6.1.1 Goal and scope

This example illustrates the compilation of water flows and emissions affecting water of a unit process.

A utility wanting to evaluate which of two planned options has the lowest direct water footprint starts by creating the direct water footprint inventory of both options, from a gate-to-gate perspective. This direct water footprint inventory can then be used in combination with water footprint impact assessment methods, considering water scarcity footprint and/or water degradation footprint, to evaluate the direct water footprint of both options.

NOTE The term “direct” is used as “what happens on the site” (see ISO 14046:2014, 3.5.14) (gate-to-gate, excluding any inputs such as infrastructure production, maintenance and outputs such as electricity). The term “indirect” is used for background processes (see ISO 14046:2014, 3.5.15).

6.1.2 Inventory

Table 2 shows the water footprint inventory associated with both options. The inventory is based on collected and modelled data and expressed per kWh of electricity produced.

Table 2 — Gate-to-gate water footprint inventory associated with two power plants options

Flows	Unit (per kWh produced)	Option 1 (power plant, situated in a location A, using through flow without cooling tower)	Option 2 (power plant, situated in a location B, with lower river flow and therefore using a cooling tower)
Address of the power plant	—	AA	BB
Location	—	Location A (name of the country and if possible drainage basin)	Location B (name of the country and if possible drainage basin)
Temporal variation	—	Assumed to be a constant use of water	Assumed to be a constant use of water
Water withdrawal	l	40	10
Water release	l	38	6
Temperature of water released	°C	25	25
Water consumed	l	2	4
Chromium (III) emitted to water	g	0,001	0,001
Oil emitted to water	g	0,02	0,02
SO ₂ emitted to air	g	0,7	0,7
NO _x emitted to air	g	0,6	0,6
Mercury emitted to air	mg	0,04	0,04
Dioxin, 2,3,7,8, Tetrachlorodibenzo-p-	ng	0,07	0,07
More if available	...	...	...

6.1.3 Interpretation

Such an inventory can be as extensive as needed to capture all emissions (as well as other information) useful to apply the impact assessment methods that will be chosen in the study. The quality of the data is sometimes specified in order to provide information about the accuracy of the water footprint that will be calculated based on this inventory. The naming of the flows in the inventory is matched with the naming of the flows in the impact assessment.

From the address of the power plants, the data of the location (e.g. the water scarcity index) can be determined within a subsequent impact assessment using satellite imagery. As the water scarcity footprint of both locations can be very different, comparison between both options on the inventory level can be misleading.

6.2 Example B - Water footprint inventory of rice cultivation

6.2.1 Goal and scope

This example illustrates calculation of water flows based on the hydrology of an area.

This example is not a traditional LCA case study, but it illustrates a special case, considering non-irrigated paddies as the baseline.

The example is shown as an exercise of a non-comprehensive water footprint inventory by utilizing existing hydrological knowledge, namely the usage of a hydrological model to analyse water footprint inventory of unit processes.

This example refers to rice cultivation, as an example of a water footprint inventory analysis, in a country in monsoon Asia with moderate rainfall and suitable rice cultivation practices. An irrigated area lies downstream of the intake facility (Figure 3) and the baseline land use is rainfed (i.e. non-irrigated) rice.

This is a “gate-to-gate” example. For the purpose of this example, energy and goods required for rice cultivation are excluded.

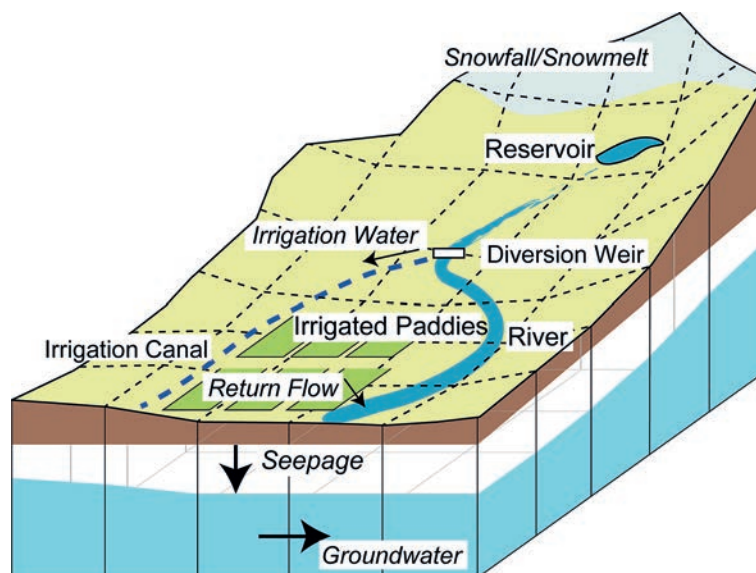


Figure 3 — Depiction of basin-wide processes

6.2.2 Inventory

The elementary flows are quantified by utilizing a hydrological model, such as DWCM-AgWU (Yoshida et al. 2012[24]; Masumoto et al. 2009[25]), at the scale of drainage basins. Agricultural situations typically require modelling because it is difficult, or even impossible, to measure all the elementary flows.

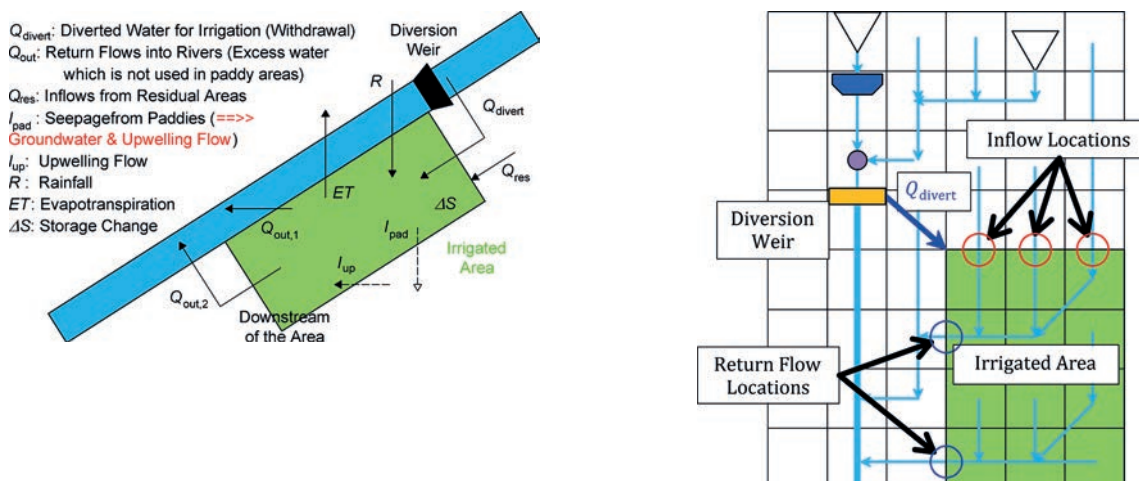
The elementary flows quantified in the water footprint inventory can be used to determine the water scarcity footprint which is described in other examples. In order to determine the water availability footprint, the water degradation footprint or a water footprint profile, other elementary flows related to water quality need to be determined.

6.2.2.1 Elementary flows

In this approach, a single process in an agricultural area receives rainfall, irrigation and residual water (water that has not been diverted from the river for the intention to irrigate this area; inflow locations) as inputs, and have evaporation, transpiration, percolation to groundwater and return flow to the river as outputs (Figure 4).

Furthermore, it is shown that all input water is withdrawn from the location of the process and all output water is released to the location of the process. Part of water output as groundwater gradually returns back into the river systems or is utilized as the source of public water supply.

In paddy areas, the source of freshwater differs between rainfed (precipitation) and irrigated paddies (irrigation water). In both cases, various types of water use exist, such as three types in rainfed agriculture (only rainfall, rainfall plus supplementary water stored in small ponds, and using flooding water) and six categories in irrigated paddies (gravity-fed water, pumped water, reservoirs, impounding of silty water (colmatage), release of river water into coastal wetlands and near-shore waters by managing controlling tides, and groundwater).



NOTE 1 Upwelling flow is defined as part of seepage returning to the surface from the ground within an irrigated area.

NOTE 2 The irrigated area is delineated for the DWCM-AgWU.

a) Water balance

b) Inflow and outflows in an irrigated area

Figure 4 — Schematics of the calculation for hydrological components and river return ratio

6.2.2.2 Calculation procedure of water footprint inventory

The water footprint inventory is determined as follows:

- the estimation in water footprint inventory of unit process for rice cultivation in paddy areas is carried out at the scale of the irrigated area;
- each elementary flow is modelled using DWCM-AgWU, which comprises water allocation and management, evapotranspiration, planting time/area (rice phenology), paddy water use and runoff models (Yoshida et al. 2012[24]; Masumoto et al. 2009[25]);
- the water balance of the baseline situation is calculated assuming no irrigation is carried out.

NOTE In the paddy-dominant areas with two or three crops within a year, paddies are classified into rainfed in rainy seasons and irrigated in dry season. As for the baseline situation, it is assumed that an irrigation system is not introduced, so paddies are regarded as rainfed types.

These results are then summed across the basin (an example in one region of the basin; Table 3) and expressed in the units m^3 per ha per irrigation period, or m^3 per kg brown rice for example.

6.2.2.3 Input parameters and calculated results of unit processes

Input parameters into the DWCM-AgWU model are land use data, meteorological data, geological and geomorphologic data, and celled basin data. The model estimates the planting area of paddies, intake amount and soil moisture at arbitrary locations in the basin. The model is validated against observed values of discharges of rivers and is shown to provide reliable estimates in the absence of measured data.

Table 3 shows the modelled results for the studied river basin of a country in Monsoon Asia. The data represent the average of daily calculations for 33 years (1976-2008).

Table 3 — Results for the calculated water footprint inventory

Items	Baseline (non-irrigated)		Rice paddy	
Unit	(m ³ /ha)	(m ³ /kg) (yield = 3,59 t/ha/ harvest)	(m ³ /ha)	(m ³ /kg) (yield = 5,39 t/ha/ harvest)
Rainfall (<i>R</i>)	8 880	2,48	8 880	1,65
Diverted water (<i>Q_{divert}</i>) ^a	0	0	14 900	2,76
Supplied water for irrigation ^b	0	0	(9 570)	(1,77)
Inflows from residual areas (<i>Q_{res}</i>)	84 860 (surface) and 1 610 (groundwater)	23,6 (surface) and 0,45 (groundwater)	84 860 (surface) and 1 610 (groundwater)	15,7 (surface) and 0,30 (groundwater)
Returns into rivers (<i>Q_{out}</i>)	92 060 (surface) and 320 (groundwater)	25,6 (surface) and 0,09 (groundwater)	102 680 (surface) and 370 (groundwater)	19,0 (surface) and 0,07 (groundwater)
Evapotranspiration (<i>ET</i>)	2 390	0,67	5 100	0,95
Seepage (<i>I_{pad}</i>) ^c	(5 530)	(1,54)	(6 230)	(1,16)
Storage change (ΔS)	580	0,16	2 100	0,38

All the values in this table were consistently normalized by the total area of grid cells covering the whole irrigation areas (127 km²)

^a The values of this row were calculated with the amount of diverted water from rivers.

^b The values of this row were estimated with the supplied water for irrigation directly used for rice, so that they were included in those of diverted water (*Q_{divert}*).

^c The values of seepage (*I_{pad}*) were included in those of the return flow into rivers (*Q_{out}*) plus storage change (ΔS).

The yield of rough rice in the region is 5,39 t/ha. Although the apparent withdrawal of water for irrigation is 9 570 m³/ha (1 780 l/kg rough rice), the water evaporated is 5 100 m³/ha (946 l/kg rough rice), or the water evaporated and that seeps is 11 330 m³/ha (2 110 l/kg rough rice).

The baseline (chosen in this example being the natural system) implies a non-irrigation system with rainfed paddies. The production of rough rice is 3,59 t/ha in the area, assuming rainfed practices in Monsoon Asia. As the withdrawal of water for irrigation is zero, the water evaporated is 2 390 m³/ha (668 l/kg rough rice), or the sum of the water that evaporates and that seeps is 7 920 m³/ha (1 480 l/kg rough rice).

The difference between the baseline and the irrigated system gives the following results for water use: Due partly to the difference of yields between irrigated and baseline systems, the total water of both evapotranspiration and seepage (water consumption for rice) for an irrigation system decreases just by 100 l/kg rough rice to the baseline. This number indicates that irrigation in this example is quite an efficient water use activity.

The groundwater recharging of rice paddies in this particular example is 1 160 l/kg at basin level.

The major factor contributing to the water inventory, in this example, is irrigation water use.

This example shows the value of modelling at the basin scale rather than that at the field scale as the amount of water consumed by a crop is not necessarily the amount of water diverted for irrigation. This is where the consideration of a baseline in the modelling is important.

6.3 Example C – Water scarcity footprint of municipal water management

6.3.1 Goal and scope

This example illustrates how the water scarcity footprint of a system varies depending upon location, its application and use in options comparison.

A water utility is investigating the water scarcity footprints of three options (A, B and C) for the supply of 100 m³ of water to a user in the industrial sector (therefore the functional unit is 100 m³). The boundaries of the system are illustrated in [Figure 5](#) showing where water is extracted from the environment, and returned to the environment.

The three options for supply of water are:

- A: Freshwater from Reservoir X in a region with high water scarcity;
- B: Freshwater from Reservoir X + freshwater from Reservoir Y in a region with relatively low water scarcity;
- C: Freshwater from Reservoir X + recycling of treated waste water back to Reservoir X.

The elementary water flows are the freshwater inflows to the reservoir(s) (runoff and rainfall), evaporation losses and treated waste water discharged to the sea. For simplicity, other flows such as losses at the water treatment plant and in the distribution network are not considered. The water footprint inventory associated with background processes used in each of the three scenarios is neglected, as it is the same in each case (assuming that reservoir X and Y are of the same size and structure, and distance to the user).

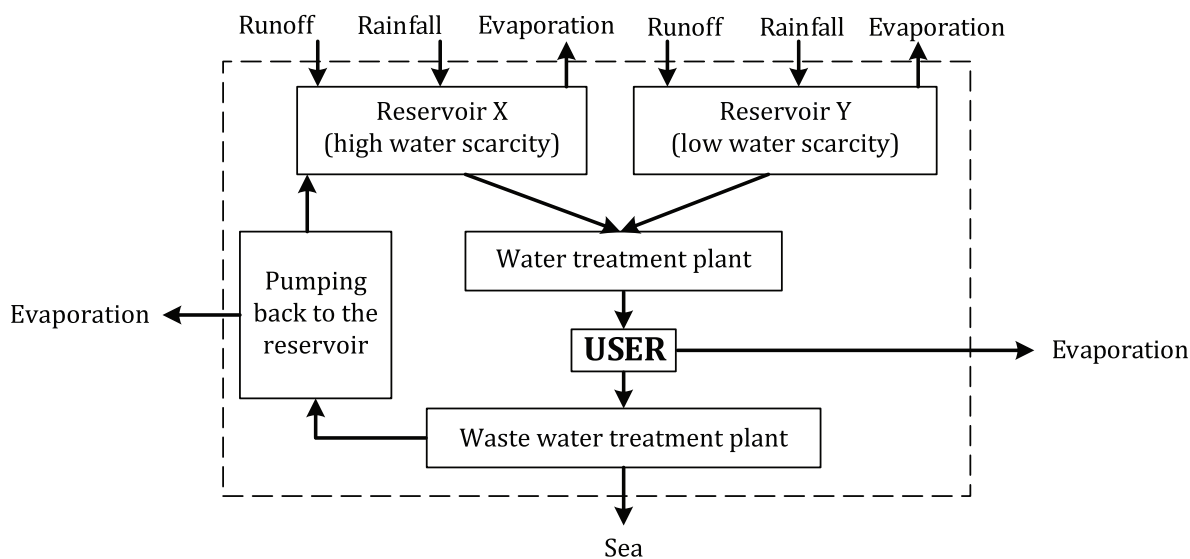


Figure 5 — Option for the supply of water to user

6.3.2 Inventory

The inventory is shown in [Table 4](#). Losses incurred during pumping back to the reservoir are estimated at 9 %. A life cycle inventory using background databases shows that treating used water to the level that can be returned to user, including the associated infrastructure and energy, consumes 1 m³ per 10 m³ reused water.

Table 4 — Inventory of the different options (in m³ per functional unit)

Line no.	Region	Option A ^a	Option B ^a		Option C ^a	
		X	X	Y	X	Z
1	Sum of runoff and rainfall inputs to the reservoir	111	71	40	71	—
2	Pumping back to the reservoir X (after losses from pumping back)	—	—	—	40	—
3	Evaporation from reservoir	11	7	4	11	—
4	Water input to water treatment plant	100	64	36	100	—
5	Water delivered to user	100	64	36	100	—
6	Water evaporated by user	30	19,2	10,8	30	—
7	Used water to waste water treatment plant	70	44,8	25,2	70	—
8	Treated waste water discharged to the sea	70	44,8	25,2	26	—
9	Losses during pumping back to reservoir X	—	—	—	4	—
10	Water consumed associated with the infrastructure used to allow the reuse (treating treated used water to the level that can be returned to the reservoir as well as the associated infrastructure and energy)	—	—	—	—	4

^a This table uses fictive values which are not intended to be reproduced.

6.3.3 Impact assessment

The water scarcity footprint is calculated as the water consumed multiplied by the characterization factor for scarcity (being here, for example, the method of WULCA (Boulay et al. 2016)^[5]) for each region where water consumption occurs (indicated in [Figure 5](#)).

The location Z where the water is consumed is unknown and is therefore assumed to be at the global average characterization factor for water scarcity (value of 20 for non-agricultural use type). The results of the impact assessment are shown in [Table 5](#).

Table 5 — Water scarcity footprint results (per functional unit)

Region	Option A	Option B		Option C	
	X	X	Y	X	Z
Water consumption (m ³)	111	71	40	71	4
Characterization factor for the local water scarcity	80	80	4	80	20
Water scarcity footprint (m ³ H ₂ O-eq)	8 880	5 680	160	5 680	80
Water scarcity footprint (m ³ H ₂ O-eq)	8 880	5 840		5 760	

6.3.4 Interpretation

In this example, option C has the lowest water scarcity footprint, followed closely by option B. However, the differences between the water footprint results of alternative products, processes or organizations may not always be significant. In fact, in this example, when considering uncertainties associated with inventory values and especially the characterization factors for local water scarcity, it is fair to assume that options B and C have a similar water scarcity footprint but are both lower than option A.

NOTE It does not make a difference whether the water is evaporated by the user or discharged into the sea as in both cases it is not returned to the environment as freshwater. The impacts related to water scarcity occur at the place of water withdrawn and not where the water is evaporated or released into the sea.

6.4 Example D – Water scarcity footprint of rice cultivation (cradle-to-gate)

6.4.1 Goal and scope

This illustrative example describes the calculation of a water scarcity footprint, from cradle to farm gate of rice cultivated in a high water stress location, according to the method of Ridoutt and Pfister (2010)[6], using local characterization factors from Pfister et al. (2009)[7].

6.4.2 Inventory

In this example, the unit process “rice cultivation” involves elementary flows of rainfall (0,63 MI/ha) and surface water used for irrigation (9,9 MI/ha) during the cropping period (Figure 6). Other flows, determined by APSIM (Keating et al. 2003[26]) modelling, are evaporation from ponded water (3,2 MI/ha), transpiration (6,4 MI/ha) and drainage to saline coastal groundwater (0,93 MI/ha). At the larger spatial scale, encompassing many individual rice fields, sideward flows between individual rice fields are disregarded. APSIM modelling is also used to determine that no deep drainage occurs under a scenario without rice cultivation and irrigation.

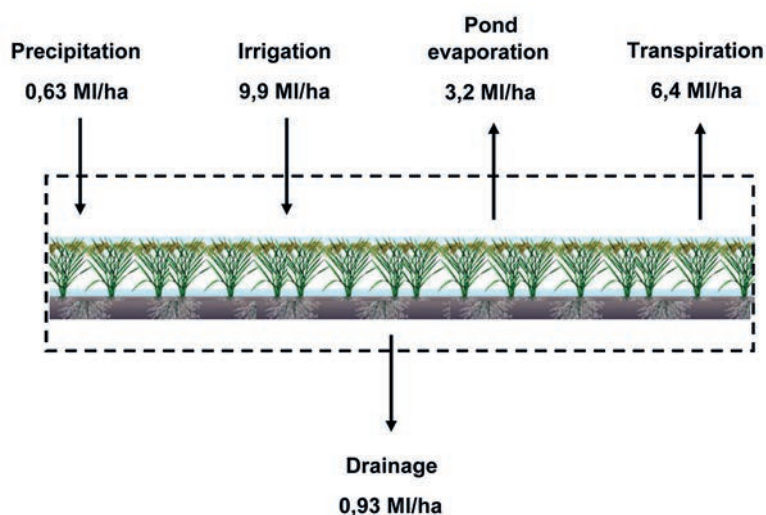


Figure 6 — Elementary flows of water in the rice cultivation example

Rice cultivation also uses a variety of material inputs (e.g. fuels, fertilizers and other agricultural chemicals). The water consumed to manufacture the material inputs used to cultivate 1 ha of rice field is estimated as 0,012 MI based on best available data from a data provider. The location of water use for the production of these material inputs is unknown.

The production of rough rice is 8,7 t/ha at farm gate.

6.4.3 Impact assessment

The input of freshwater for irrigation is 9,9 MI/ha (1 134 l/kg rough rice) at a location of high water scarcity (WSI of 1,00).

The rice cultivation system results in an increase of drainage (0,93 MI/ha). However, this drainage is to saline coastal groundwater and is therefore no longer useable as freshwater.

The freshwater consumed in the manufacture of material inputs (0,012 MI/ha or 1,4 l/kg rough rice) occurs at an unknown location. Therefore, the national average WSI (in this case 0,72) is applied.

To calculate the water scarcity footprint according to Ridoutt and Pfister (2010)[6], each instance of water consumed is multiplied by the relevant local WSI and divided by the global average WSI. These