Chapter 3 THE DATA COLLECTION AND COMPILATION PROCESSES

This chapter is based on the list of data items of the IRWS. The different sources of data are discussed as well as the particularities of the data corresponding to different aspects of the natural and economic water cycles. The importance of prioritizing the data items according to each country's water policies are highlighted.

The methodologies to collect data are discussed, including the use of water monitoring networks, surveys, censuses and administrative records. How and when estimates should be used is another topic of this chapter. The chapter also addresses the issues of data editing, imputation and validation. The chapter also includes a description of any relevant adjustments that are needed for the water accounts. The explanations are illustrated with several examples and exercises.

I. Physical data items of stocks and flows within the environment
- Surface water stocks (data items A)
- Groundwater stocks (data items A)
- Precipitation and Evapotranspiration (data items B and C.2)
- Inflows and outflows to/from other territories and the sea (data items B.2 and C.2)
- Other flows within the environment (data items D)

II. **Physical data items of flows to/from and within the economy**
- Abstractions of water (data items E)
- Water supplied and received by economic units (data items F and G)
- Returns of water (data items H)
- Losses (data items I)

III. **Physical data items related with polluting releases**
- Wastewater supplied and received (data items F and G)
- Wastewater returns (data items H)
- Waterborne releases to the economy and emissions (data items J and K)

IV. Monetary data items
- Value and costs of water and sewerage services (data items L)
- Taxes, subsidies and investment grants (data items M and N)
- Assets, investments and depreciation (data items O to Q)
- Tariffs and charges for water supply and sewerage services (data items R)

V. Social demographic data items
- Main source of drinking water used by populations (MDG, data items S)
- Main type of toilet and sewage disposal used by populations (MDG, data items T)

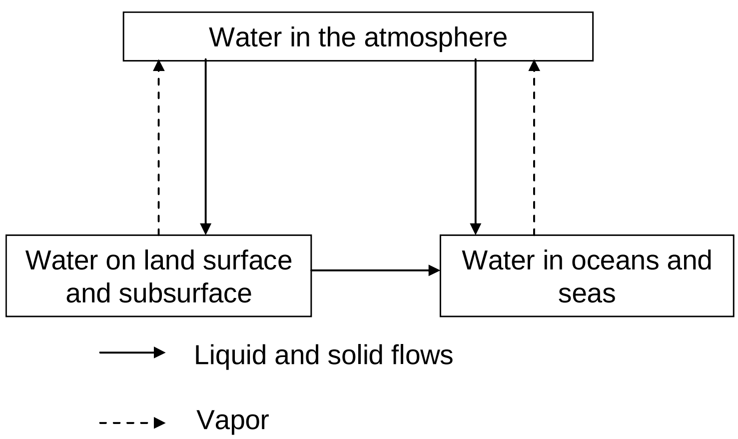
.I. Physical data items of stocks and flows within the environment, subheadings A to D in the IRWS

Physical data items of stocks and flows within the environment include the following:

- A. Inland water stocks
  - A.1. Surface water stocks
  - A.2. Groundwater stocks
- B. Inflow of water to a territory´s inland water resources
  - B.1. Precipitation
  - B.2. Inflow of water from neighboring territories
- C. Outflow of water from a territory’s inland water resources
  - C.1. Evapotranspiration from inland water resources
  - C.2. Outflow of water to neighboring territories and the sea
- D. Natural transfers between other resources in the territory
  - D.1. From surface water to groundwater
  - D.2. From groundwater to surface water
  - D.3. Between surface water resources
  - D.4. Between groundwater resources

The natural cycle of water, the hydrological cycle, involves connections between the atmosphere, the oceans, and land surface and sub-surface, as shown in the following figure.

Figure 3.1.1 The water cycle



Source: UNSD.- SEEA-CF 2012. Figure 5.11.1.

The SEEA-Water focuses on the inland water resources of a country or territory and the flows of water to and from the economy of that country or territory. Inland water resources include surface water, groundwater and soil water within the boundaries of a country or territory. The data items that are collected for water accounts are described below:

Stocks of water resources (data item **A**) include **surface water stocks** (data item **A.1)**, **groundwater stocks** (data item **A.2**), and **soil water stocks** (data item **A.3**).

Surface water stocks include, among others, the water stored in **artificial reservoirs** (data item **A.1.1)** and **lakes** (data item **A.1.2**). Usually the different water management agencies keep track of the volume of water stored in artificial reservoirs and lakes. The depth of water in artificial reservoirs and lakes is measured using measuring sticks (limnimeters) permanently installed in some specific locations of the reservoir or lake. The depth of water is transformed into volume using storage capacity curves. Usually daily, or sometimes even hourly, measurements are available. The availability of the measurements depends on the relevance of the reservoir or lake for water management. The volume of water in reservoirs and lakes used for flood protection has to be closely monitored especially during a storm. Also, artificial reservoirs and lakes used for water supply or hydroelectricity are constantly monitored.

Measuring the volume of water in **rivers and streams** (data item A.1.3) is usually considered not relevant for water resources management and may be difficult to properly use when compiling water accounts, so for most cases it is recommended not to use them in the accounts. The volume of water in **wetlands (A.1.4)** may also be difficult to obtain. In some cases lakes are classified as wetlands. The volume of water in **snow, ice and glaciers** (data item **A.1.5**) may be difficult to estimate, but may be relevant for some countries.

Groundwater stocks (data item **A.2**) are not as readily available as the information on surface water stocks. Groundwater stocks may be estimated from the water tables in aquifers based on records from piezometric measurements in different points. It is very important to first understand the delimitation of the different aquifer systems of the country or territory.

Soil water stocks (data item **A.3**), which is the amount of water in the unsaturated layers of soil, may be harder to measure or even to estimate.

Stocks of inland water resources are increased by precipitation and inflows of water from other countries or territories. Also economic activities and households may increase the stocks of inland water resources by returning some or all the water they abstracted, as will be described in the following section of this chapter.

Precipitation (data item **B.1**) within countries or territories is usually one of the main sources of renewable water resources. Data about precipitation is collected daily or even hourly through meteorological or climatologic stations, usually operated by national meteorological agencies. The national meteorological agencies may work in coordination with other agencies, which due to the nature of their activities, collect meteorological and climatic data (e.g. agencies in charge of electricity production, airport authorities, etc).

For water accounts the data collected in the different stations (points) has to be aggregated to obtain the total volume of precipitation falling in the territory. In order to aggregate data from each station, which is expressed in height units (e.g. millimeters or inches), it is necessary to determine a weighted average of the precipitation based on the area of influence of each rainfall gauge as will be described bellow.

Inflows of water from upstream countries or territories (data item **B.2**) is another important source of renewable water for many countries that share watersheds or river basins (transboundary watersheds). They include surface and groundwater naturally flowing from the neighboring territories. Inflows include the flows of rivers or streams crossing the borders of two countries, and the flows of the rivers or streams that are used as borders. For the latter it is necessary to estimate the share of the bordering river or stream that corresponds to each of the bordering countries. The flow of groundwater from one country to another may be more difficult to trace, and few agreements or treaties between countries consider it.

Data about the amount of water flowing through transboundary rivers may be collected regularly using stream gauges. If there is a treaty among the territories sharing the watersheds, the amount of water crossing the borders may be clearly specified (data item **B.2.1**), and it may be regularly monitored by the transboundary agency set in place for the compliance of the treaty.

Groundwater flowing across borders is difficult to measure and only estimates, based on the characteristics of the soil and precipitation patterns, may be available.

Stocks of inland water resources are decreased by evapotranspiration, outflows to other countries or territories, and the sea. Also, economic activities and households may decrease the stocks of inland water resources by abstracting water, as will be described in the following section of this chapter.

Evapotranspiration (data item **C.1**) is the total quantity of water transferred from the Earth to the atmosphere. A large portion of the precipitation is almost immediately returned to the atmosphere as evaporation and transpiration. The rest of the precipitation, often called effective precipitation, falls on the ground and flows through the territory (data item D) as surface runoff or as infiltration in the soil.

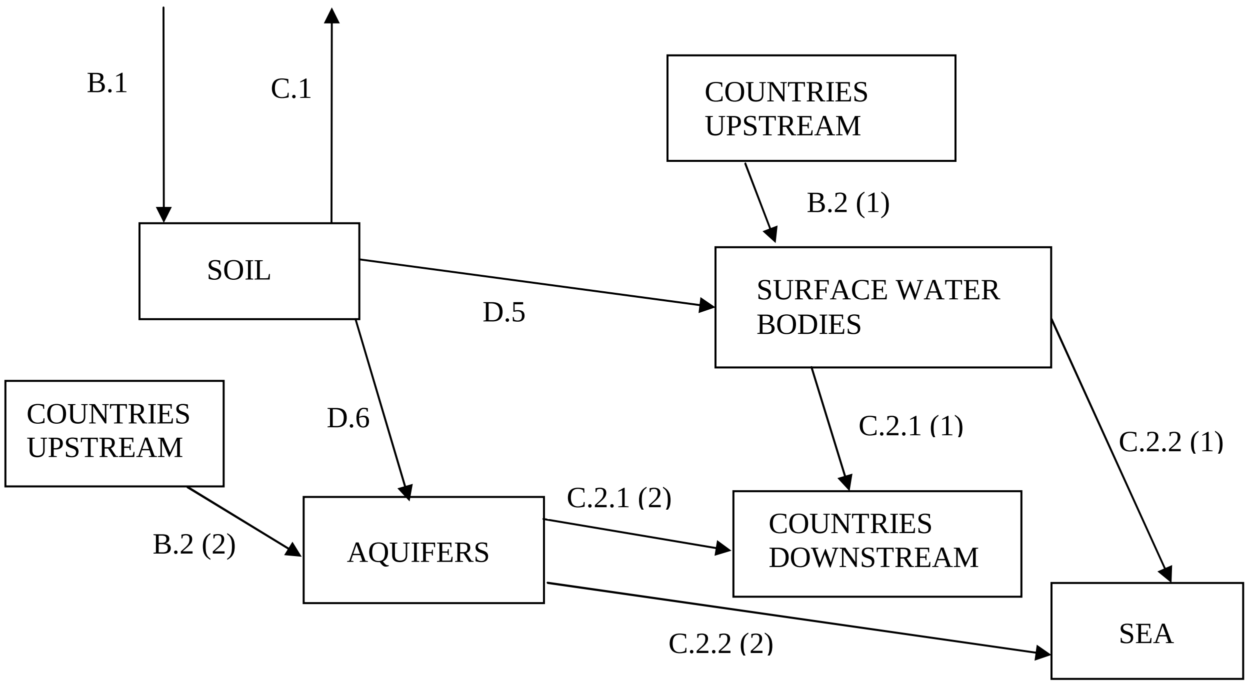
The evapotranspiration is not regularly measured as the precipitation is. The evapotranspiration is estimated through several methods. Often the evapotranspiration is estimated as a residual of precipitation less the amount of water that flows as surface runoff and the amount that percolates or infiltrates underground recharging the aquifers. Runoff and infiltration are estimated using empirical coefficients specific for each territory. Measurements from stream gages also provide data useful for the estimation of the runoff. Estimates of the evapotranspiration can be provided by the agency in charge of calculating the water balances (or water budgets), typically the Ministry or Agency in charge of water resources management. Evapotranspiration (data item C.1) should not be confused with the potential evaporation measured with pans (pan evaporation) in climatologic stations, nor with the reference evaporation (ET_o) used for calculating crop evapotranspiration for irrigation plans.

Outflows of water to downstream territories (data item **C.2.1)** is the same as inflows of water (data item B.2) described above, but viewed from the side of the upstream territory.

Outflows of water to the sea (data item **C.2.2**) include surface and groundwater "naturally" flowing to the sea. They include the amount of water from rivers and streams that flow to the sea. They also include the amount of groundwater flowing to the sea. If there are stream gauges at the mouth of rivers then these measurements can be used to estimate the total amount of surface water flowing to the sea. The flow of groundwater to the sea is more difficult to estimate. Estimates can be made by the specialists based on the soil characteristics and measurements of the piezometric levels of the water flowing to the sea.

<u>Natural transfers between other resources</u> in the territory occur between surface, groundwater and soil water resources. It is common to simplify the water cycle as precipitation falling on the soil (data item B.1), then becoming surface water (data item D.5) or groundwater by infiltrating to the aquifers (data item D.6), or simply returning to the atmosphere by evapotranspiration (data item C.1). Water eventually leaves the country or territory by flowing to the sea (data item C.2.2) or flowing to another country or territory downstream (data item C.2.1). Se figure 3.1.2 below.

Figure 3.1.2 Simplified diagram of flows of the natural water cycle



Natural flows are affected by abstractions and returns of water done by the different economic activities and households, as will be described in the next section of the chapter.

<u>Integrating data into the accounts</u>

The data available from different sources has to be processed in order to be incorporated in the accounts. The data items corresponding to the hydrologic cycle need to be combined with data about flows to the economy and from the economy (abstractions [E], returns [H], and losses [I]), which will be described in the following section of this chapter.

It is unlikely that a country has information about all the data items, therefore it is important to set priorities in the process of data collection and compilation.

The table below shows the standardized asset account table with the data items needed to complete it.

Table 3.1.1 Physical asset account for water resources showing relevant IRWS data items

	Artificial reservoirs	Lakes	Rivers and streams	Wetlands	Glaciers, snow and ice	Aquifers	Soil water	TOTAL
Opening stock of water	**Opening A.1.1**	**Opening A.1.2**		**Opening A.1.4**	**Opening A.1.5**	**Opening A.2**		**Opening A.1 + Opening A.2**
Additions to stock								
Precipitation	B.1 (1)	B.1(2)	B.1(3)	B.1(4)	B.1(5)		B.1(6)	B.1 (1 to 6)
Inflows from other countries	B.2 (1)					B.2 (2)		B.2
Inflows from other inland water resources	D.2 + D.3 + D.5					D.1 + D.4 + D.6		D.1 + D.2 + D.3 + D.4 + D.5 + D.6
Returns	H.1.1.1	H.1.1.2	H.1.1.3	H.1.1.4		H.1.2 + I.1		H.1 + I.1
Reductions in stock								
Evaporation and/or transpiration (evapotranspiration)	C.1.1 (1)	C.1.1 (2)		C.1.1 (3)	C.1.1(4)*		C.1 - C.1.1 (1 to 4)	C.1
Outflows to other countries	C.2.1 (1)					C.2.1 (2)		C.2.1
Outflows to other inland water resources	D.1 + D.3					D.2 + D.4	D.5 + D.6	D.1 + D.2 + D.3 + D.4 + D.5 + D.6
Outflows to the sea	C.2.2 (1)					C.2.2 (2)		C.2.2
Abstractions	E.1.1.1	E.1.1.2	E.1.1.3	E.1.1.4		E.1.2		E.1
Closing stock of water	**Closing A.1.1**	**Closing A.1.2**		**Closing A.1.4**	**Closing A.1.5**	**Closing A.2**		**Closing A.1 + Closing A.2**

Source: adapted from table 5.11.2 of the System of Environmental-Economic Accounts (SEEA)

The information shown may be too much to be collected on a first stage. Therefore the table can be constructed with a first set of data items as shown below. The following table shows the most relevant data items, which could be used in a first stage of preliminary accounts.

Table 3.1.2 Physical asset account showing IRWS data items to be collected on a first stage

	Artificial reservoirs	Lakes	Rivers and streams	Aquifers	Soil water	TOTAL
Opening stock of water	**Opening A.1.1**	**Opening A.1.2**		**Opening A.2**		**Opening A.1 + Opening A.2**
Additions to stock						
Precipitation					B.1	B.1
Inflows from other countries			B.2			B.2
Inflows from other inland water resources	D.5			D.6		D.5 + D.6
Returns	H.1.1			I.1		H.1 + I.1
Reductions in stock						
Evaporation and/or transpiration (evapotranspiration)					C.1	C.1
Outflows to other countries			C.2.1			C.2.1
Outflows to other inland water resources					D.5 + D.6	D.5 + D.6
Outflows to the sea			C.2.2			C.2.2
Abstractions	E.1.1			E.1.2		E.1
Closing stock of water	**Closing A.1.1**	**Closing A.1.2**		**Closing A.2**		**Closing A.1 + Closing A.2**

In the table above it is assumed that simply all the precipitation (data item B.1) falls on the whole land area of the country, without identifying the precipitation that falls on the reflecting pools of artificial reservoirs, lakes, and wetlands, which typically represent less than 10% of the area of a country.

All the evapotranspiration (C.1) is lumped into the soil water column. It is assumed that the water falling on the soil either runs off as surface water (D.5) or infiltrates to aquifers (data item D.6). Water entering the country or territory is in rivers and streams (B.2). This simplification provides the following equation:

$$B.1 - C.1 - D.5 - D.6 = 0$$

Therefore, the evapotranspiration can be estimated as follows: C.1 = B.1 – D.5 – D.6. This equation and more detailed ones are used for water balances done by water agencies and ministries. Water balances are a very important source of information for the water accounts.

A brief description of the raw data and processing needed to incorporate the data in the accounts is described below.

Data item	Raw data that can be used	Processed data to for the accounts
A.1.1 Water stocks in artificial reservoirs	• Water levels measured in limnimeters at different points in time. • Storage capacity curves.	• Integrated inventory of artificial reservoirs. • Volume of water at the beginning or end of each year, or even of each month. • Also useful to have volume of water at the beginning or end of each month.
A.1.2 Water stocks in lakes	• Water levels measured in limnimeters at different points in time. • Storage capacity curves	• Integrated inventory of lakes. This inventory could be integrated to the inventory of artificial reservoirs. • Volume of water at the beginning or end of each year, or even of each month. • Also useful to have volume of water at the beginning or end of each month.
A.1.3 Water stock in rivers and streams	• Flow of water measured in stream gages. To be used for estimating flows and not stocks.	• Not recommended to consider as a stock or water.
A.1.4. Water stock in wetlands	• For some wetlands, possibly water levels measured in limnimeters at different points in time. • Estimate of the volume of water in wetlands.	• If the wetland can be considered a lake, integrate in inventory of lakes and process as a lake. • Other wetlands can be incorporated in a specific

Data item	Raw data that can be used	Processed data to for the accounts
		inventory of wetlands.
A.1.5. Water stock in snow, ice and glaciers	• Estimates of the volume of snow, ice and glaciers.	• Water content in volume of snow, ice and glaciers.
A.2 Groundwater stocks	• Piezometric levels at some points.	• Inventory of aquifers (specify delimitations). • Estimates of the volume of water at the beginning or end of each year.
A.3 Soil water stocks	• Estimate of humidity in the soil at different points in time.	• Estimate of the volume of water in soil. Need to separate from wetlands (configuration defined) and aquifers (areas with 100% saturation).
B.1 Precipitation	• Daily precipitation data by climatologic station.	• Average annual precipitation volume for the whole country or territory, or by hydrologic units. Precipitation can be added is available as volume, or converted if height and area are provided. • Also, as a reference, long term average annual and monthly precipitation ("normal" precipitation) expressed as height and as volume.
C.1 Evapo-transpiration	• Daily evaporation measured in climatologic stations using evaporation pans.	• It can be estimated as the difference between total precipitation less surface runoff and infiltration (see explanation above).
B.2 Inflows from countries upstream.	• Data from stream gages. • Data from reservoirs shared with the country upstream. • Information of international treaties for transboundary watersheds and aquifers.	• Annual volume of surface water flowing from one country to the other. • Also, estimates of the annual volume of groundwater flowing from one country to the other.
D.5 Surface runoff	• Data from stream gages	• Annual volume of surface water that would flow in a watershed if no abstractions and returns existed. Information from water balances by hydrologic units.
D.6 Infiltration to aquifers	• Piezometric levels, aquifer configurations, types of soil.	• Annual volume of water that infiltrates to the aquifers.
C.2.1 Outflows to	• Data from stream gages.	• Same as B.2, but in relation to

Data item	Raw data that can be used	Processed data to for the accounts
countries downstream	• Data from reservoirs shared with the country downstream.	downstream countries.
C.2.2 Outflows to the sea	• Data from stream gages	• Annual volume of water discharged to the sea by rivers and streams. • Also, estimates of the volume of water discharged by aquifers to the sea.

Processing water stock data

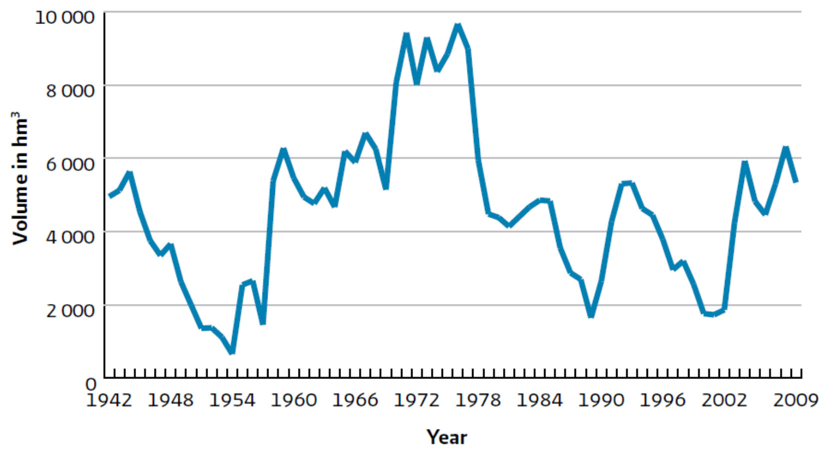
Surface water

Data on surface water stocks may be easier to obtain than that of other water stocks. It is therefore advisable to start the data compilation process with surface water stocks.

An inventory of artificial reservoirs and lakes is usually the starting point. For each artificial reservoir or lake it is important to collect data about the storage capacity, as well as the volume of water stored at regular intervals of time (once a year or even once a month). The level of water is usually measured as depth of water in the reservoir or lake. The depth of water is transformed into volume using storage capacity curves, which may change with time due to silting of the reservoirs. Bathymetric studies have to be performed in order to redefine the configuration of the reservoirs and lakes, and determine the storage capacity curves when they change over the years (usually through long periods of time).

Long time series of water stocks in specific lakes and reservoirs, as well as the aggregated data of all the lakes and reservoirs of a country or territory are useful for understanding the cyclic variations of precipitation and runoff in a country or territory. The graph below shows the volume of water stored in a lake from 1942 to 2009 (for the 1st of January of each year). The graph is helpful for understanding the cycles of droughts. Most likely, in the area of the example, severe droughts occurred around the years 1954, 1990, and 2002.

Figure 3.1.3 Water stock in a lake 1942 to 2009



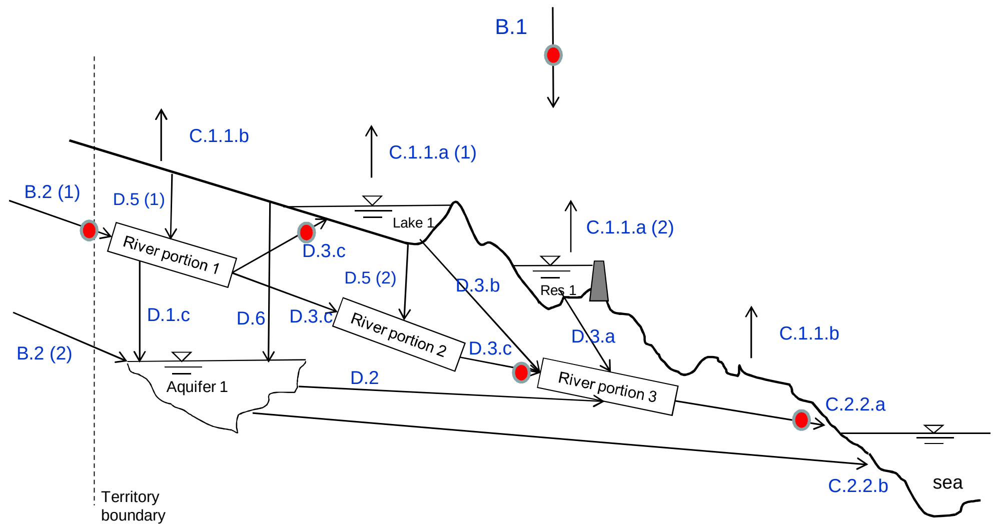
Groundwater

For groundwater stocks it is useful to create an inventory of aquifers and identify the volume of water recharged to each aquifer, as well as the amount of water abstracted through specialized studies. It is necessary to first define the configuration of the aquifer systems (recharge area, storage zone, discharge area, etc.) Piezometric levels at different points of the aquifer can be useful for identifying changes in stock of water of each aquifer. All this information is collected and process by the agencies in charge of water resources management: water resources ministry, water agency, or water commission.

Processing water flow data

The following figure depicts the main natural flows of water in a country or territory. The red circles show the points in which the flows are traditionally measured: B.1(precipitation) is measured with rain gages in climatologic stations, B.2(1) (surface water from neighboring territories), D.3.c (flows from rivers to other surface waters) and C.2.2.a (surface water to the sea) are measured using stream gages located at selected points of rivers and streams. Empirical coefficients and models are used to estimate the other flows, which may be calibrated using the measured flows.

Figure 3.1.4. Typical points of measurement of the flows of the natural water cycle



Precipitation

In order to obtain the precipitation of a country or territory it is necessary to convert the precipitation data collected in different stations located throughout the territory into a total volume of water. In order to do this, an "area of influence" has to be assigned to each data point, to compensate for the irregular distribution of the stations.

There are different methods to obtain the precipitation of a country or territory based on the data from rainfall stations. A widely used method is the Thiessen polygons method, which consists on dividing the territory into regions surrounding each rainfall station. The resulting regions are such that every point inside of them is closer to the station to which it belongs than to any other station. This method in mathematics is known as the method of Voronoi diagrams.

Also, the isohyets can be drawn by interpolating the different data points in order to obtain curves of equal precipitation. From the contours formed it is possible to determine the volume of precipitation that fell on a territory.

The methods mentioned above can be applied using Geographic Information Systems (GIS) software. Sometimes it is necessary to average precipitation for different regions. For this, it is important to use the area of each region to obtain the volumes of precipitation, which can then be added.

PRECIPITATION EXAMPLE (Akvokolekta country):

According to the Meteorological Bureau of the country of Akvokolekta, the average precipitation in the territory in 2010 was 601 mm. Since the area of the country is 2 395 km^2 then the total volume of precipitation in the country in 2010 was:

$2\,395\ km^2 \times 601\ mm \times 1000\,000\ m^2/km^2 \times\ 0.001\ mm/m = 1\,439\,395\ m^3$

Which is equivalent to 1.44 million cubic meters or 1.44 hm^3.

The Water Resources Unit of Akvokolekta estimated that the evapotranspiration in the country in 2010 was of about 58% of the precipitation:

Evapotranspiration = 1.44 hm^3 x 0.58 = 0.835 hm^3

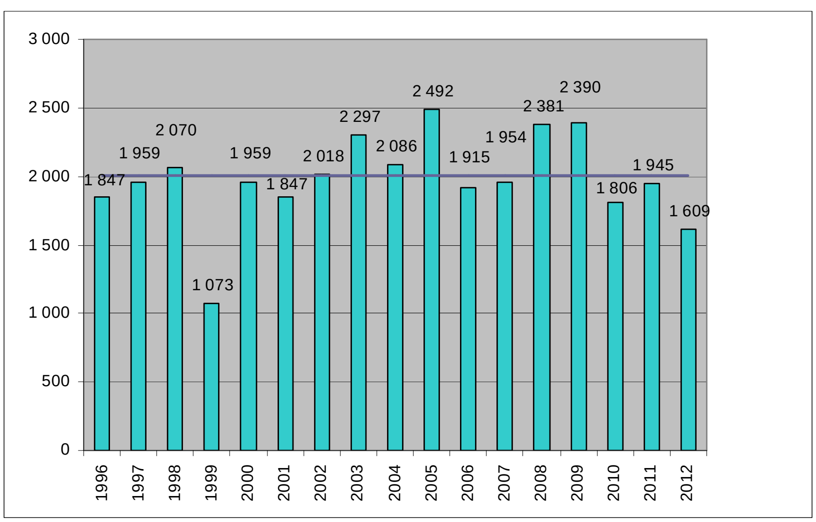
The following data is necessary for water accounts:

- Annual accumulated precipitation: precipitation falling during the year in a country or territory. It is useful to have long time series in order to identify variations through the years.
- Annual normal precipitation: normal is a long term average used for climatologic variables. It corresponds to the annual average for a period of 30 years or more (e.g. 1961-1990, or 1971-2000).
- Monthly normal precipitation: the average monthly precipitation for a period of 30 years or more. This information is useful to identify the annual pattern of rain, in many cases with a clearly identified rainy season and a dry season.

The data should be expressed as volume of water to be used in water accounts, and also in height or depth units (e.g. millimeters or inches) for comparison purposes, and also because the raw data is collected in height or depth units.

The figure below shows the precipitation in the island of Mauritius from 1996 to 2012. In the year 1999, a strong "La Niña" year the precipitation was 47% below the 1971-1990 normal.

Figure 3.1.5. Average annual precipitation in Mauritius



Evapotranspiration

Evapotranspiration can be estimated as the difference of precipitation less surface runoff and less infiltration to the aquifer, as explained above: C.1 – B.1 – D.5 – D.6

In dry countries, where evaporation is limited by the available water, evapotranspiration increases with the amount of water entering the territory (B.2). That is, if more water enters the territory more water is available for evaporation. This amount may not be very significant when compared with the total amount of precipitation and evapotranspiration in a country. In wet countries evapotranspiration does not change with additional water entering the territory, since without B.2 there is already enough water for reaching the full evaporation potential.

Evapotranspiration may be in the range of 30% to 70% in countries with abundant precipitation (more than 1000 mm/year), and is usually more than 90% in countries with low precipitation (precipitation of less than 600 mm). Values between 70% and 90% are found in all the other countries. Some examples are shown below:

LONG TERM AVERAGE ANNUAL PRECIPITATION IN DIFFERENT COUNTRIES

Algeria:	89 mm/year (211 975 hm^3/year). Evapotranspiration = 95% of precipitation.
Australia:	472 mm/year (3 617 000 hm^3/year). Evapotranspiration = 88% of precipitation.
Mauritius:	2 011 mm/year (3 751 hm^3/year). Evapotranspiration = 30% of precipitation.
Mexico:	760 mm/year (1 489 000 hm^3/year). Evapotranspiration = 73% of precipitation.
Brazil:	1 782 mm/year (15 173 516 hm^3/year). Evapotranspiration = 64% of precipitation.

Also the evaporation (data item C.1.1) can be calculated for the different artificial reservoirs and lakes, even though it usually represents a small portion of the total evapotranspiration (data item C.1), it is useful for estimating the water available for use from artificial reservoirs and lakes.

Surface runoff and infiltration to the aquifers

Usually data is collected from stream gages located at different points of rivers and streams. The data has to be interpreted in order to calculate the total runoff (data item D.5) in a watershed or catchment, and then aggregated for a country or territory. Empirical coefficients are used to estimate surface runoff in watersheds that do not have stream gages. The aquifer recharge or infiltration to aquifers (data item D.6) is also estimated based on the characteristics of each aquifer recharge zone. Rain runoff models can be used for developing better estimates of D.5 and D.6 in specific watersheds.

The amount of water flowing to the sea (data item C.2.2) can be directly measured in rivers and streams that have stream gages located at their mouth, and estimated for the cases in which measurement is not available. The same for the inflows from countries upstream (data item B.2) and outflows to countries downstream (data item C.2.1).

Examples

The following table shows the asset accounts for Mexico with average approximate figures. For the average approximate figures it is assumed that in the long term the changes in stocks are negligible. The numbers in red are residuals for balancing the table.

Table 3.1.3 Physical asset account for Mexico with average approximate figures

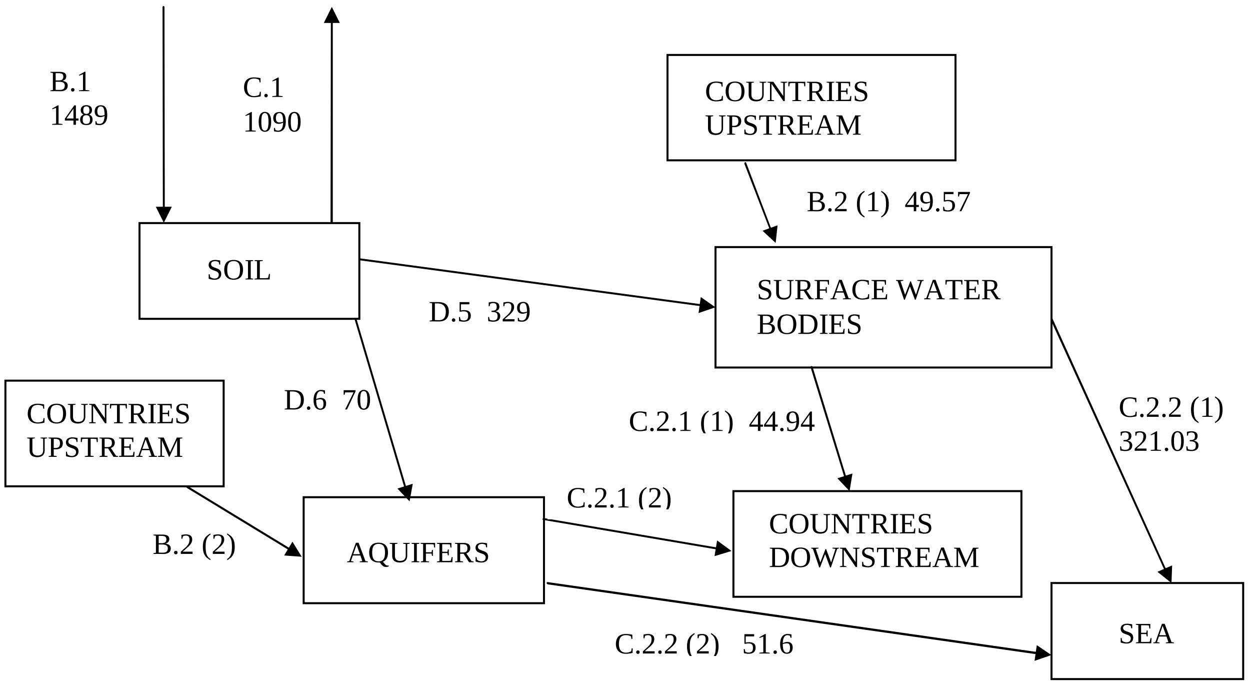
(units in billion cubic meters of water, km^3)

	Artificial reservoirs	Lakes	Rivers and streams	Aquifers	Soil water	TOTAL
Opening stock of water	**Opening A.1.1**	**Opening A.1.2**		**Opening A.2**		**Opening A.1 + Opening A.2**
Additions to stock		**540.87**		**81.7**	**1489**	**2111.57**
Precipitation					1489	1489
Inflows from other countries		49.57				49.57
Inflows from other inland water resources		329		70		399
Returns		162.3		11.7		174
Reductions in stock		**540.87**		**81.7**	**1489**	**2111.57**
Evaporation and/or transpiration (evapotranspiration)					1090	1090
Outflows to other countries		44.94				44.94
Outflows to other inland water resources					399	399
Outflows to the sea		321.03		51.6		372.63
Abstractions		174.9		30.1		205
Closing stock of water	**Closing A.1.1**	**Closing A.1.2**		**Closing A.2**		**Closing A.1 + Closing A.2**

Source: based on CONAGUA.- Statistics for Water in Mexico 2011.

The information in the table can be presented as a diagram, as shown below.

Figure 3.1.5 Simplified diagram showing flows of the natural water cycle in Mexico
(units in billion cubic meters of water, km^3)



Source: based on CONAGUA.- Statistics for Water in Mexico 2011.

Some basic indicators that can be derived from the table above are the following:

- Internal renewable water resources = B.1 – C.1 = 1 489 – 1 090 = 399
- Total renewable water resources = B.1 – C.1 + B.2 = 399 + 49.6 = 448.6
- Dependency ratio = B.2/(B.1 – C.1 + B.2) = 0.11 = 11%

Table 3.1.4 Physical asset account for the Netherlands with data of 2010
(units in billion cubic meters of water, km^3)

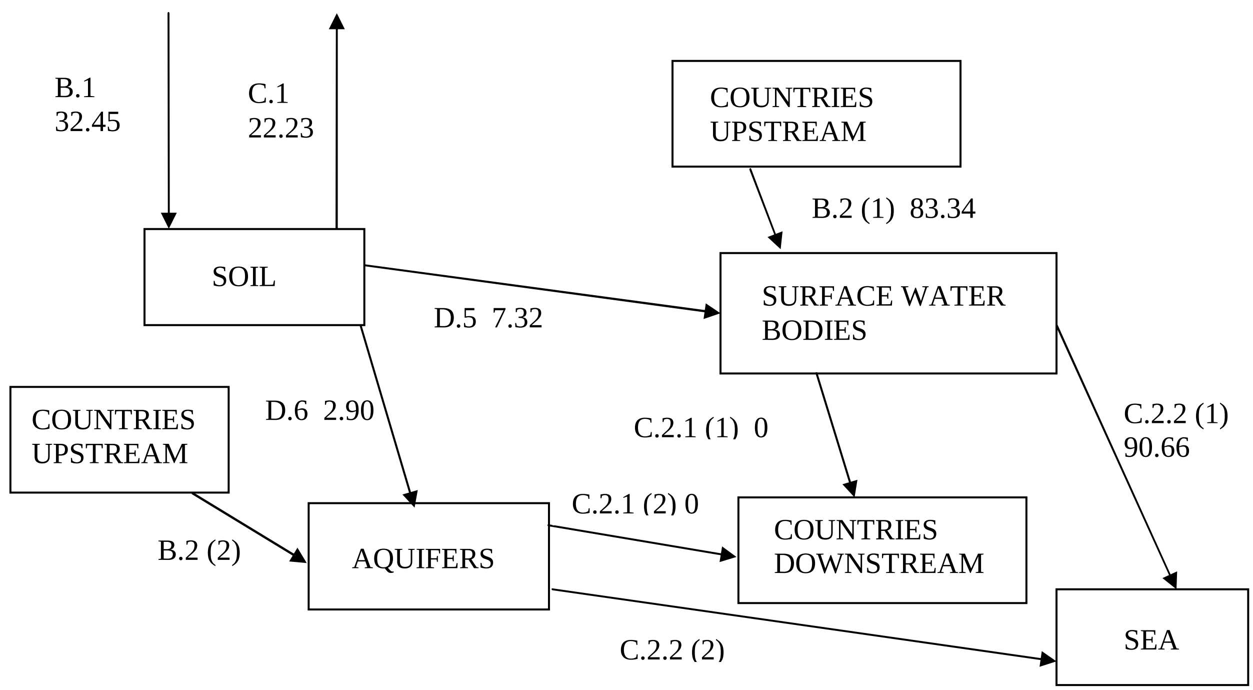
	Artificial reservoirs	Lakes	Rivers and streams	Aquifers	Soil water	TOTAL
Opening stock of water	**Opening A.1.1**	**Opening A.1.2**		**Opening A.2**		**Opening A.1 + Opening A.2**
Additions to stock		**90.66**		**2.9**	**32.45**	**126.01**
Precipitation					32.45	32.45
Inflows from other countries		83.34				83.34
Inflows from other inland water resources		7.32		2.90		10.22
Returns						0
Reductions in stock		**90.66**		**2.9**	**32.45**	**126.01**
Evaporation and/or transpiration (evapotranspiration)					22.23	22.23
Outflows to other countries						0
Outflows to other inland water resources					10.22	10.22
Outflows to the sea		90.66		2.9		93.56
Abstractions						0
Closing stock of water	**Closing A.1.1**	**Closing A.1.2**		**Closing A.2**		**Closing A.1 + Closing A.2**

Source: based on information provided by CBS Netherlands.

The information in the table can be presented as a diagram, as shown below.

Figure 3.1.6 Simplified diagram showing flows of the natural water cycle in the Netherlands

(units in billion cubic meters of water, km^3)



Source: based on information provided by CBS Netherlands.

Some basic indicators that can be derived from the table above are the following:

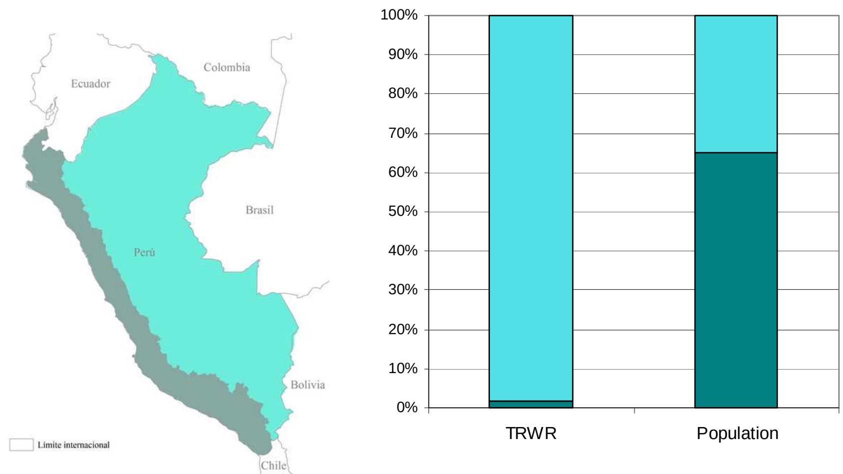
- Internal renewable water resources = B.1 – C.1 = 32.45 – 22.23 = 10.22
- Total renewable water resources = B.1 – C.1 + B.2 = 10.22 + 83.34 = 93.56
- Dependency ratio = B.2/(B.1 – C.1 + B.2) = 0.89 = 89%

Scale issues

Aggregating data through space and time (national and annual) may hide important contrasts. Therefore, while it is important to have some aggregates at the national and annual level, in many cases it is also very important to have the information for smaller territorial areas (e.g. hydrographic regions, river basins, or watersheds) and for seasons or months of the year, as illustrated by the examples below.

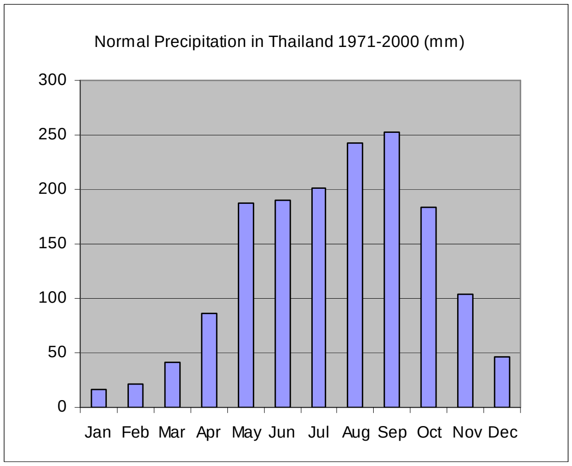
In Peru the average precipitation of the country is around 1600 mm/year. However, 80% of the population lives on the Pacific side, where the average precipitation is only 274 mm/year.

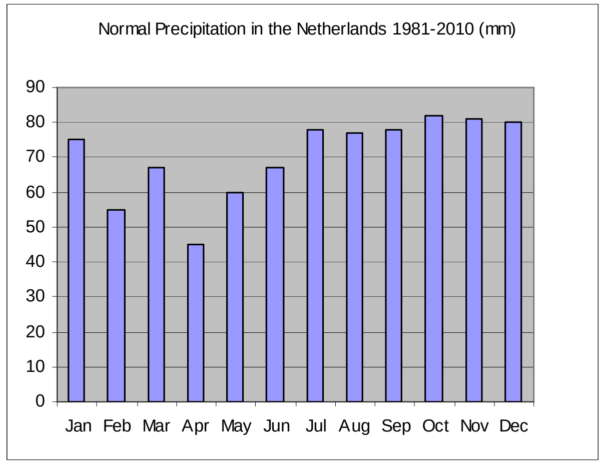
Figure 3.1.7 Geographical contrast of renewable water in Peru



In Thailand the annual average precipitation (normal precipitation 1971-2000) is 1 573 mm/year. However, 80% of it falls in the wetter half of the year, between May and October. On the other hand, the Netherlands receives an average precipitation of 845 mm/year (normal precipitation 1981-2010), but has a more uniform pattern of precipitation, receiving 52% of the precipitation in the wetter half of the year.

Figure 3.1.8 Precipitation patterns in different countries.





Initial national aggregated assessments are useful to guide the process of water accounts and statistics compilation. However, disaggregation of the data should be considered for the mid-term and long-term plans of implementation of water accounts and statistics.

Water data is usually organized by hydrologic regions comprising one or several watersheds or catchment areas. The hydrologic regions may be defined in a nested way, in order to have different levels of detail. The boundaries of the hydrologic regions rarely match the administrative and/or political boundaries, which makes it difficult to combine hydrologic information with economic and social information. Regions combining hydrologic and administrative or political boundaries (possibly at municipal level) may be created in order to be able to combine the different types of information.

Water balances, as well as data about water abstractions, are usually available in an annual basis, and therefore additional efforts need be made in order to have seasonal or monthly accounts, in case they are considered necessary.

BIBLIOGRAPHY:

World Meteorological Organization.- Guide to Hydrological Practices.- Volume I. Hydrology – From Measurement to Hydrological Information.- 2008. (WMO No. 168)

World Meteorological Organization.- Guide to Hydrological Practices.- Volume II. Management of Water Resources and Application of Hydrological Practices.- 2009. (WMO No. 168)

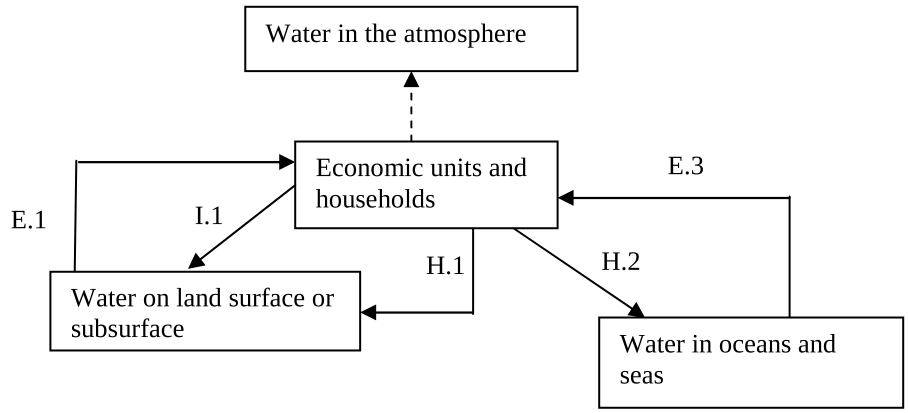
.II. Physical data items of flows to/from and within the economy

Physical data items of flows to/from and within the economy include the following:

- E. Abstraction of water
  - E.1. From inland water resources
    - E.1.1. From surface water
    - E.1.2. From groundwater
    - E.1.3. From soil water
  - E.2. Collection of precipitation
  - E.3. Abstraction from the sea
  - E.a. For own use
  - E.b. For distribution
- F. Water supplied to economic units
  - F.1. Water supplied by resident economic units to resident economic units
  - F.2. Water exported to other territories (water exports)
- G. Water received by economic units
  - G.1. Water received by resident economic units from resident economic units
  - G.2. Water imported by resident economic units from the rest of the world (water imports)
- H. Returns of water to the environment by economic units
  - H.1. To inland water resources
  - H.2. To the sea
  - H.3. To land
  - H.a. Returns of water to the environment after treatment by economic units
  - H.b. Returns of water to the environment without treatment
- I. Losses of water
  - I.1. Losses of water (CPC Ver.2 1800) in distribution

The different economic units of a country or territory abstract water (data item E.1) from inland water resources for performing the activities of production, consumption and accumulation. Water also flows from the economy to inland water resources or the rest of the environment due to returns after use (data item H.1) and also due to losses (data item I.1). A portion of the water abstracted is returned to the environment as evaporation and another portion (usually smaller) is incorporated in products. Additionally, some water is abstracted from the seas and oceans, usually for desalination (data item E.3), and some water is discharged in the seas and oceans (data item H.2). These flows are shown in the following figure.

Figure 3.2.1 Diagram of flows of water between the economy and the environment (not all flows shown)



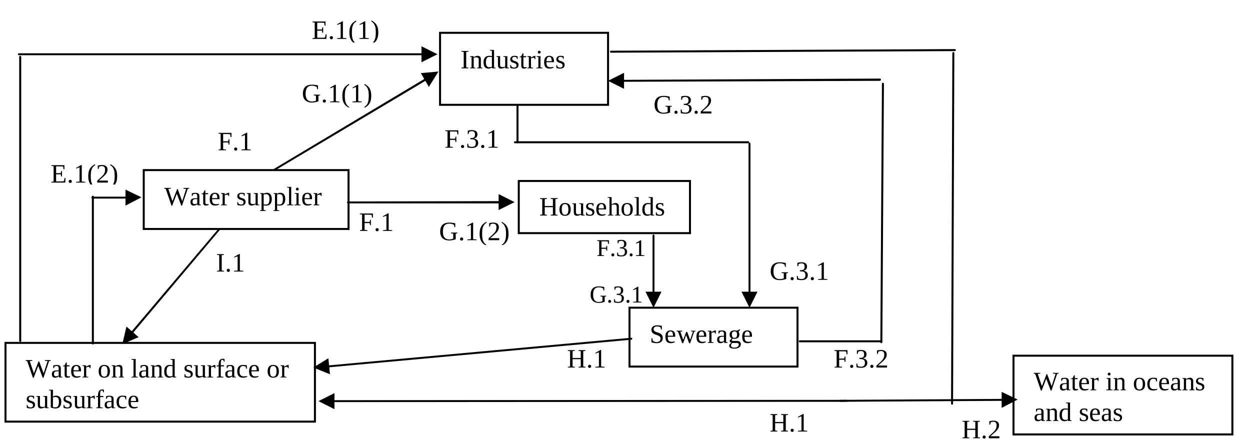
Flows of water in the economy and to/from the environment

Data about abstractions of water from inland water resources (data item E.1) by economic activities, especially from surface water (data item E.1.1) and from groundwater (data item E.1.2) are considered essential for fact based water management. Once water is abstracted from inland water resources, or even from the oceans and seas, it is important to understand how it is used by the different economic activities and households, and then returns to the environment. It is assumed that the amount of water that is accumulated in the economy is negligible, and therefore, all the water abstracted by the economy has to leave the economy as returns (data item H.1), as losses (data item I.1) or as water consumption (mainly evapotranspiration and a small portion is incorporated in products).

Once water is abstracted, it enters the economy and flows from one activity to another until it is returned to the environment. Water abstracted may be supplied to other economic units (data item F.1), mainly by the water supply industry. Water supplied is received (data item G.1) by other economic units and households.

Water is also reused in the economy and therefore wastewater can be delivered for further use (data item F.3.2), as shown in the diagram below.

Figure 3.2.2 Diagram of flows of water within the economy and to/from the environment (not all flows shown)



For the organization of the information it is important to classify the different economic activities according to the International Standard Industrial Classification of All Economic Activities (ISIC), or other equivalent classification system, so that the data is comparable with the one collected for other accounts and statistics, as well as with data from other countries. See chapter 2 for a detailed description of this.

Integrating data into the accounts

Diagrams, such as the ones shown above, are easy to understand, but when more elements are added they become too crowded and difficult to read. Also, diagrams cannot be easily entered in a computer. For the reasons mentioned above, tables are used instead of diagrams. The tables used are coherent with the supply and use tables used for the System of National Accounts, which allows for the calculation of indicators that combine physical and monetary information.

The supply and use tables are recorded considering that data is collected from each economic unit or household (the boxes in the diagrams above) and that the connections between them are unknown. The basic structure of the supply and use tables of the SEEA is shown below. A complete explanation can be found in chapter 2.

Table 3.2.1. Simplified physical supply table

	SUPPLY	Industries (except water supply and sewerage)	Water supply ISIC 3600	Sewerage ISIC 3700	Households	Environment to Economy
Product	Natural water (CPC 18000)		F.1			
Natural inputs	Inland water resources					E.1 (1+2)
Residuals	Losses of water		I.1			
Residuals	Sewage	F.3.1 (1)		F.3.2	F.3.1 (2)	
Residuals	Treated wastewater					
Residuals	Water returns					H.1 + H.2
Residuals	Water consumption					

Table 3.2.2. Simplified physical use table

	USE	Industries (except water supply and sewerage)	Water supply ISIC 3600	Sewerage ISIC 3700	Households	Economy to Environment
Product	Natural water (CPC 18000)	G.1(1)			G.1(2)	
Natural inputs	Inland water resources	E.1 (1)	E.1 (2)			
Residuals	Losses of water					I.1
Residuals	Sewage	G.3.2		G.3.1		
Residuals	Treated wastewater			H.1 + H.2		H.1 + H.2
Residuals	Water returns	H.1				
Residuals	Water consumption					

Only some flows are shown in the tables above for illustration purposes. More details are usually added by breaking down the column of industries into several columns showing the different groups of industries.

The rows in the supply table show the water that is flowing out of each of the industries indicated in the columns. The arrows pointing down illustrate this. In a similar way, the rows in the use table show the water that is flowing into each of the industries indicated in the columns.

A brief description of the raw data and processing needed to incorporate the data in the accounts is described below.

Data item	Raw data commonly available	Processed data for the accounts
E.1 Abstraction of water from inland water resources (for drinking water supply). ISIC 3600-1	• Inventory of drinking water utilities or companies. • Water "produced" by drinking water utilities or drinking water companies. • Volume of the water rights held by water utilities. • Volume declared by water utilities for the payment of water fees or royalties.	• Integrated inventory of water utilities. • Total amount of water abstracted by water utilities. • Important to disaggregate in surface water (E.1.1) and groundwater (E.1.2) abstracted.
E.1 Abstraction of water from inland water resources (for agriculture). ISIC 01 to 03.	• Inventory of irrigation associations or agriculture water suppliers. • Area irrigated and types of crops from agricultural censuses and surveys. • Volume of the water rights held by agricultural users or irrigator associations. • Volume declared by agricultural users for the payment of water fees or royalties.	• Total amount of water abstracted by agriculture. Useful to separate the water abstracted by the irrigation associations or water suppliers to agriculture, from farmers directly abstracting water. • Important to disaggregate in surface water (E.1.1) and groundwater (E.1.2) abstracted.
E.1 Abstraction of water from inland water resources (for non agriculture industries. Off-stream)	• Volume of the water rights held by industries. • Volume of the water rights held by industries. • Volume declared by industries for the payment of water fees or royalties.	• Total amount of water abstracted by non agriculture industries (excluding power plants). • Important to disaggregate in surface water (E.1.1) and groundwater (E.1.2) abstracted.
E.1 Abstraction of water from inland water resources (for cooling in thermoelectric plants) ISIC 3510-1	• Inventory of thermoelectric plants. • Electricity generated, type of cooling system and volume of water used in each plant.	• Total amount of water abstracted for power plants that use water for cooling. • Important to disaggregate in surface water (E.1.1) and groundwater (E.1.2) abstracted.
E.1 Abstraction of	• Inventory of hydroelectric	• Total amount of water

Data item	Raw data commonly available	Processed data for the accounts
water from inland water resources (for hydroelectricity) ISIC 3510-2	plants. • Electricity generated and volume of water turbinated in each hydroelectric plant.	abstracted for hydroelectricity. The abstractions include water that is turbinated more than once through plants in cascade.
E.1 Abstraction of water from inland water resources (for the operation of waterway locks) ISIC 5222	• Inventory of waterway locks. • Volume of water required in each operation of the lock. • Number of times the locks are operated in a year.	• Total amount of water abstracted for the operation of waterway locks.
E.2 Collection of precipitation	• Estimate of the number of buildings with rainwater tanks for the collection of precipitation. • Volume of water stored in the rainwater tanks.	• Amount of water collected in rainwater tanks or other means.
E.3 Abstraction from the sea	• Inventory of desalination plants. • Volume of water "produced" in the desalination plants.	• Amount of water abstracted by desalination plants.
F.1 Water supplied (drinking water) ISIC 3600-1	• Water billed to the different users.	• Amount of water billed to households. • Amount of water billed to the different industries connected to the water supply network.
F.1 Water supplied (non drinking water) ISIC 3600-2	• Inventory of non-drinking water suppliers, e.g. suppliers of water for irrigation.	• Water supplied (non drinking). Includes bulk water or water supplied to irrigation.
F.3.1 Wastewater for treatment or disposal	• Same as G.3.1, but may be collected from the side of the economic activities discharging to the sewers.	• Wastewater entering the sewer network.
F.3.2 Wastewater for further use	• Wastewater to be reused from inventories of WWTPs. • Surveys to different industries to know the amount of wastewater they are reusing.	• Wastewater to be reused.
G.1 Water received	• Same as F.1.	• Same as F.1.
G.3.1 Wastewater received for treatment or disposal	• Inventory of WWTPs with flows of operation. • Flows at different points of the sewer network.	• Wastewater entering the sewer network.
G.3.2 Wastewater	• Same as F.3.2, but may be	• Wastewater received by the

Data item	Raw data commonly available	Processed data for the accounts
received for further use	collected from the side of the users of reused water.	economic units for further use.
H. Returns of water by economic units	• Water consumption coefficients for the different economic units and households not connected to the sewerage network. • Abstractions of water (E) and water received (G) by the different economic activities and households to be able to estimate the returns.	• Estimates of the returns generated by the different economic activities and discharged directly to inland water resources (H.1) or to the sea (H.2).
I.1 Losses of water in distribution	• Water utilities measure the amount of water "produced" (injected to the water supply network) and water billed by water utilities.	• Unaccounted for Water (UFW) or Non revenue water (NRW) to be used as proxies of losses of water in distribution.

WWTPs = Wastewater Treatment Plants

One of the most relevant pieces of information is water abstraction by the different industries. With the data of abstractions the other data can be estimated if it is not available. The following paragraphs will focus on the data collection process for water abstractions.

The strategy to collect data depends on the type of water management system that is in place in the country. In some countries the water management system requires the declaration of volumes abstracted by the users, or the collection of data by the water supply industry, among other mechanisms that generate administrative data useful for the accounts. In other cases different censuses and surveys, such as agricultural censuses or surveys to water supply industries, may provide the data needed to compile the accounts.

Water management administrative records

Some countries, such as Australia and Chile, have a system of water rights and keep a registry of the amount of water that each user is allowed to abstract. The registry of water abstraction rights may provide a first approximation of the abstractions of water, especially if the registry is kept up to date, and water rights are verified by the authorities.

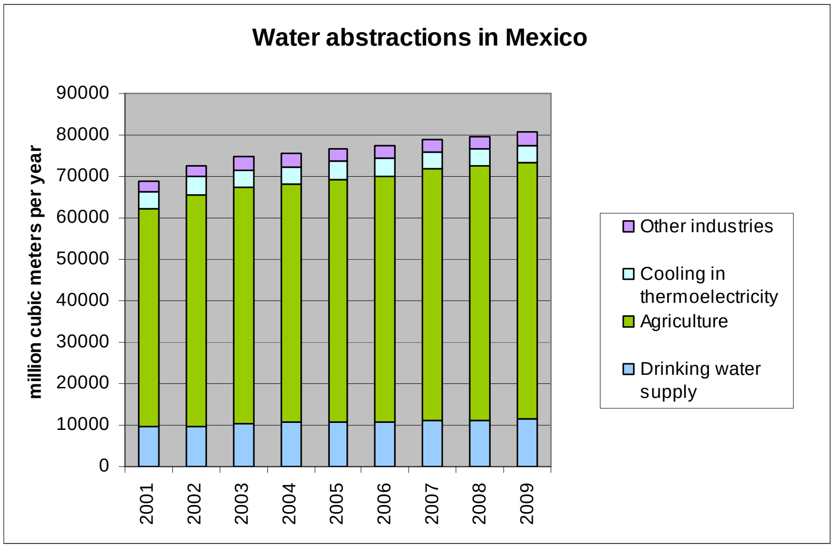
Other countries, such as France and Spain, require the abstractors to pay a fee or royalty for each volumetric unit of water abstracted. The abstractors have to report the amount of water abstracted and this information may be verified by the authorities.

Other countries, such as Mexico, have a dual system, and the information from both mechanisms can be contrasted.

The quality of the information from these records depends on the efficacy of the water management system. Water rights or permits have to be verified by the authorities and the payment of fees has to be enforced. Other problems are due to the fact that water users tend to request water rights with volumes higher than the actual volume abstracted. Often, the water rights are not classified according to ISIC categories and therefore it becomes difficult to get detailed information by industry.

EXAMPLE: Registry of water rights in Mexico.

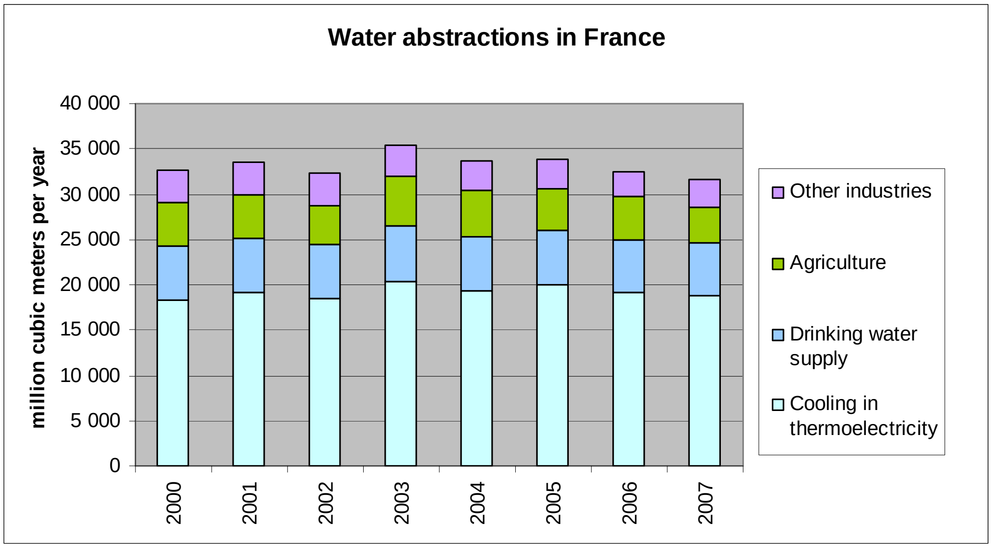
Major reforms to the water management system in Mexico created a Public Registry of Water Rights. Further reforms in 1999 promoted the regularization of water rights and the improvement of the registry. The following graph was constructed using the information in the registry.



Source: CONAGUA.- National Water Information System. https://sisgrh.imta.mx/sina

EXAMPLE: Declaration of volumes abstracted for the payment of fees in France.

In the French water management system water users have to declare the amount of water they abstract and pay a fee for each cubic meter of water abstracted. Besides funds for water management, this system provides valuable information about the amount of water abstracted. The following graph was constructed using these data.



Source: Commissariat Général au Developpement Durable.- Le financement de la gestion des ressources en eau en France.- Etudes & Documents.- January 2012.

If there is no registry of water rights and/or fees or royalties collected for the water abstracted, estimates will have to be made based on different data, such as population, irrigated area, type of industries, industrial production, electricity generated, etc. In any case, it is important to start with rough estimates to have an idea of orders of magnitude of the different abstractions. Then, conventional statistical data collection mechanisms should be performed.

Water abstractions receive different names in the water management literature, such as water "withdrawals," even more misleading, the word "use" often means abstraction in the water management literature. In order to avoid confusion, in the SEEA-Water and IRWS, the term "abstraction" was selected to specifically designate the water that flows from the environment to the economy. It is considered a natural input, as opposed to a produced input from another economic unit.

Typically, in water resources management, water abstracted for hydroelectricity and for the operation of locks is not considered an abstraction. For completeness, in the SEEA-Water and IRWS water turbinated in hydroelectricity and water for the operation of waterway locks are considered abstractions of water.

It is therefore useful to distinguish two types of abstractions: for **off-stream uses** and for **in-stream uses**. Off-stream uses take the water out of the water source to use it somewhere else (also known as consumptive use). In-stream uses do not remove water from its source, or water is immediately returned with little or no alteration. The table below shows the typical way in which water abstractions are grouped by water managers. Further detail is recommended once an initial assessment is performed.

Off-stream uses include the following:

Water Management Group	Abstractor of water	Main Users of water abstraction	Main purpose of abstraction
Water supply for human settlements	Water utilities or companies (ISIC 3600)	Households and industries connected to water supply networks	Produce drinking water to distribute it to households and industries through water supply networks.
	Households	Households	Use in households
Agriculture	Agricultural industries (ISIC 01-03)	Agricultural industries (ISIC 01-03)	Irrigation of crops, raising livestock, raising fish (aquaculture)
	Water suppliers for irrigators (ISIC 3600), e.g. irrigator associations.	Agricultural industries (ISIC 01-03)	Convey water to farmers for irrigation
Industrial water (mainly manufacturing, cooling sometimes included here)	Water utilities or companies (ISIC 3600)	All other industries not included in other sections of the table.	Use in manufacturing processes, mining, beverage production, etc.
	Industries using the water they abstract (self abstraction)		
Cooling water (for thermoelectricity)	Thermoelectric power establishments (ISIC 3510)	Thermoelectric power establishments (ISIC 3510)	Cooling of hot steam used to move turbines.

In-stream uses

Water Management Group	Abstractor	User	Purpose of abstraction
Water for hydroelectricity	Hydroelectric power plants (ISIC 3510)	Hydroelectric power plants (ISIC 3510)	Use of the mechanical energy of water to move turbines.
Water for operation of navigation locks	Waterway lock operators (ISIC 5222)	Waterway lock operators (ISIC 5222)	Lifting and lowering of ships.

There are other activities, such as navigation, fishing, and recreational activities, which do not remove the water from the source, but merely make use of it as it is. These are called **on-site uses** and they are not addressed in these guidelines.

Below is a description of the main issues regarding each different type of use.

Water supply to human settlements

a). Water utilities or water companies

Water utilities or companies can be public or private. They are directly responsible for delivering water to households and industries. Water utilities (**industry class 3600** of the International Standard Industrial Classification of All Economic Activities [ISIC]) abstract water from various sources. Depending on the quality of the water at the source, water utilities may treat the water abstracted to make it appropriate for human consumption. Then the water is distributed to the final consumers through a water supply network.

Water utilities[1] belong to the same ISIC class as other suppliers of water (such as irrigation associations in charge of supplying water to farmers), but they should be kept separate for the purposes of water accounts and statistics, since the nature of their activities is different to that of water utilities, which usually do not provide water to farmers, since the water they produce has drinking quality and would usually be too expensive to use for agricultural purposes.

To perform their activities water utilities collect the following data:

Data item	Brief description	Main issues
Abstractions of surface water (data item E.1.1)	The amount of water abstracted from artificial reservoirs, lakes, rivers or streams.	The data available may refer to "water produced," which is measured at the point where it is injected to the water supply network. Losses between the point of abstraction and the entrance of the water supply network may be neglected (in the order of 2%). Sometimes water is measured at the water treatment plants. Any of these measurements can be used in lieu of the actual abstraction.
Abstractions of groundwater (data item E.1.2)	The amount of water pumped from aquifers or collected from springs.	
Abstractions of sea water (data item E.3)	Water treated in desali-nation plants, if they exist, before being injected to the water supply network.	Data should be collected regularly for the operation of the desalination plant.
Amount of water supplied (data item F.1)	Amount of water billed to the users.	The amount of water billed to the users may be measured with meters at the point of connection to the water supply network. When meters are not available the amount of water delivered is estimated. The water billed is separated into water billed to households (representing between 70% and 90%), and water billed to the different types of industries, a detailed breakdown may not be available.
Losses of water in distribution (data item I.1)	Difference between the amount of water injected in the water supply network and the amount of water delivered to the users (water billed).	Water utilities typically use the difference of "water produced" and "water billed" as a proxy for losses. This proxy is known as Unaccounted For Water (UFW) or the Non Revenue Water (NRW). Estimates of the proportion of UFW or NRW that corresponds to leaks, theft or errors in measurements may be available. UFW or NRW may be more than 20%. In many cases it may be close to 50%.

The responsibility of drinking water supply may be municipal, provincial or national. Depending on the institutional arrangement the data collection strategy should be designed. In some cases there is a national regulator or association that collects the data from the individual utilities. In other cases the data needs to be collected directly from the municipalities. In this case a specific census or survey needs to be performed.

EXAMPLE OF DATA COLLECTION MECHANISMS IN COUNTRIES

- In Great Britain the Office for Water (Ofwat) regulates the 10 private companies that provide the water supply service. The companies have to provide all the detailed operation data to

[1] The term water utility will be used to refer to government or privately owned companies that provide the service of drinking water supply.

Ofwat.

- In the Netherlands the Dutch Drinking Water Association (Vewin) collects data from the 10 companies that deliver the service and produces a statistical report every year.
- In Mexico the responsibility of drinking water supply belongs to each of the more than 2400 municipalities. INEGI, the National Statistics Office, with the collaboration of the National Water Commission performs an economic census for all the water utilities in the country every five years.
- In Brazil the responsibility of drinking water supply belongs to each of the more than 5000 municipalities. IBGE, the National Statistics Office performs a census to collect data from all the water utilities ("Pesquisa Nacional de Saneamiento Basico").
- In Mauritius there is only one utility (Central Water Authority) which supplies drinking water and produces an annual report with all the data related to the activity.

Sample forms and reports are provided in the annexes.

In order to better control the quality of data related to water utilities, it is useful to have the following:

- An inventory of water utilities or water companies. Some water utilities are also wastewater utilities.
- An inventory of water treatment plants.
- An inventory of desalination plants.

Economic censuses or surveys to industries may provide more detailed data about the amount of water that is supplied to each type of industry. On a first stage the amount of water supplied by the water utility to industries may be sufficient. On a second stage the censuses and surveys may provide the details according to the types of industries classified by ISIC categories.

<u>b). Bulk water companies</u>

Often water has to be conveyed long distances before it is distributed through water supply networks. There are some enterprises that deliver water ("bulk water") to water utilities for distribution. These companies are also classified as ISIC 3600. In water accounts it may be necessary to include these companies as a separate activity generating a different product in order to correctly quantify the amount of water produced.

<u>c). Households</u>

Typically, households receive the water they need from a water supply network operated by a water utility. Usually between 70% to 90% of the water supplied by water utilities is for households, the rest is supplied to the different industries connected to the water supply network.

In rural areas or low density population urban areas households may have their own well and abstract the water they need with a pump. For completeness, it is important to estimate the amount of water that is abstracted by households. Typically this amount is small compared to the water abstracted by water utilities and may be neglected.

The amount of water used by households varies depending on the socioeconomic level of the household, the climate, and the accessibility of water.

EXAMPLE: HOUSEHOLD WATER USE
In Great Britain the average is 136 L/person/day of water received in households (data item G.1) from the water utilities.

Source: 2005-2006 Ofwat report.

d) Industries connected to the water supply network

Water utilities supply water to most of the industries located within the reach of the drinking water supply network. Usually between 10% to 30% of the water supplied through the drinking water supply network is for all the different types of industries connected, such as, hotels, restaurants, reatil stores, financial institutions, manufacturing industries, and government service offices. See below a more detailed description of water use in industries.

e) "Water consumption," losses and returns

Practically all the water abstracted by economic activities is returned to the environment (the accumulation is negligible) and reincorporated to the water cycle. The water abstracted is first returned to the environment in the form of losses. Some of the losses go to the atmosphere and become vapor, others return to inland water resources. The water that reaches the economic activities for which it was intended is then evaporated, transpired in the processes, and a portion is incorporated in the products.

The remaining water is then discharged to the sewers (data item F.3.1) or returned to the environment (data item H). A more details discussion about this will be found in the next section of the chapter.

In most water-distribution systems, a large percentage of the water is lost in transit from the abstraction point to the point of final use. The losses (data item I.1) measured as unaccounted for water (UFW) or non-revenue water (NRW) is typically 20-30 percent of the abstraction. Some systems, especially older ones, may lose as much as 50 percent. Water loss can be attributed to several causes, including leakage, metering errors, public usage such as fire-fighting and pipe flushing, and theft. Leakage is usually the major cause. (Adapted from IRC Paper)

UFW or NRW can be estimated by calculating the difference between the amount of water abstracted by the water utility (plus the water received from bulk water suppliers) and the amount of water billed to the consumers.

Agriculture

Abstractions of water by agriculture, forestry and fishing include the water abstracted for irrigation of crops (the largest portion), water abstracted for raising livestock, and water abstracted for aquaculture. Some countries may also estimate the amount of water that is taken up by the roots of the plants and trees that form forests. Irrigation of golf courses is classified separately under the operation of sport facilities (ISIC 9311).

Determining the amount of water abstracted by agriculture, forestry and fishing is usually very difficult. Several methods can be used to estimate the amount of water abstracted, but none of them may prove accurate enough. It is suggested that several methods are used in order to provide different references that can increase the reliability of the estimates.

When available, registries of water rights or water permits should be used. They provide a first approximation and depending on the maturity of the water rights system, they may provide comparable statistics. Data from agricultural censuses and surveys should also be used to provide additional elements for the calculation of the abstractions.

The following paragraphs provide guidelines for each of the four cases mentioned above (irrigation, livestock, aquaculture, and forests):

<u>a). Irrigation</u>

Crops require water for the photosynthesis, a process that allows plants to transform the solar energy into the chemical energy (glucose) they need to live and thrive. Water is taken up by the roots of the plants from the soil in the root zone and then transported to the leaves and transpired through the leaves of the plants. If enough water is available in the soil then the crops will be able to grow healthy. To ensure the healthy growth of the crops (more production), soil water, which is fed by the precipitation is often complemented with irrigation, a technique in which water is abstracted from surface or groundwater sources and is transported up to the root zone, so that it can be used by the crops.

The amount of water abstracted by the crops is calculated by estimating the <u>**crop evapotranspiration (not to be confused with evapotranspiration in the water cycle, which is data item C.1)**</u>, which is the amount of water that is evaporated from the soil where the crops grow plus the amount of water that is transpired by the crops. If there is no irrigation (rainfed agriculture) then all the abstraction of water by the crops is considered to be **soil water abstraction (E.1.3)** and can be estimated as the crop evapotranspiration, even though in some cases the crops might not be getting the total amount of crop evapotranspiration that they would need to grow healthy. The amount of soil water abstraction (E.1.3) is also known as the "green water" that is used by the crops.

If irrigation is used to complement precipitation occurring in the fields, then it is assumed that the amount of precipitation is not enough to cover the total amount needed by the crops. It means that the crop evapotranspiration is larger than the rain effectively being available to be used by the crops. Therefore the amount of **surface water (E.1.1)** and **groundwater (E.1.2)** abstracted (also known as "blue water") for irrigation can be estimated as the complement of the crop evapotranspiration not covered by precipitation, plus the additional water abstracted due to losses in conveying water from the sources to the fields.

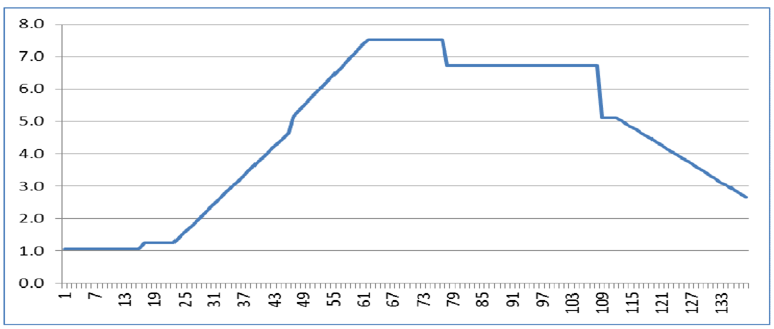
To estimate crop evapotranspiration many factors have to be considered, such as solar radiation, air temperature, relative humidity, and wind speed. The soil texture, structure, density, and chemistry are also important factors. Also the plant type, root depth and foliar density, height, and stage of growth. Crop evapotranspiration can be measured using lysimeters, but it is expensive and time consuming. Instead empirical formulas are often used. The formulas combine the different factors mentioned above. For simplicity, it is common practice to use a reference crop evapotranspiration based on standard grass, for which biophysical characteristics are well studied, and a crop coefficient to convert the reference crop evapotranspiration to the actual crop evapotranspiration for a specific crop.

EXAMPLE OF CROP EVAPOTRANSPIRATION OR CROP WATER REQUIREMENT

The table below shows the reference evapotranspiration for the San Joaquin Valley in California. It shows the number of cubic millimeters that evaporate each month per square millimeter of standard grass (mm/month).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Reference evapotranspiration, ETo (mm/month)	31	57	94	130	173	198	220	197	145	102	53	31

For corn the crop coefficients are kc_1 = 0.19, kc_2 = 1.06, and kc_3 = 0.55, which convert the reference daily evapotranspiration (ETo) into the specific evapotranspiration (ETc) for corn. The graph below shows the specific daily evapotranspiration of corn for the 137 days it takes from planting to the end of season in mm/day (May to September).



The total crop evapotranspiration (ETc) for the cycle is 638 mm. If the precipitation effectively provided 250 mm of water during the season, then an additional 388 mm of water have to be provided from surface and groundwater sources. One hectare of corn requires: 10 000 m^2 x 0.388 m = 3 880 m^3 of water to complement natural precipitation. If there is double cropping (two planting and harvesting seasons) then the water requirements for the second cycle have to be added.

For more information refer to module. *3.B.4 Estimating abstractions for irrigation.*

Crops that do not receive irrigation (known as rainfed crops or dryland agriculture) satisfy their water needs by using the moisture of the soil. This is known as the "green water." This might be enough in some regions where precipitation provides enough water at the right time of the crop growth.

Irrigation complements "green water" with water that is abstracted from inland water resources and then transported to the roots of the plants ("blue water") to complement the naturally available water. Depending on the proportion of green and blue water, irrigation might be called full or supplementary irrigation.

b). Livestock

The water requirements for livestock can be estimated with the population of livestock and the water requirements for each type of livestock in the climate where the livestock is. It is then necessary to estimate what proportion of the water requirement is provided by naturally occurring water and what proportion is provided by man-made works.

c) Water suppliers for irrigators

Water suppliers for irrigators belong to the same ISIC class as water utilities (**industry class 3600** of the International Standard Industrial Classification of All Economic Activities [ISIC]). They include irrigation associations in charge of supplying water to farmers and other types of arrangements. Even though they are in the same ISIC class as water utilities, they should be kept separated. Since this usually involves large irrigation projects, good estimates of the amount of water abstracted should be available from the supplier (e.g. irrigation district, user association, etc.)

d). "Water consumption," losses and returns agriculture

In agriculture a large amount of water is usually lost between the point of abstraction and the point of irrigation. Losses can be in the order of 40% of the water abstracted. The primary variables associated with losses in conveyance of water to farms are (from USGS guidelines):

(1) water source (groundwater or surface water),
(2) condition of irrigation canals/ditches/pipes,
(3) distance transported, and
(4) climatic conditions.

Water abstracted from sources near fields often does not have as much loss when compared to water that is transported over long distances. It is not uncommon for groundwater-irrigation wells to be within a relatively close distance to the field that is being irrigated. Irrigation water can be diverted adjacent to the field and can be transported under a pressurized-pipe system or directly into the irrigation system, which tends to have lower losses due to the more efficient transport systems. In areas where the irrigation water is diverted adjacent to the field, losses may be considered negligible and the majority of losses are considered to be occurring because of the irrigation-system efficiency.

Losses can be estimated based on areas with similar regional characteristics that have known losses.

Industrial water (excluding agriculture and cooling or thermoelectric plants)

This group consolidates a wide range of economic activities ranging from financial institutions, construction sites, retail stores, and manufacturing industries. Some of the establishments that belong to this group are located in urban areas and are connected to the water supply network, receiving their water from water utilities.

a) Service industries

Retail stores, hotels, restaurants, financial institutions, government offices, and others are usually connected to the drinking water supply network and do not abstract their own water. The amount of water they use is the amount of water they receive from the water supply network (data item G.1).

The data about the amount of water used can be obtained from water utilities, even though the level of disaggregation may not be desirable, and the classification according to ISIC may be difficult.

Some hotels located outside of the cities and/or close to the coast, may have their own boreholes or wells, or they may even have their own desalination plant and abstract water from the sea (data item E.3).

b) Manufacturing industries

Manufacturing industries may be connected to the drinking water supply network or have their own well or borehole to abstract water for their needs, especially those industries located out of the cities. Therefore, the water they use is the sum of the water received from the water supply network (data item G.1) and the water they abstract themselves (data item E.1)

c) Mining and quarrying

This includes the abstraction of water used in the extraction of minerals that might be in the form of solids, such as coal, iron, sand, and gravel; liquids, such as crude petroleum; and gases, such as natural gas. It includes quarrying, milling, re-injecting abstracted water for secondary oil recovery, and other operations associated with mining activities.

Cooling in thermoelectric plants (ISIC 3510-1)

More than 70% of the electricity in the world is produced in thermal power plants (thermoelectric plants), which include plants that use as fuel nuclear reactions, natural gas, oil, and coal, among others. In these plants heat is transformed into mechanical energy. Thermal power plants can be classified by type of fuel they use or by the type of moving fluid used (steam turbine, gas turbine, combined cycle...). To estimate water abstractions the type of fuel is more relevant than the type of moving fluid used.

Water is used in different cycles of the energy producing process. The most relevant in terms of water use is the cycle to remove heat (cooling) from the steam moving the turbines. Abstractions for cooling of thermoelectric plants represents more than 50% of national water off-stream abstractions in several European countries (Eurostat 2010). In the US this abstraction represented 49% of the total off-stream abstractions in 2005, and about 28% of these abstractions were saline surface water.

There are two general types of cooling technologies: the once-through (open-loop) cooling and the closed loop (recirculation) cooling.

Open-loop cooling systems (also known as once-through systems) require the largest amount of water abstraction because water is not recirculated. Water is abstracted, circulated through the heat exchangers, and then returned to a water body. This technology is common in older facilities.

Closed-loop cooling systems use cooling ponds and cooling towers to recirculate water within the system, thus reducing the overall water abstraction requirements. Abstractions of water to replace cooling water lost to evaporation, blowdown, drift, and leakage are considered “makeup” water. A cooling pond is a shallow reservoir with a large surface area to remove heat from circulation water. A cooling tower is a structure designed to remove heat from water.

The FAO Aquastat, based on estimates by the Electric Power Research Institute, suggest the following approximate coefficients:

Cooling System	**Type of fuel**	**Abstraction of water (m^3/MWh)**	**Evaporation or Water consumption (m^3/MWh)**
Open-loop (once-through)	Nuclear	95 – 230	1.5
Open-loop (once-through)	Fossil, biomass, waste	76 – 190	1
Closed-loop	Nuclear	3 – 4	3
Closed-loop	Fossil, biomass, waste	2 – 2.3	2

As it can be seen in the table shown above, the type of cooling system is the most significant factor that determines the amount of water abstracted for thermoelectric plants. Open-loop systems abstract an average amount of water that is in the range of 100 m^3/MWh, while close-loop systems abstract an average amount in the range of 2 or 3 m^3/MWh. On the other hand, water consumption is within the same range for all types of cooling systems.

The water used for cooling may be freshwater, saline water, or even reused water. The water could be abstracted from surface water sources (E.1.1) or from the sea (E.3.). It is rarely abstracted from groundwater sources due to the large volumes required. Sometimes the water is supplied by other economic units, e.g. treated wastewater supplied by a wastewater utility.

Hydroelectricity (ISIC 3510-2)

Hydroelectric plants use the force of gravity moving water to produce electricity. Water is passed through a turbine that moves a generator that produces electricity. The water used is immediately returned to the water body from which it was abstracted and therefore this use is considered an instream use.

There are basically two types of hydropower plants:

- Conventional plants, with medium to large drops (could be up to hundreds of meters of height differential), usually requiring a dam for the storage of large quantities of water.
- Run-of-the-river power plants, which do not require the storage of water. They are small or micro hydro power plants with a difference in the level of water of less 10 meters. They only use the amount of water naturally flowing through a river or stream. They are located in rivers large continuous flows of water throughout the year.

Roughly about 19% of the electricity generated in the world is hydroelectric. The amount of water that passes through hydroelectric turbines to produce electricity in the world (sometimes the same water is turbinated several times) is roughly four times larger than the amount of water abstracted for off-stream uses. However, this water is traditionally reported separate from the other uses, since all the water abstracted is immediately returned to the water course from which it was abstracted with minimum changes in physical properties. Also, the same water may be used several times in a river and therefore the aggregated amount of water turbinated may be much higher than the amount of water flowing through the river.

In order to better control the quality of data related to water utilities, it is useful to have the following:

- An inventory of hydroelectric plants.
- The electric production capacity of each plant and the actual amount of electricity generated each year.

According to simple physical principles, the energy produced in a hydroelectric plant is directly proportional to the volume (V) of water turbinated and the difference in elevation of the water before and after passing through the turbine (H). The proportionality is given by the density of water and the efficiency of the plant. Therefore, if the amount of energy produced is known, as well as the difference in elevation, the volume of water turbinated may be estimated.

<u>Operation of waterway locks (ISIC 5222)</u>

Large amounts of water are used to raise and lower the level of the boats in waterways when passing through dams or when there is a need to go through waterways that are at different elevations. Water is returned to the water body immediately after use in the locks and therefore is considered an instream water use, which is recorded as an abstraction according to the IRWS.

EXAMPLE: WATER USED FOR LOCKS IN THE PANAMA CANAL

In the Panama Canal ships are raised from the sea level to lake Gatun located about 26 meters above sea level using 3 locks. Then the ships are lowered using other 3 locks to be returned to the sea level on the other side of the continent. Each lock operation requires 191 000 m^3 of freshwater. In one year about 2 600 million m^3 of freshwater from lake Gatun are used for the operation of the Panama Canal locks to move about 12 500 ships.

<u>Connecting the pieces of information</u>

All the information described above can be integrated in supply and use tables in order to show and integrated picture and to be able to calculate integrated indicators. The supply and use tables are useful for assuring the consistency of the data, to identify data gaps, and to set priorities for data collection.

The following numeric example, “Shipland Example” shows the different components of the Physical Supply and Use Tables. The standardized way of presenting the tables is to first show the supply table and then the use table. However, for didactic purposes it is easier to present them the other way around.

Table 3.2.3. Simplified Physical Use Table for the Shipland Example (hm3/year)

	USE	ISIC 01-03 Agriculture and livestock	ISIC 05-33, 41-43,38,39,45-99 Manufacture and services	ISIC 3510-1 Cooling (thermoelectricity)	ISIC 3510-2 Hydroelectricity	ISIC 3600-1 Water utilities (drinking water)	ISIC 3600-2 Sewerage (sewage collection and treatment)	ISIC 5222 Operation of waterway locks (ACP)	House-holds	Economy to Environment	TOTAL
Natural inputs	Inland water resources-off steram uses	487	100	100		410		133			1230
Natural inputs	Inland water resources - instream uses				9861			2558			12419
CPC 18000-1	Drinking water		87						232		319
CPC 18000-2	Bulk or raw water					133					133
Residuals	Losses of water										0
Residuals	Sewage to sewers						256				256
Residuals	Untreated sewage to environment									210	210
Residuals	Treated sewage to environment									46	46
Residuals	Water returns									12796	12796
Residuals	"Water consumption"									222	222
	TOTAL	**487**	**187**	**100**	**9861**	**543**	**256**	**2691**	**232**	13,274	27 631
	Difference = Supply - Use	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
	% "water consumption"	28%	20%	5%					20%		

The use table shows that the economic activities abstract (data item E.1) 1 230 million cubic meters of water per year (hm3/year), excluding in-stream abstractions (hydroelectricity and operation of waterway locks). Hydroelectricity and the operation of locks use (data item E.1) 12 419 hm3/year of water.

Manufacture and service industries abstract (data item E.1) 100 hm3/year of water and they also receive (data item G.1) 87 hm3/year of water. Water utilities abstract (data item E.1) 410 hm3/year of inland water resources and receive (data item G.1) 133 hm3/year of water.

Table 3.2.4. Simplified Physical Supply Table for the Shipland Example (hm^3/year)

	SUPPLY	ISIC 01-03 Agriculture and livestock	ISIC 05-33, 41-43,38,39,45-99 Manufacture and services	ISIC 3510-1 Cooling (thermoelectricity)	ISIC 3510-2 Hydroelectricity	ISIC 3600-1 Water utilities (drinking water)	ISIC 3600-2 Sewerage (sewage collection and treatment)	ISIC 5222 Operation of waterway locks	House-holds	Environment to Economy	TOTAL
Natural inputs	Inland water resources-off steram uses									1230	1230
Natural inputs	Inland water resources - instream uses									12419	12419
CPC 18000-1	Drinking water					319					319
CPC 18000-2	Bulk or raw water							133			133
Residuals	Losses of water	151				224					375
Residuals	Sewage to sewers		70						186		256
Residuals	Untreated sewage to environment						210				210
Residuals	Treated sewage to environment						46				46
Residuals	Water returns	202	80	95	9861			2558			12796
Residuals	"Water consumption"	134	37	5	0	0		0	46		222
	TOTAL	**487**	**187**	**100**	**9861**	**543**	**256**	**2691**	**232**	13,649	28 006

The table shows that water utilities supply (data item F.1) 319 million cubic meters (hm^3) of drinking water per year. Water utilities lose (data item I.1) 224 hm^3/year in the distribution network, which is 41% of the total amount of water abstracted or received.

Households discharge 186 hm3/year of sewage to the sewers and manufacture and service industries discharge 70 hm3/year of sewage to the sewers. The sewerage utilities discharge 210 hm3/year of untreated sewage to the environment and 46 hm3/year of treated sewage to the environment.

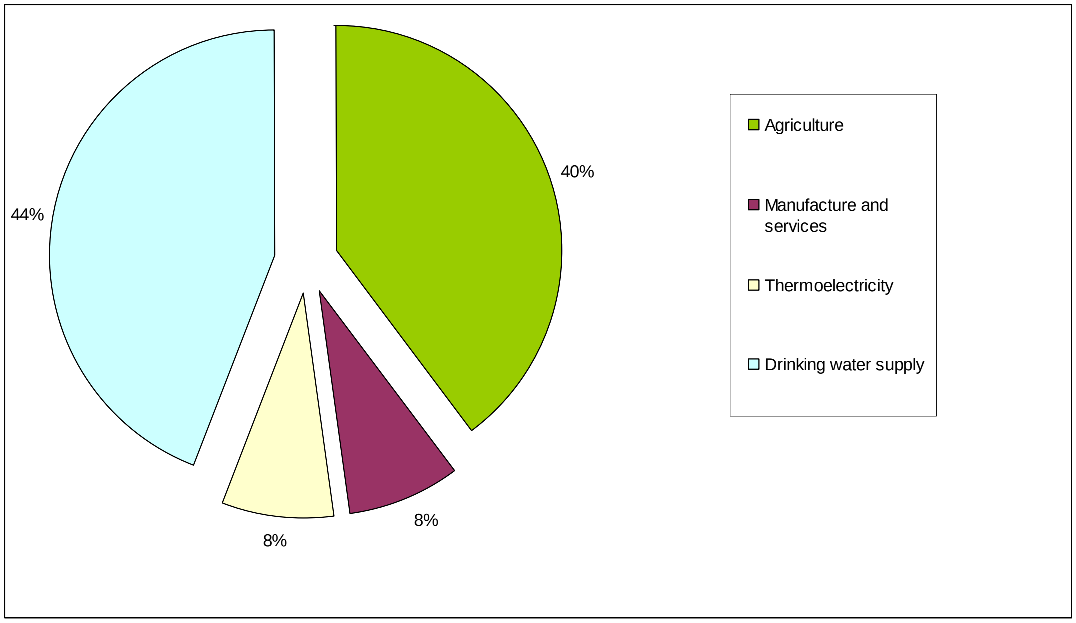
The information in the PSUT can be combined with the information of the previous section in order to have a complete picture and to derive some indicators. The following asset table is presented.

Table 3.2.5. Simplified Asset Accounts for the Shipland Example (hm^3/year)

	Artificial reservoirs	Lakes	Rivers and streams	Aquifers	Soil water	TOTAL
Opening stock of water	**Opening A.1.1**	**Opening A.1.2**		**Opening A.2**		**Opening A.1 + Opening A.2**
Additions to stock	**142 511**				**214 500**	**357 011**
Precipitation					214 500	214 500
Inflows from other countries	0					0
Inflows from other inland water resources	129 340					129 340
Returns	13 171					13 171
Reductions in stock	**142 511**				**214 500**	**357 011**
Evaporation and/or transpiration (evapotranspiration)	500				85 160	85 660
Outflows to other countries						0
Outflows to other inland water resources					129 340	129 340
Outflows to the sea	128 362					128 362
Abstractions	13 649					13 649
Closing stock of water	**Closing A.1.1**	**Closing A.1.2**		**Closing A.2**		**Closing A.1 + Closing A.2**

Assuming that Shipland has 3.45 million inhabitants and that its continental surface is 75.5 thousand km^2, the following information and indicators can be derived from the tables.

- Precipitation 2 885 mm/year
- Evapotranspiration 40%
- Offstream abstractions 1 230 hm3/year
- Internal Renewable Water Resources (IRWR) = Precipitation less Evapotranspiration = 128 840 hm3/year
- Total Renewable Water Resources (TRWR) = IRWR + inflows from other countries = 128 840 hm3/year
- TRWR per capita = TRWR/population = 37 345 m3/person/year
- Off-stream abstractions (E.1off) = 1230 hm3/year
- Proportion of renewable resources abstracted (MDG 7.5) = E.1off/TRWR=1230/128 840 = 1%
- The pie below shows the proportion of water abstracted by each sector.



- Distribution losses of water in drinking water supply networks are 224/543 = 41%
- Losses of water in agriculture = 151/487 = 31%

More indicators can be calculated by combining physical quantitative information with emissions and monetary data, as will be shown in the next sections of the chapter.

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.III. Physical data items related with polluting releases

The following data items in the IRWS are related with emissions to water:

- F. Water supplied to economic units
  - F.3. Wastewater supplied by resident economic units to resident economic units
  - F.4. Wastewater exported to the rest of the world (wastewater exports)
- G. Water received by economic units
  - G.3. Wastewater received by resident economic units from resident economic units
  - G.4. Wastewater received from the rest of the world (wastewater imports)
- H. Returns of water to the environment by economic units
  - H.1. To inland water resources
  - H.2. To the sea
  - H.3. To land
  - H.a. Returns of water to the environment after treatment by economic units
  - H.b. Returns of water to the environment without treatment
- J. Waterborne polluting releases to other economic units
  - J.1. Waterborne releases supplied by resident economic units to resident economic units
  - J.2. Exports of waterborne polluting releases
  - J.3. Imports of waterborne polluting releases
- K. Waterborne emissions to the environment
  - K.1. From point sources to the environment
  - K.2. From diffuse sources to the environment

In the previous section of this chapter the data items related to the abstraction and delivery of water to the different economic units and households were covered. This section covers all the data items related with water leaving the economic units after use. It also covers the data items related to the incorporation of pollutants to the returned water.

Economic units use water for their different activities and then discharge it directly to the environment or to a sewer network. The activities that use water often add pollutants to the water they return. In some cases water is not returned to the environment or discharged to the sewer network but reused in the economy.

Water policy makers require information to understand the impacts of the water returned to the environment and the pollutants added. They also require information about how water is reused in the economy reducing the amount of water that needs to be abstracted directly from the environment.

Wastewater

Wastewater by type of water users discharging

The same economic units that were mentioned in the previous section as users of water discharge wastewater after using the water they abstracted or received from other economic units. For the purposes of accounts and statistics, wastewater is defined as all the water that is discarded that is no longer required by the owner or user. A brief discussion for each type of user follows:

Households return about 80% of the water they abstract or receive to the environment, to a sewer network or to another sanitation facility (septic tank, latrine, etc.). Households located in densely populated areas usually discharge all their wastewater to the sewer network and it is possible to estimate the volume of wastewater generated based on the data of the volume of water supplied to households by water utilities[2] and the percentage of water that is consumed. Households located in areas of low population densities (rural areas) may discharge their wastewater to the sewer network or they may discharge it in septic tanks or drains that discharge the water to a river, to a lake or simply to a land area.

In order to estimate the amount of water discharged by households to sewers and to the environment it is important to collect information from population censuses and household surveys about the proportion of people that discharge wastewater to the different sanitation facilities: sewers, septic tanks, latrines, or open defecation (see section on water-related social-demographic data items).

Industries connected to the sewer network discharge the water that is not consumed in their processes to the sewer network. Some economic units, especially those with polluting processes, may be required to perform some type of treatment of the wastewater before discharging it to the sewer network. Other economic units, especially service industries and financial institutions, may discharge their wastewaters the same way as households. The volume of wastewater discharged is a percentage (in the order of 80% to 90%) of the volume of water used.

Sewerage industries collect wastewaters from households and industries and treat them in wastewater treatment plants (WWTP) before returning the treated wastewater to water bodies or land. In many cases a WWTP is not available and the wastewaters are returned to the environment without treatment. Sewerage industries also collect storm water (rainwater that runs off in urban areas and is collected in the sewer networks or a separate drainage network). In some areas there is a separate system for the collection of storm water, so that sewage and rainwater are not mixed, otherwise, a mixture of sewage and rainwater is sent to WWTPs or to the environment. The problem with mixing sewage and rainwater is that the volume of rainwater may be very large (often in short periods of time), exceeding the capacity of the WWTPs.

Industries not connected to the sewer network return their wastewater to a water body or to land. Regulations may impose specific requirements for discharging wastewaters and the industries may have to operate their own wastewater treatment plant (WWTP).

Agriculture returns a portion (roughly between 20% and 40%) of the water used to water bodies or to land (then it infiltrates to the aquifers). The return of water is not punctual, as in the cases mentioned above, but in a diffuse way. For this reason the waterborne pollution in returns of water from agriculture are considered non-point sources of pollution (see below non-point sources of pollution). The SEEA-Water classifies the discharges of water from agriculture as wastewater. However, for water resources management, the returns of water from agriculture are not considered wastewaters.

Thermoelectric plants use water for cooling. A small portion (between 1% and 5%) of the water used is evaporated and the rest is returned to water bodies. Sewerage industries typically do not collect the wastewater from thermoelectric plants. The SEEA-Water classifies the returns of water from

[2] In this document the term water utility is used to refer to drinking water supply companies..

thermoelectric plants as wastewater. However, for water resources management, the returns of water from thermoelectric plants are not typically considered wastewaters.

Hydroelectric plants return all the water used to water bodies. The SEEA-Water classifies the returns of water from hydroelectric plants as wastewater. However, for water resources management, the returns of water from hydroelectric plants are not typically considered wastewaters.

Data collection

The data described below is useful for the compilation of water accounts and statistics.

The experts in the National Statistics Office should work in close collaboration with the experts in the Ministry of Environment, the Ministry of Water and/or the National Water Authority to compile or estimate the data required. The following are common sources of data:

- Water and/or sewage utilities, companies, associations or regulators.
- Departments in charge of controlling polluting discharges (they may issue permits and develop inventories of polluting discharges).
- Research institutions which may have specific industry indices or coefficients useful for estimating water consumption.

Data collection of wastewater should be done in conjunction with data collection of emissions, since the two topics are closely related.

Households

- Number of households and number of inhabitants per household from population censuses, household surveys and population projections. Water utilities have the number of water supply connections, which is useful to estimate the population receiving water from the water utility. It is also necessary to have data on the number of households connected to sanitation facilities different to sewers (see section on water-related social-demographic data items).
- Data from water utilities on the amount of water supplied to households (IRWS data item F.1). This should be based on the readings of meters in households.
- Estimate of the proportion of water used that is consumed by households. Typically about 20% of the water used is not returned or discharged (water consumption), but if possible a more specific number should be used. This proportion is not typically measured, but the result of specific research or estimates.
- Data from the sewer industry about the wastewater collected, usually measured at WWTPs is useful to estimate the amount of wastewater discharged to the sewers by households.

Industries connected to the sewer network

- Data from water utilities on the amount of water supplied to industries (IRWS data item F.1). This should be based in the readings of meters in industries. If possible the data should be disaggregated by type of industry. It should be grouped according to ISIC or other equivalent classification.
- Data from the sewer industry about the number and types of industries connected to the sewer network.

- Data from the sewer industry about the amount of wastewater collected, usually measured at WWTPs is useful to estimate the amount of wastewater discharged to the sewers by households.

<u>Sewer industries</u>

- Inventory of WWTPs with flows of operation and type of treatment (primary, secondary, tertiary) and technology (activated sludge, biodisks, etc.)
- Data from the sewerage industry about the number and types of establishments connected to the sewer network, and estimates of the volume of wastewater collected.
- Data from the sewerage industry about the number of households connected to sewer network, and estimates of the volume of wastewater collected.

<u>Industries not connected to the sewer network</u>

- Inventory of discharges from the ministry of environment or water authority. The inventory can provide data about the location of the discharges and the volume of water discharged (IRWS data item H, and possibly H.1, H.2 and H.3).

<u>Agriculture</u>

- The data used to estimate the abstractions of water in agriculture and consumption coefficients described in the previous section can be used to estimate the returns of water.

<u>Thermoelectric plants</u>

- Inventory of thermoelectric plants from the ministry of energy or electric companies. The inventory can provide data about the location of each thermoelectric plant, the amount of energy generated, the type of plant, the type of cooling system and the volume of water used.

<u>Hydroelectric plants</u>

- Inventory of hydroelectric plants from the ministry of energy or electric companies. The inventory can provide data about the location of each hydroelectric plant, the amount of energy generated, and the volume of water used.

<u>Data in the accounts</u>

The data collected is compiled in the supply and use tables as shown below. The column "Other industries" should be subdivided according to the specific purpose of the accounts.

A complete example is included in the guidelines.

Physical Supply Table (in million cubic metres per year)

	Water supply industry	Sewerage industry	Other industries	Households	Flows from the environment
Sources of abstracted water					
Abstracted water					
Wastewater			F.3	F.3	

and reused water					
Return flows of water		H	H	H	
Evaporation, transpiration and incorporation into products					

Physical Use Table (in million cubic meters per year)

	Water supply industry	Sewerage industry	Other industries	Households	Flows to the environment
Sources of abstracted water					
Abstracted water					
Wastewater and reused water		G.3			
Return flows of water					H
Evaporation, transpiration and incorporation into products					

The tables facilitate the verification of the consistency of data. The sum of the rows in the supply table has to be the same as the sum of the rows in the use table. The sum of columns should also be the same in the supply and in the use tables; however, data from the other sections is required to complete the columns.

Waterborne polluting releases

Pollutants and measuring tests

Returns of water to the environment usually include pollutants added by the economic units as a result of their production processes or consumption patterns, which affect the receiving water bodies (or land) in various ways. In order to compile water accounts and statistics a list of pollutants has to be defined according to the specific needs of each country, including national and international legislation.

The variety of pollutants that can be found in wastewaters is as wide as the number of elements and compounds existing in the planet. Different countries and organizations may group the pollutants differently according to their specific needs.

Emission statistics and accounts are based on the results of tests or analyses (e.g. BOD, COD, TSS) done to wastewater samples. These **tests** are used to quantify the different types of **pollutants** or substances that cause **pollution problems** in water. It is important to clearly distinguish these three elements. A brief description of each of the three elements is presented below.

1. **Pollution problems.** The discharge of pollutants to water may have an impact on public health, on the aquatic life and also on some economic activities, which may incur in additional costs for treating the polluted water before using it. Many diseases in humans are transmitted by the ingestion of water contaminated with pathogens. Fish require oxygen in water to live and thrive, but organic matter discharged in water causes the proliferation of micro-organisms that consume the oxygen present in water. Aquatic weeds and algae may increase in an uncontrolled way due to an excess of nutrients (mainly nitrates and phosphates) present in water. Even treated wastewater may contain small quantities of pollutants that are harmful for aquatic life and humans, such as some metals, pesticides and pharmaceutical products.

2. **Pollutants**. Polluting discharges include pathogens, which cause diseases in humans when ingested. They also include organic matter, which is food for microorganisms that reproduce and deplete the oxygen needed by fish. Phosphates and nitrogen contained in fertilizers are nutrients that cause the proliferation of aquatic weeds and algae, which may affect other forms of aquatic life and cause problems for navigation.

3. **Tests.** There is a wide variety of chemical and biological tests used to detect and quantify the different types of waterborne pollutants in wastewaters, and also in water bodies. Some tests are fairly inexpensive and easy to perform and other tests are expensive and difficult to perform correctly. The choice of the tests in each country depends on the type of pollution problems that affect the country, the pollutants present in water, the way in which the information will be analyzed and presented, as well as the availability of data.

The following table summarizes the main pollution problems with the pollutants that cause them and the tests to measure them.

Problem	Pollutants	Tests	Main issues
Transmission of diseases through water	Pathogenic viruses, bacteria, protozoa, and parasitic worms (helminthes) from excreta of people with diseases.	• Fecal coliforms • E. coli • Enterococci	• Relevant in countries with low access to improved sanitation and improved water sources. • Important in water bodies where people swim. • Data refers to specific locations and is not suitable for aggregation in accounts. • This pollution is easily removed by disinfection in WWTPs.
Reduction of	Organic Matter	• Biochemical oxygen	• The most widespread type of

Problem	Pollutants	Tests	Main issues
dissolved oxygen in water.		demand (BOD) • Chemical oxygen demand (COD) • Total organic carbon (TOC)	pollution. Commonly referred as conventional or classic pollution. • Most of it is removed by conventional WWTPs with secondary treatment. • May be less relevant in countries with high levels of wastewater treatment.
Proliferation of aquatic weed and algae (eutrophication)	Nutrients	• Total Nitrogen (TN) • Total Phosphorus (TP) • Total Kjehldahl Nitrogen (TKN)	• Conventional WWTPs do not remove most of the nutrients. A tertiary treatment is necessary. • Important if the water goes to lakes or other water bodies with slow moving water. • Fertilizers used in agriculture are an important source of nutrients and they are difficult to control because they are non-point sources of pollution.
Poisoning of aquatic life and humans	Toxic substances that often accumulate through the food chain (E.g. metals, persistent organic pollutants, and cyanides). Also known as micro-pollutants.	• Tests to detect the presence of metals (e.g. Arsenic, Cadmium, Chromium) • Tests to detect persistent organic pollutants (POPs), such as PCBs. • Tests to detect cyanides.	• These pollutants are not removed in conventional WWTPs. Special tertiary treatment techniques are needed. • The tests are often expensive and there is no widespread use. • This category includes metals, persistent organic pollutants (e.g. pesticides and pharmaceutical substances) • Since they are usually present in small quantities, may not be suitable for aggregation in accounts.
Other	Substances that change the physical properties of water. It includes a wide variety of pollutants.	• Total Solids (TS) • Total suspended solids (TSS) • Temperature • Conductivity • Acidity (pH) • Color	• The determination of solids in wastewater is a simple and inexpensive way of quantifying the overall amount of pollution, when information from more specific tests is not available. • Temperature is useful for quantifying the amount of heat discharged to water, especially from cooling processes.

Problem	Pollutants	Tests	Main issues
			• Conductivity reflects the presence of salts. • Acidity and color reveal the presence of other pollutants, mainly from manufacturing processes.

The choice of the tests used to measure the pollution or to refer the statistics will depend on the pollution problems that are considered relevant for the accounts and statistics to be performed, as well as the potential availability of data. Economies at early stages of development will usually put more emphasis on "conventional" or "classic" pollutants, such as organic matter. In more advanced economies with ample wastewater treatment capacity, nutrients or poisonous substances may be more policy relevant.

In any case, it is recommended to start the data collection and compilation of statistics and accounts with quantities referring to classic tests, such as BOD, COD, TSS, TN and TP, which are more widely available and easier to incorporate in the accounting format. Other variables can be incorporated later.

A discussion of the main issues to consider for each type of pollutant and tests to measure them is presented below. A more detailed list of tests used to measure pollutants in wastewaters and water bodies is presented in **Module 3.C.1**.

a). Pathogens

Pathogenic viruses, bacteria, protozoa and helminths can be present in sewage and if not properly managed can affect people. The following are examples of pathogens that could be found in water:

- Viruses of hepatitis and polyomielitis.
- Bacteria vibrio cholera and salmonella.
- Protozoa Cryptosporidium parvum and the Giardia lamblia.
- Helminths (parasitic worms) Taenia solium and Heterobilharzia americanum.

Pathogens are difficult to monitor directly. Instead, indicator micro-organisms have been used to suggest their presence. Commonly used indicator bacteria are fecal coliforms, Escherichia coli (E. coli) and enterococci, which are not pathogens. Pathogens are easily removed by disinfection in WWTPs.

The data about pathogens can be reported in specific points, such as in places used for swimming, but it is not suitable for aggregation in emission accounts. Also, depending on the characteristics of the water bodies, pathogens may die quickly or survive longer, therefore their effect is highly variable and not suitable of aggregation throughout large areas.

b). Organic matter

Organic matter is the most common type of pollution of water bodies, since it is discharged by households and different industries. It is the main pollutant present in sewage, which contains excreta collected from households. Organic matter is food for many microorganisms that live in water. By processing their food, these microorganisms consume the dissolved oxygen in the water that contains them. The reduction of dissolved oxygen in water bodies affects the health of fish and other aquatic life. Organic matter is usually not a problem in small quantities, since it can be eliminated by the microorganisms naturally living in water bodies.

There are different tests used to estimate the amount of organic matter in a wastewater sample. The Biochemical Oxygen Demand (BOD) and the Chemical Oxygen Demand (COD) are two of the most commonly used tests:

- BOD provides an indication of the amount of waterborne biodegradable organic matter present in wastewater. It is expressed as the amount of oxygen (mg/l)[3] needed for biochemical conversion of the organic matter. It is only an indicator of the biodegradable organic matter that can be digested by aerobic micro-organisms. The test is relatively easy to perform, but it takes a minimum of five days to complete and if not performed correctly may provide erroneous results. BOD_5 is measured for a five-day period, while BOD_7 is measured for a seven-day period. BOD_5 is most commonly used around the world.
- COD provides an indication of the total amount of waterborne organic matter in wastewater, biodegradable and non-biodegradable. Since it includes non-biodegradable matter it is usually larger than BOD. It is expressed as the amount of oxygen (mg/l) needed for full chemical conversion of the organic matter. The test is faster that BOD, since it only takes about two hours to perform, compared with several days for BOD. The COD test was developed as an alternative to the lengthier BOD test.

BOD and COD are regularly measured by WWTP operators, since they are instrumental for the operation of the plants.

Other tests have been developed to measure organic matter, such as the Total Organic Carbon (TOC), which is usually more expensive and requires specialized equipment.

The measurements are done for samples of wastewater and are expressed as concentrations (e.g. mg/L). In order to be able to aggregate the data it is necessary to convert the concentrations into loads, which are expressed in mass units (e.g. kg or tons). To do this it is necessary to measure or estimate the corresponding amount of wastewater for which the concentrations were measured, as it will be explained and exemplified below.

WWTPs usually eliminate more than 80% of the organic matter present in wastewaters.

c). Nutrients

Phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. However, if they are present in excess, they cause dramatic increases in aquatic plant

[3] Milligram per liter (mg/L) is equivalent to 0.001 g of substance in one liter of water. Equivalent to 1 part per million (ppm).

growth and changes in the types of plants, causing eutrophication. Phosphorus is less abundant in undisturbed water bodies, therefore even small increases in phosphorus can have a significant impact.

Phosphorus and nitrogen are present in discharges from WWTPs, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas. The amount of nutrients present in wastewater is typically measured by:

- Total nitrogen (TN) provides a measure of the amount of nitrogen present in wastewater in different nitrogen compounds. TN includes organic nitrogen, ammonia, nitrates and nitrites, which are measured using different tests. Each of these forms of nitrogen is biologically convertible to one of the other forms. The measurements are typically expressed as concentration of nitrogen (mg/L).
- Total phosphorus (TP) provides a measure of the amount of phosphorus present in wastewater including organic and inorganic (mineral) phosphorus. The measurements are typically expresses as concentration of phosphorus (mg/L).

Nitrogen and phosphorus are often measured by the operators of WWTPs.

As in the case of organic matter, the measurements done at different locations may be integrated in the accounts by aggregation. In order to be able to aggregate the data it is necessary to convert the concentrations (e.g. mg/L) into loads in mass units (e.g. kg or tons). To do this it is necessary to measure or estimate the corresponding amount of wastewater for which the concentrations were measured, as it will be explained and exemplified below.

A large proportion of nutrients are discharged to the environment in the form of non-point sources, making it difficult to measure. Indirect estimation, such as through the sales of fertilizers should be used in addition to the data collected from point sources.

WWTPs with only secondary treatment do not remove nutrients. Tertiary treatment processes are necessary to remove residual nitrogen and phosphorus after secondary treatment.

d). Poisonous substances

The substances included in this category are those that cause harm to living beings in small quantities and usually accumulate in the food chain, which means that the concentration is larger in the predator than in the prey. The main substances included in this category are metals and metalloids, organic chemical pollutants (e.g. from pesticides) and cyanides. These substances are detected with chromatography and spectroscopy techniques.

- Many metals, especially some "heavy metals," such as lead (Pb), mercury (Hg) and cadmium (Cd) are highly toxic. They are called "heavy metals" because they have a high atomic mass. Some "metalloids," such as arsenic (As) are also very toxic. Also some "light metals," such as beryllium (Be) are also toxic. Metals and metalloids are often found in compounds, which are also toxic.
- Persistent organic pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. Many of them are compounds of chlorine (organohalogens), such

as polychlorinated biphenyls (PCBs), and some are used as pesticides, such as DDT. They do not decompose easily and can be transported long distances across international boundaries.
- Cyanides are compounds that have carbon and nitrogen, but are considered "inorganic" even though they have carbon. They are toxic substances that result from mining and other industrial processes.

Since relatively small quantities of these pollutants have a great effect, they are also called micro-pollutants. Their effect is usually more punctual and their aggregation may not be as meaningful as that of the other pollutants. Nevertheless aggregates can show general emission trends and possible threats due to their widespread use.

WWTPs with only secondary treatment do not remove micro-pollutants. Tertiary treatment processes are necessary to remove these pollutants.

e). Other pollutants that change the physical properties of water

There are other tests and measurements that do not specifically measure any of the pollutants mentioned above, but are useful for the compilation of statistics and accounts, such as Total Suspended Solids (TSS) and temperature:

- Total Suspended Solids (TSS) provides an unspecific measure of the amount of waterborne pollutants in wastewater that can pass a filter. The measurements are typically expressed as concentration of nitrogen (mg/L).
- Temperature is useful to estimate the amount of heat that is discharged in the wastewater. The temperature is typically measured in Celsius or Fahrenheit degrees.
- Conductivity measures the ability of water to pass an electrical current. It is used as an indicator of the presence of salts in water. Salts tend to concentrate in returns from irrigated agricultural fields. It is commonly measured in Siemens per meter.

TSS is regularly measured by WWTP operators, since it is instrumental for the operation of the plants and can be aggregated for emission accounts.

Other characteristics such as pH, odor, color and turbidity may also be measured, but may not be easily used for emission accounts.

Module 3.C.1 presents a list of tests used to measure pollutants in wastewaters and water bodies.

Sources of pollution

.a). Point source pollution emissions

Point-source emissions have a clearly identifiable outlet: pipes, ditches, channels or tunnels that directly discharge wastewater to a water body (or to land). Non-point source emissions (often from diffuse emissions) do not have a clearly identifiable outlet, such as in agriculture, or the number of outlets is too large to be identified individually, such as in the case of households not connected to sewers.

It is relatively easier to control data from point source emissions than from non-point source emissions. Point source emissions can be associated to inventories of discharges to water, which should include WWTPs operated by sewerage utilities or companies and by the different industries.

.b). Non-point source emissions

Data of emissions from non-point sources can be estimated indirectly from the amount of pesticides and fertilizers used in the case of agriculture.

.c). Sources of polluting wastewaters

The following table shows the main sources of some of the pollutants found in wastewaters

Group of Pollutants	Pollutants	Main wastewater sources
Pathogens	Pathogenic viruses, bacteria and helmiths.	• Households • Hospitals • Hotels.
Organic Matter	Biodegradable	• Households. • Agroindustries (food industries).
Nutrients	Nitrogen	• Fertilizers in returns and runoff from agricultural fields. • Discharges from WWTPs.
	Phosphorus	• Fertilizers in returns and runoff from agricultural fields. • Discharges from WWTPs. • Detergents in sewage.
Poisonous substances	Metals	• Urban runoff. • Steel industry. • Industries using electroplating. • Pesticides, herbicides, defoliants (specially arsenic). • Industries that use coal (specially lead). • Refrigeration and air conditioning industries (cadmium). • Leather tanning industry (chromium).
	Persistent Organic Pollutants (POPs): PCBs, PBTs, etc.	• Pesticides (e.g. DDT), herbicides. • PCBs are used as coolants and in electric components. • Pharmaceuticals (from pharmaceutical industries and from household sewage after consumption).
Other	Heat	• Water used for cooling (E.g. thermoelectric

		plants).
	Color	• Leather tanning industry.

Data collection

Data collection will depend on the list of pollutants that are considered relevant for the accounts and statistics to be performed. As mentioned above it is recommended to start the compilation of the accounts with measures of pollutants that are more widely available, such as BOD, COD, TSS, TN and TP.

The experts in the National Statistics Office should work in close collaboration with the experts in the Ministry of Environment, the Ministry of Water and/or the National Water Authority to compile or estimate the data required. The following are common sources of data:

- Water and/or sewage utilities, companies, associations or regulators.
- Departments in charge of controlling polluting discharges (they may issue permits, and develop inventories of polluting discharges).
- Research institutions which may have specific industry indices or coefficients useful for estimating emissions.

a). Point source emissions

It is important to first estimate the waterborne pollution in wastewater collected by sewerage from households (IRWS data item J.1). To estimate it the following data is useful:

- number of households connected to sewers,
- number of people per household, and
- average amount of polluting emissions per person.
- population connected to sewers and to other sanitation facilities.

The average amount of polluting emissions per person, can be based on measurements from the sewer industry. A population equivalent load is used in many countries to express the pollution in terms of people.

EXAMPLES:

The Dutch association of drinking water companies (Vewin) estimates that the pollution load per inhabitant, measured according to BOD, COD, TKN, TP and SST is as follows:

Measurement test or indicator	Discharge (Grams/inhabitant/day)
BOD5	50-65
COD	90-150
TKN	14-18
TP	2-4
TSS	45-68

Source: Vewin statistics 2008

In France the population equivalent load is defined as follows:

Measurement test or indicator	Discharge (Grams/inhabitant/day)
BOD5	60
COD	135
TN	9.8
TP	3.5

The amount of TSS, BOD5, COD, TN and TP, among other quantities, collected by the sewer network can be estimated based on the number of people connected to the sewer network and the population equivalent.

EXAMPLE:
In a country of 50 million inhabitants 85% of the population is connected to the sewer network. The population equivalent daily load is 70 g of TSS, 60g of BOD5 and 130 g of COD.
The load expressed as:

BOD5 is	50 million x 60 g/day x 365 days =	1.1 tons/year
COD	50 million x 130 g/day x 365 days =	2.4 tons/year
TSS	50 million x 70 g/day x 365 days =	1.3 tons/year

The load collected by sewerage is 85%

BOD5	0.9 tons/year
COD	2.0 tons/year
TSS	1.1 tons/year

Data from the WWTPs is very useful to estimate the discharges collected by the sewer system and the emissions discharged to water bodies (data item K.1 in the IRWS). Operators of WWTPs systematically collect data about the wastewater influent (flow entering the WWTP) and the effluent (flow leaving the WWTP). An inventory of WWTPs with the amounts of polluting emissions entering and leaving (influent and effluent) the plants, type of plants and method of treatment is very useful for the development emission statistics and accounts.

The operators of WWTPs usually perform frequent tests and may have long records of daily (or even hourly) concentrations of the different indicators. Annual load (mass) values (concentrations multiplied by the corresponding flow) should be used for emission accounts. The operation data from the WWTPs can be compared with the calculations of household emissions to determine industrial pollution collected by the sewer system (IRWS data item J.1). The sewerage utility may also have data about the industries discharging to the network and the amount of pollution discharged.

For industries not connected to the sewer network an inventory of discharges from the ministry of environment or water authority may be available. The inventory can provide data about the location of the discharges and the pollutants discharged (IRWS data item K.1). In some countries a chart to estimate the polluting emissions is published (e.g. in France the government publishes a “Tableau des coefficients specifiques de pollution pour l’estimation forfaitaire (TEF),” which is used for the payment of pollution fees).

EXAMPLE OF CHARTS TO ESTIMATE POLLUTION

In France, the Water Agencies (“Agences de l’Eau”) collect a fee for the mass of emissions discharged to water by industries and households. The following discharges pay a fee:

- Biochemical Oxygen Demand for five days (BOD_5)
- Chemical Oxygen Demand (COD)
- Total suspended solids (TSS)
- Acute toxicity measured with Daphnia
- Dissolved salts, measured with conductivity tests
- Reduced nitrogen (Kjendahl nitrogen) (“azote réduit” NR)
- Nitrogen oxide (“azote oxydé” NO, nitrates and nitrites)
- Total phosphorous (TP)
- Absorbable Organohalogens
- Toxic metals and metalloids. Calculated 10As+50Cd+Cr + 5Cu+50Hg + 5 Ni + 10 Pb + Zn
- Heat

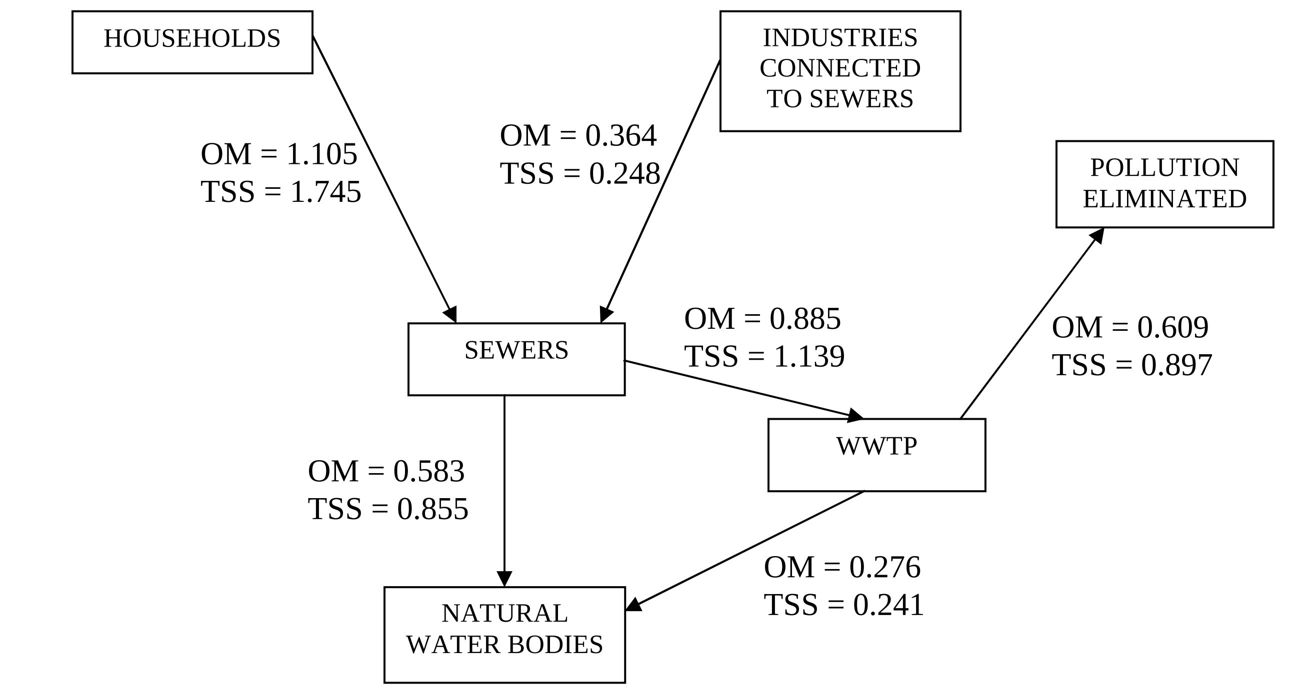
The fees have to be paid for each kilogram (or other units of measurement) of emissions discharged to water bodies. The physical and monetary amounts have to be declared to the authorities. If measurement devices are not installed, there is an estimation chart with coefficients for each type of industry (the “Tableau d’Estimation Forfaitaire”). With this information accounts and statistics are integrated. See **Module 3_K_2** for more details about the pollution coefficients.

Agriculture is a special case of industry that returns large amounts of water. However, the waterborne emissions of these returns are considered non-point sources of pollution (IRWS data item K.2) because they don’t have a specific point of discharge. The main pollutants in agricultural returns are the result of the application of fertilizers and pesticides. Pollution due to fertilizers can be measured based on nitrogen and phosphorus tests. Pollution due to pesticides can fall in the category of Persistent Organic Pollution (POPs). These pollutants are spread in large areas washed by natural runoff resulting from precipitation or the water applied through irrigation.

The data on point source emissions can be aggregated and shown in flows between the different economic units as shown below.

EXAMPLE OF POLLUTION FLOWS IN FRANCE

The following diagram was published in the 1990s by the Ministry of Environment of France in preparation of the 1992 water law. The diagram shows the point polluting emissions discharged through sewerage. OM = Organic Matter, and TSS = Total suspended solids. WWTP = Wastewater Treatment Plants. Quantities in million tons per year.



The diagram shows that the waterborne emissions to water bodies in France had about 0.859 tons/year (0.583+0.276) of organic matter and 1.096 tons/year of total suspended solids (0.855 + 0.241). Wastewater treatment plants eliminate 41% of the organic matter and 45% of the suspended solids. Households are responsible for 75% of the organic emissions and 88% of the suspended solids.

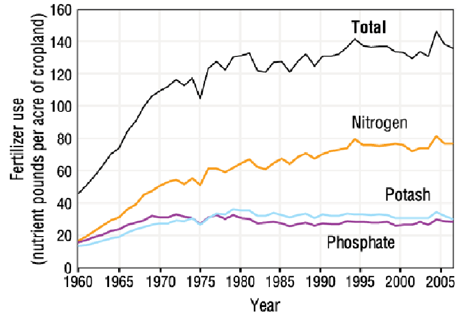
NOTE: organic matter is estimated as the average of COD and BOD.
Source: Ministere de l'Environnement .- Pour que l'eau vive: Trois années de concertation et de décisions sur la gestion de l'eau en France.- Paris 1992

b). Non-point source emissions

Statistics and accounts of waterborne emissions from non-point sources to the environment (data item K.2 in the IRWS) can be estimated based on the guidelines provided above for the case of agriculture and households (in the case they are not connected to the sewer network). Also data of pesticides and fertilizers purchased by farmers (agriculture) can be useful in estimating the emissions.

EXAMPLE: The US Environmental Protection Agency has estimated the amount of fertilizers used in agriculture in the United States. This is closely related to non-point pollution of water bodies.

Exhibit 4-16. Commercial fertilizer use in the U.S., 1960-2006[a]



[a]Based on sales data. Per-acre use based on the total acreage of harvested or failed cropland, as determined by USDA's National Agricultural Statistics Service.

Data source: *USDA ERS, 2007a, 2007b*

Data in the accounts

The data collected is compiled in the supply and use tables as shown below. The column "Other industries" should be subdivided according to the specific purpose of the accounts. The list of substance measurements or pollutants has to be done according to the list of pollutants identified in the data collection and compilation strategy.

A complete example is included in the guidelines.

Physical Supply Table for Gross Releases of Substances to Water (in tons per year)

Substance measurements	Water supply industry	Sewerage industry	Other industries	Households	Flows from the environment
Emissions (to the environment)					
TSS		K	K	K	
BOD5		K	K	K	
COD		K	K	K	
TN		K	K	K	
TP		K	K	K	
Chromium		K	K	K	
Mercury		K	K	K	

Releases (to the economy)					
TSS			J	J	
BOD5			J	J	
COD			J	J	
TN			J	J	
TP			J	J	
Chromium			J	J	
Mercury			J	J	

Physical Use Table for Gross Releases of Substances to Water (in tons per year)

Substance measurements	Water supply industry	Sewerage industry	Other industries	Households	Flows to the environment
Emissions (to the environment)					
TSS					K
BOD5					K
COD					K
TN					K
TP					K
Chromium					K
Mercury					K
Releases (to the economy)					
TSS		J	J	J	
BOD5		J	J	J	
COD		J	J	J	
TN		J	J	J	
TP		J	J	J	
Chromium		J	J	J	
Mercury		J	J	J	

The tables facilitate the verification of the consistency of data. The sum of the rows in the supply table has to be the same as the sum of the rows in the use table.

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http://water.epa.gov/type/rsl/monitoring/vms50.cfm

.IV. Monetary data items

Monetary data items, subheadings L to R in the IRWS:

- L. Value and cost of water and sewerage services
  - L.1. Value of shipments/sales/turnover
  - L.2. Compensation of employees
  - L.3. Purchases of goods and services
  - L.4. Purchases of water
  - L.5. Purchases of sewerage services
- M. Taxes
  - M.1.1 Taxes on products
  - M.1.2 Other production taxes
- N. Subsidies and investment grants
  - N.1. Subsidies received
    - N.1.1 Subsidies on products
    - N.1.2 Other subsidies on production
  - N.2. Investment grants
- O. Assets
- P. Capital expenditures
- Q. Depreciation
- R. Tariffs and charges
  - R.1. Volumetric tariffs and charges for water supply
  - R.2. Fixed charges for water supply
  - R.3. Volumetric tariffs and charges for sewerage services
  - R.4. Fixed charges for sewerage services

<u>Monetary Supply and Use Tables</u>

The main advantage of compiling the Physical Supply and Use Tables (PSUT) described in section 2 is to be able to combine the monetary information of the national accounts with physical quantities. The tables have the same structure in order to facilitate the combination of information.

Monetary data items L, M, N, P and Q are usually part of the information collected by national accountants to integrate the production accounts. The SNA supply and use tables showing the IRWS data items are shown below:

Table 3.3.1. Monetary supply table showing IRWS data items

SUPPLY (at basic prices)	Industries (except water supply and sewerage)	ISIC 3600 Water supply	ISIC 3700 Sewerage services
All other products	not in IRWS		
Natural water (CPC 18000)		L.1.1	
Sewerage (CPC 94110)			L.1.2
T O T A L	**not in IRWS**	**L.1.1**	**L.1.2**

The supply table is recorded preferably in basic prices. Basic prices, as shown in figure 3.3.1 include subsidies on products and exclude taxes on products.

The supply table above shows, in each row, the output by products from each industry shown in the columns. All products can be produced by the different industries, but if the industries are broken into establishments and classified accordingly, it is expected that most of the output from the water supply industry (ISIC 3600) is natural water (CPC 18000), and most of the output from the sewerage industry (ISIC 3700) is sewerage service (CPC 94110). It is expected that the other industries do not produce water or provide sewerage services, or that the production is relatively small. Therefore the production numbers appear mainly in the diagonal, as shown above.

The use table below shows, in each row, the intermediate consumption by products by each industry shown in the columns. By subtracting the totals in the use table to the totals in the supply table value added is found.

Value added represents the contribution of labor and capital to the production process (SNA 6.71). Therefore the compensation of employees (data items L.2.1 and L.2.2) is part of the value added. Also, other taxes on production (data items M.1.2.1 and M.1.2.2) are part of the value added.

Table 3.3.2. Monetary use table showing IRWS data items

USE (at purchasers' or producers' prices)	Industries (except water supply and sewerage)	ISIC 3600 Water supply	ISIC 3700 Sewerage services
All other products	not in IRWS	L.3.1	L.3.2
Natural water (CPC 18000)	L.4		
Sewerage (CPC 94110)	L.5		
T O T A L	**not in IRWS**	**L.3.1**	**L.3.2**

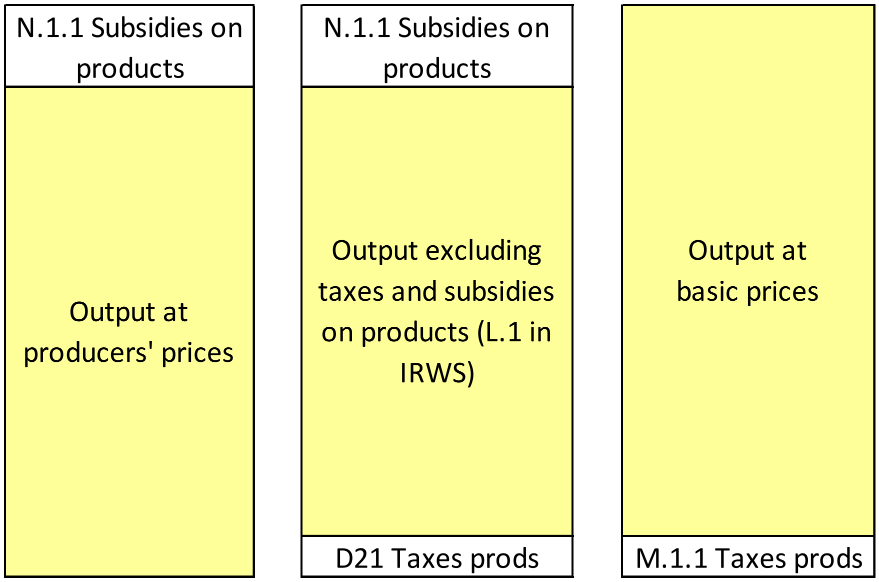
GROSS VALUE ADDED (at basic prices)	**not in IRWS**	**L.1.1 - L.3.1**	**L.1.2 - L.3.2**
Of which: Compensation of employees	not in IRWS	L.2.1	L.2.2
Other taxes on production	not in IRWS	M.1.2.1	M.1.2.2

The supply table is shown in basic prices and the use table in purchasers' or producers' prices (see below the discussion regarding prices), so the value added obtained is defined as "Gross Value Added (GVA)" at basic prices in the SNA. These prices reflect what is actually payable and receivable by the producer.

Purchasers' prices are equal to basic prices plus taxes less subsidies on products (data items M.1.1 and N.1.1), plus separately invoiced transport charges, plus wholesalers' and retailers' margins, plus Value Added Tax (VAT) not deductible by the purchaser. Water and sewerage industries do not invoice transport charges separately. Also, there are no wholesalers' or retailers' margins. Therefore purchasers' prices are equal to producers' prices.

The relationships of prices are shown in the figure below.

Figure 3.3.1. Relationships between basic and producers' prices



Therefore, if L.1.1 and L.1.2 do not include neither taxes nor subsidies on products, then:

L.1.1 + M.1.1.1 = output of natural water at producers' prices (CPC 18000), and
L.1.2 + M.1.1.2 = output of sewerage services (CPC 94100) at producers' prices
L.1.1 + N.1.1.1 = output of natural water at producers' prices (CPC 18000), and
L.1.2 + N.1.1.2 = output of sewerage services (CPC 94100) at producers' prices

It is important to mention that values in accounting tables are recorded in accrual terms, this means that they are recorded at the time economic value is created, transformed, exchanged, transferred or extinguished. For this reason, output is recorded as the amount receivable (which corresponds to billed amounts). However, often water and sewerage utilities are unable to collect the total amounts billed. For this reason it is important to record in the financial assets the accounts receivable, which often will not be collected and will have to be written off. A complete example is shown in chapter 5.

Capital Accounts

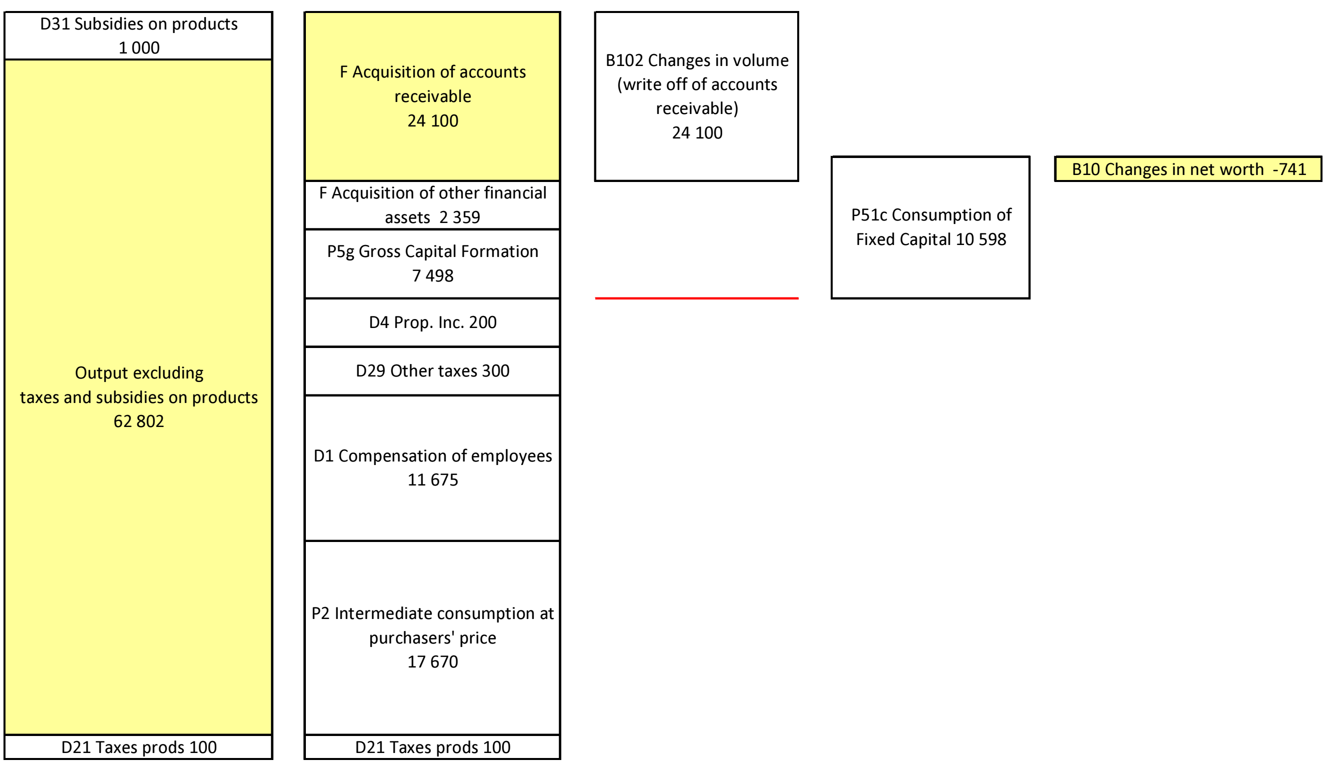
The capital accounts, analogous to the physical asset accounts presented in the first section of this chapter, show the value of the water supply and sewerage assets through time.

Table 3.3.3. Capital account showing IRWS data items

	Water supply	Sewerage
Opening stock of fixed capital	**Opening O.1.1**	**Opening O.1.2**
Increases of value of fixed capital		
Gross fixed capital formation	P.1.1	P.1.2
Other changes in value of fixed assets	not in IRWS	not in IRWS
Reductions of value of fixed capital		
Consumption of fixed capital	Q.1.1	Q.1.2
Other reduction in value of fixed assets	not in IRWS	not in IRWS
Closing stock of fixed capital	**Closing O.1.1**	**Closing O.1.2**

The following figure shows the interrelations of the different data items described above for the case in which the output (value of shipment/sales/turnover) is enough to have a net fixed capital formation. The column on the left shows the financial supply and the columns of the right shows the financial demand.

Figure 3.3.2. Relationships among different IRWS monetary data items for the scenario in which all expenses are financed



The case shown in the figure has two characteristics: all the expenses are financed by the sales of water, and the fixed capital (the water supply infrastructure) is improved, since there is a net fixed capital formation. The following table shows the different combinations:

Scenario	Tariffs and changes in net worth	Description
1. Independent and creating a better future	"Tariff"/"3Ts" = 100% Changes in net worth > 0	The users finance the industry through the payment of tariffs. The changes in net worth are positive, which means that the industry has enough financial resources to cover the consumption of fixed capital, and also the expansion or improvement of the infrastructure.
2. Independent, but business as usual	"Tariff"/"3Ts" = 100% Changes in net worth = 0	The users finance the industry through the payment of tariffs. The changes in net worth are zero, which means that the industry has enough financial resources to cover the consumption of fixed capital, but no additional resources are available for expansion or improvement of the infrastructure.
3. Independent, but living from history	"Tariff"/"3Ts" = 100% Changes in net worth < 0	The users finance the industry through the payment of tariffs. The changes in net worth are negative, which means that the industry does not have enough financial resources to cover the consumption of fixed capital. There is a financial gap that will be reflected by the deterioration of the infrastructure.
4. Dependent, but making a better future	"Tariff"/"3Ts" < 100% Changes in net worth > 0	The payment of tariffs by the users is complemented with taxpayers money or funds from foreign aid. The changes in net worth are positive, which means that the industry has enough financial resources to cover the consumption of fixed capital, and also the expansion or improvement of the infrastructure.
5. Dependent, and in business as usual	"Tariff"/"3Ts" = 100% Changes in net worth = 0	The payment of tariffs by the users is complemented with taxpayers money or funds from foreign aid. The changes in net worth are zero, which means that the industry has enough financial resources to cover the consumption of fixed capital, but no additional resources are available for expansion or improvement of the infrastructure.
6. Dependent and living from history	"Tariff"/"3Ts" < 100% Changes in net worth < 0	The payment of tariffs by the users is complemented with taxpayers money or funds from foreign aid. The changes in net worth are negative, which means that the industry does not have enough financial resources to cover the consumption of fixed capital. There is a financial gap that will be reflected in the deterioration of the infrastructure.

The three Ts

In order to better communicate the different scenarios to policy makers, the OECD has defined the three Ts of drinking water supply and sanitation. The three Ts are "Tariffs," "Taxes," and "Transfers."

- "Tariffs" refer to the sales of water to the users, excluding taxes and subsidies.
- "Taxes" refer to the financial resources received from the local, provincial or national government, and include subsidies on products and other transfers for operation or capital expenditures.
- "Transfers" refer to the financial resources received from other countries and may be applied via subsidies on products or other different transfers for operation and capital expenditures.

The three first scenarios depicted above are cases in which "Tariffs" is a 100% and "Taxes," and "Transfers" are 0% of the total expenditures.

The last three scenarios depicted above are cases in which "Tariffs" are less than a 100%, and "Taxes" and "Transfers" are more than 0%.

Regardless of the mixture of the three Ts, it is important to note that cases 1 and 4 are highly desirable, cases 2 and 5 are less desirable, and cases 3 and 6 should definitely be avoided.

Water supply and sewerage tariffs and charges

Tariffs and charges (data item R) connect the monetary data with the physical data. Tariffs and charges are prices which link quantities ("physical quantities") with value. The SNA provides the following definition: value (v) at the level of a single, homogeneous good or service is equal to the price per unit of quantity (p) multiplied by the number of quantity units (q), that is v = p * q. (SNA 15.10).

In a similar way tariffs and charges (data item R.1) multiplied by quantities supplied (data item F.1) are equal to value (data item L.1). However, there is usually an offset, which is a fixed amount charged independently of the quantity of product supplied. Therefore:

For water supply:

L.1.1 = F.1 * R.1 + R.2 (F.2 could also be included if there are exports of water)

For sewerage:

L.1.2 = F.3*R.3 + R.4 (F.4 could also be included if there are exports of wastewater)

The water supplied (data item F.1) is the water billed to the users, which is charged at a volumetric rate (data item R.1) in addition to a minimum or fixed charge, charged regardless of the amount of water used (data item R.2).

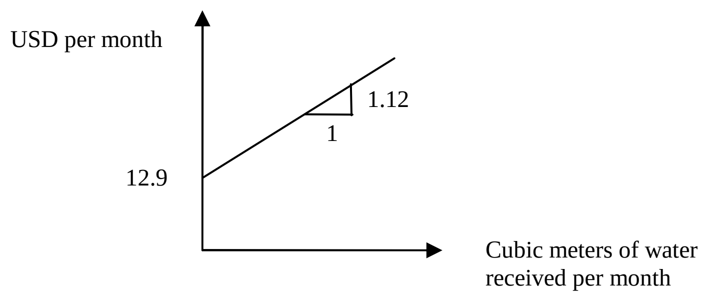
In a similar way, sewerage is charged based on the volume of wastewater collected (data item F.3.1), a volumetric rate (data item R.3) and a minimum or fixed charge (data item R.4). Often, only the water supplied is measured, and the sewage collected is simply estimated based on the amount of water billed.

EXAMPLE:

Metered Water Rates in New York City, for households.

A. The charge for water measured by meter is $3.17 per one hundred cubic feet provided (1.12 USD/m^3)
B. The minimum charge imposed for water service is $0.43 per day per water meter within a Bill Period.

The following figure shows the tariff structure



The wastewater charge for any property supplied with water from the Water Supply System is one hundred fifty-nine percent (159%) of the charges for water supplied to that property from the system, including any surcharges, unless otherwise provided in the Rate Schedule.

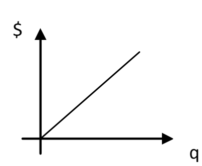
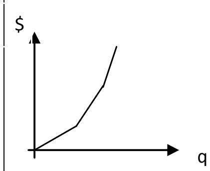
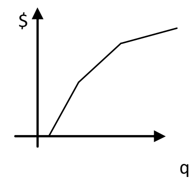
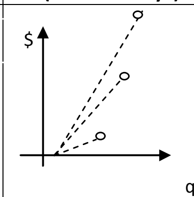
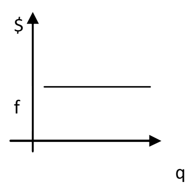
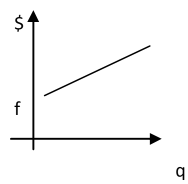
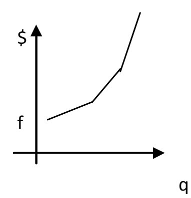
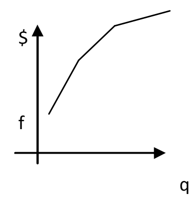
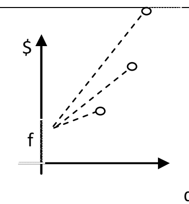
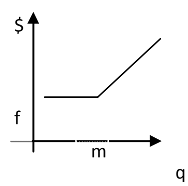
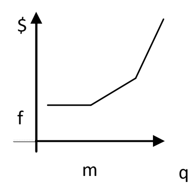
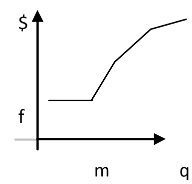
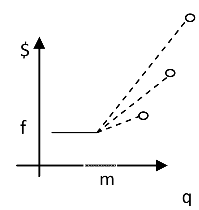
Source: New York City Water Board, water and wastewater rate schedule, effective July 2011

Water supply and wastewater collection companies or utilities may have different tariff structures. However, the price structure usually has the following elements:

- A fixed price (f), which is independent of the amount of water consumed (data item R.2 and R.4).
- A minimum volume (m), for which consumers only pay the fixed price and beyond which a volumetric price is applied.
- Blocks for which different unit prices are established (data items R.1 and R.3).

The figure below shows the various possibilities of tariff structures. The graphs show the volumetric amount of water billed in the horizontal axis, and the total monetary amount to be paid in the vertical axis. The tariff structure type C-3 is very common in many countries.

Figure 3.3.3. Tariff structures used for water supply and sewerage

TYPE	A (flat)	B Constant increase	C IBT= Increasing Block Tariffs ("with memory")	D DBT= Decreasing Block Tariffs	E VDT= Volume Differentiated Tariffs ("no memory")
1. Without fixed part	0				
2. With fixed part					
3. With fixed part and minumum volume					

In the graphs, f= fixed part of the tariff, which is paid regardless of amount of water used (data item R.2 and R.4), q is quantity of water billed (data item G.1) in physical data.

Tariff structures may be different for households (sometimes referred as "domestic or residential tariff") and for the different industries connected to the water supply network.

In many cases there are tariff collection problems, so only one portion of the water billed is actually paid. It is therefore important to quantify the proportion of water billed that is actually paid.

Integrating data into the accounts

Some of the data required may have already been collected for the compilation of national accounts. It may have been collected through economic censuses or surveys applied to water supply and sewerage industries. Additional data may be required from the establishments performing the activities of water supply and sewerage. It is therefore key to identify water supply and sewerage utilities.

In addition to water utilities, other industries may perform the activities of water supply and sewerage as a secondary activity. Also households may perform the activities on own account. Data needs to be collected or estimated from these industries or households.

A brief description of the raw data and processing needed to incorporate them in the accounts follows. General information about the collection of economic data from industries can be found in the collection of monetary data from industries can be found in the International Recommendations for Industrial Statistics 2008:

Data item	Raw data that can be used	Processed data to for the accounts
L.1. Value of shipment/sales/ turnover	• Inventory of water and sewerage utilities. • Data on sales of water from financial accounts of water and sewerage utilities. • Output of the ISIC 3600 and ISIC 3700 columns in the national accounts.	• Sales should exclude taxes on products, and exclude subsidies on products. • Compare data with national accounts data.
L.2 Compensation of employees	• Data on remuneration paid to employees from financial accounts from of water and sewerage utilities.	• The value of remuneration in cash or in kind paid to the employees.
L.3 Purchases of good and services	• Data on sales of water from financial accounts of water and sewerage utilities. • Intermediate consumption of the ISIC 3600 and ISIC 3700 columns in the national accounts at purchaser's prices.	• Purchases should include taxes on products and exclude any subsidies on products.
M.1.1 Taxes on products	• Data on the taxes payable by the purchaser for the amount of water received from the utilities or the sewerage service received. It excludes VAT because it is "deductible" (SNA 7.89)	• Basic prices exclude all taxes on products.
M.1.2 Other production taxes	• Data on all taxes payable that are not taxes on products. They include payroll taxes, recurrent taxes on buildings or other structures, and taxes on pollution (SNA 7.97).	• Important to include taxes, "royalties" or "duties" paid for the volume of water abstracted or the pollution discharged in water bodies. These taxes may also be considered as rent (property income) for the use of subsoil resources or royalties for permission to extract resources (SNA 7.154 and 7.160)
N.1.1 Subsidies on products	• Data on the subsidies for the amount of water received	• Basic prices include all subsidies on products.

Data item	Raw data that can be used	Processed data to for the accounts
	from the utilities or the sewerage service received.	
N.1.2 Other subsidies on production	• Data on subsidies, except subsidies on products, that are receivable by the producer for engaging on the production of water or sewerage. They include subsidies on payroll, and subsidies to reduce pollution.	• Includes subsidies for reducing pollution.
O.1 Gross value of fixed assets	• Inventory of water and sewerage infrastructure. Valuation of the infrastructure	• Difficult to calculate with precision. Need to make estimates based on the main components of the infrastructure.
P.1 Capital expenditure (CAPEX)	• Value of expenditures on new and fixed assets. • Fixed capital formation from the national accounts. Need to find mainly in construction rows.	•
Q. Depreciation	• The loss of value of fixed asset. Need to use SNA methodologies. • Fixed capital consumption in the accounts.	• Compare data from financial accounts and national accounts.
R. Tariffs and charges	• Tariff schedules from water and sewerage utilities. See the structures shown in figure 3.3.3	• Find average tariffs for households and different types of industries.

<u>Connecting the pieces of information</u>

The monetary supply and use tables for the Shipland Example are shown below.

Figure 3.3.4. Monetary Supply Table of Shipland (million dollars per year)

		ISIC 01-03	ISIC 05-33, 41-43,38,39,45-99	ISIC 3510-1	ISIC 3510-2	ISIC 3600-1	ISIC 3700	ISIC 5222
	SUPPLY ↓	Agriculture and livestock	Manufacture and services	Cooling (thermoelectricity)	Hydroelectricity	Water utilities (drinking water)	Sewerage (sewage collection and treatment)	Operation of waterway locks
Various CPCs	All other products	1200	6000	400	200	50	45	1700
CPC 18000-2	Bulk or raw water							0.05
CPC 18000-1	Drinking water							
	TOTAL	**1200**	**6000**	**400**	**200**	**50**	**45**	**1700.05**

Figure 3.3.5. Monetary Use Table of Shipland (million dollars per year)

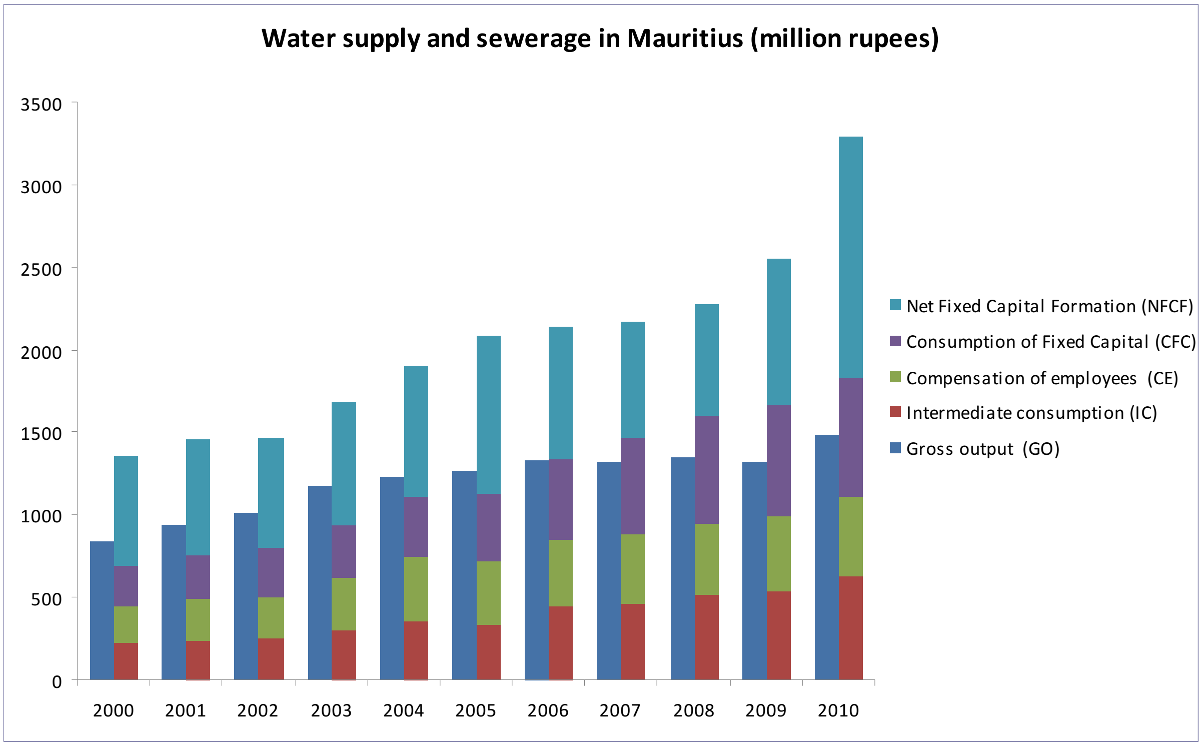
		ISIC 01-03	ISIC 05-33, 41-43,38,39,45-99	ISIC 3510-1	ISIC 3510-2	ISIC 3600-1	ISIC 3700	ISIC 5222
	USE ↑	Agriculture and livestock	Manufacture and services	Cooling (thermoelectricity)	Hydroelectricity	Water utilities (drinking water)	Sewerage (sewage collection and treatment)	Operation of waterway locks (ACP)
Various CPCs	All other products	320	435	75	15	30	25	118
CPC 18000-2	Bulk or raw water							0.1
CPC 18000-1	Drinking water							
	TOTAL	**320**	**435**	**75**	**15**	**30**	**25**	**118.1**
	GROSS VALUE ADDED	**880**	**5990**	**325**	**185**	**20**	**20**	**1581.95**

Combining the information from the monetary and the physical tables several indicators may be calculated. For example:

- Value added per cubic meter of water abstracted by the waterway locks industry 1581 mill USD/2558 mill. m3 = 0.62 USD/m3
- Value added per cubic meter of water used by the manufacture and services industries 5990 mill USD/187 mill m3 = 32.0 USD/m3

<u>Examples</u>

The graph below shows the gross output, intermediate consumption, compensation of employees, consumption of fixed capital, and net fixed capital formation for the Republic of Mauritius between 2000 and 2010.



Source: Statistics Mauritius. Preliminary data. DO NOT CITE.

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.V. Water-related social-demographic data items

Social demographic data items in the IRWS are listed under subheadings S, population by main source of drinking water, and T, population by type of toilet and sewage disposal. These data items are the basis for reporting on indicators 7.8 and 7.9 of the Millennium Development Goals (MDG).

Population by main source of drinking water

The population using improved drinking water sources (data item S.1) is defined as the population using drinking water from a facility that, by nature of its construction or through active intervention, is protected from outside contamination and in particular from contamination with fecal matter.

Improved drinking water sources include:

- piped water into dwelling,
- piped water into plot or yard;
- public tap/standpipe;
- borehole/tube well;
- protected dug well;
- protected spring;
- rainwater collection and bottled water. Users of bottled water are considered to have access to improved sources only when they have a secondary source which is of an otherwise improved type.

Improved drinking water sources do not include:

- unprotected wells,
- unprotected springs,
- water provided by carts with small tanks/drums,
- tanker truck-provided water and bottled water (if a secondary source is not improved)
- surface water taken directly from rivers, ponds, streams, lakes, dams, or irrigation channels.

The data can be obtained from censuses, which are generally conducted every 10 years, and from household surveys, which are generally conducted every 3 to 5 years. Line ministries and water utilities keep records on the number and type of facilities constructed. This information can be useful when a census or survey is not available or for data between censuses and surveys.

The following disaggregation of the data is desirable:

	Rural	Urban	Total
Piped connections on premises			
Of which:			
Piped into dwelling			
Piped to yard/plot			
Public tap or standpipe			
Tubewell or borehole			
Protected dug well			

Protected spring			
Rainwater			
Unimproved sources			

Based on categories presented at www.wssinfo.org

Geographical and socio-economic disaggregation is desirable. Information on who usually goes to collect water for the household, especially in rural areas, by sex and age group is useful for analysis of gender equality issues.

Population by type of toilet and sewage disposal used

The population using improved sanitation facility (data item T.1) is defined as the population using a sanitation facility that hygienically separates human excreta from human, animal and insect contact.

Improved sanitation facilities include:

- flush/pour-flush toilets or latrines connected to a sewer,
- septic tank, or pit;
- ventilated improved pit latrines;
- pit latrines with a slab or platform of any material which covers the pit entirely, except for the drop hole;
- composting toilets/latrines.

Improved sanitation facilities do not include:

- public or shared facilities of an otherwise improved type;
- flush/pour-flush toilets that discharge directly into an open sewer or ditch or elsewhere;
- pit latrines without a slab;
- bucket latrines;
- hanging toilets or latrines;
- open defecation in the bush, field or bodies of water.

The following disaggregation of the data is desirable:

	Rural	Urban	Total
Flush toilet to piped sewer system			
Flush toilet to septic tank			
Flush/pour flush to pit latrine			
Ventilated improved pit latrine (VIP)			
Pit latrine with slab			
Composting toilet			
"flush/pour flush to unknown place"			
Unimproved sanitation			

Based on categories presented at www.wssinfo.org

In order to compile the tables shown above, it is important to define urban and rural population. The definitions are different in different countries. Some countries define it based on the number of inhabitants of a geographical unit. Delimitations based on maps of different population densities may yield more realistic delimitations.

Geographical and socio-economic disaggregation is desirable. Information on who usually goes to collect water for the household, especially in rural areas, by sex and age group is useful for analysis of gender equality issues.

Data processing

A brief description of the raw data and processing needed to incorporate them in the accounts is described below:

Data item	Raw data commonly available	Processed data for the accounts
S.1.1 Piped water into the housing unit/living quarters	• Number of households with piped water from population censuses and household surveys • Number of drinking water supply connections to households from drinking water utilities	• Based on the criteria to define urban and rural population, and the number of people that form a household it is possible to estimate the number of people with piped water. • Connections refer to dwellings where more than one household can live. Need to define the number of people in each dwelling. • Censuses and surveys can be used as reference to check administrative data from water utilities.
S.1.2. Public standpipe	• Number of households that use water from public standpipes from population censuses and household surveys • Number of public standpipes through which the water utilities supply water.	• Based on the criteria to define urban and rural population, and the number of people that form a household it is possible to estimate the number of people that use public standpipes. • Water utilities may provide the number of standpipes installed. An estimate of the number of people that use each standpipe may be useful to estimate the coverage. • Censuses and surveys can be used as reference to check administrative data from water utilities.

<table>
<tr><th>Data item</th><th>Raw data commonly available</th><th>Processed data for the accounts</th></tr>
<tr><td>S.1.3 Boreholes</td><td>• Data from population censuses and household surveys.</td><td>• Similar to previous case</td></tr>
<tr><td>S.1.4 Protected dug wells</td><td>• Data from population censuses and household surveys.</td><td>• Similar to previous case</td></tr>
<tr><td>S.1.5 Protected springs</td><td>• Data from population censuses and household surveys.</td><td>• Similar to previous case</td></tr>
<tr><td>S.1.6 Rainwater collection</td><td>• Data from population censuses and household surveys.</td><td>• Similar to previous case</td></tr>
<tr><td>S.1.7 Bottled water (along with other improved sources for hygiene and cooking)</td><td>• Data from population censuses and household surveys.</td><td>• Similar to previous case</td></tr>
<tr><td>T.1.1 Flush/pour or flush toilet to piped sewer system</td><td rowspan="6">• Number of households with connections to the sewer system from population censuses and surveys
• Number of sewer connections to households from sewerage utilities</td><td rowspan="6">• Based on the criteria to define urban and rural population, and the number of people that form a household it is possible to estimate the number of people with connection to the sewer system. More details may be hard to determine.
• Connections refer to dwellings where more than one household can live. Need to define the number of people in each dwelling.
• Censuses and surveys can be used as reference to check administrative data from sewerage utilities.
• Specific surveys should be designed to obtain more detailed information.</td></tr>
<tr><td>T.1.2 Flush/pour or flush toilet to septic tank</td></tr>
<tr><td>T.1.3 Flush/pour toilet to pit</td></tr>
<tr><td>T.1.4 Ventilated improved pit (VIP) latrine</td></tr>
<tr><td>T.1.5 Pit latrine with slab</td></tr>
<tr><td>T.1.6 Composting toilet/latrine</td></tr>
</table>

The data can be obtained from censuses, which are generally conducted every 10 years, and from household surveys, which are generally conducted every 3 to 5 years. Line ministries and sewerage utilities keep records on the number and type of facilities constructed. This information can be useful when a census or survey is not available or for data between censuses and surveys.

EXAMPLE: POPULATION CENSUSES IN MEXICO
The National Institute of Statistics and Geography of Mexico (INEGI) has performed a population census every five years since 1990. The censuses include the number of households and number of inhabitants in households with the following characteristics:

1. Piped water inside the household
2. Piped water outside of the household, but in the plot.
3. Access to piped water from a neighboring household
4. A public tap or standpipe
5. Household drains connected to the public sewerage network.
6. Household drains connected to a septic tank
7. Household drains that discharge to a river, lake or to the sea.
8. Household drains that discharge to a cliff or crack

In partnership with the National Water Commission of Mexico (CONAGUA) the information collected is analyzed according to different sizes of population centers. See results in module 3.S.1.

Source: CONAGUA.- Análisis de la Información del Agua de los Censos y Conteos 1990 a 2005.- Mexico 2007.

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