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Pilot Arno Water Accounts

Deliverable: D2.2 Assessment of data availability

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1 Introduction

The PAWA project is composed of 4 successive technical activities and 2 horizontal activities as presented in the **Figure 1**.

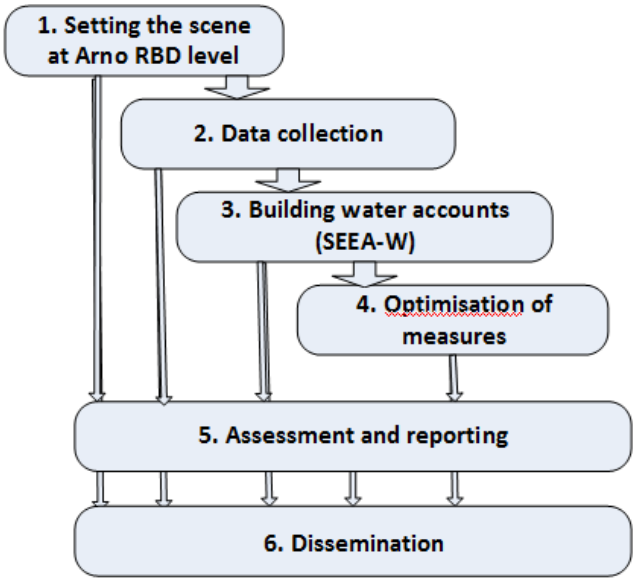

Figure 1 – Schematization of the PAWA activities.

During the first activity, three sub-basins have been identified as priority areas to prepare water accounts on a monthly basis (see **D1.2 Prioritization list of sub-basins**):

- Chiana;
- Bisenzio;
- Pisa.

This deliverable concerns the assessment of data availability as a result of Activity 2 "Data collection". Performing such an assessment implies not only taking into account the most straightforward evaluations like data availability/unavailability, but also appraising thoroughly each single data item from a qualitative point of view to understand if and how the collected data can be used for the PAWA final aim and outputs.

The project partners used the following approach:

- Identifying existing relevant datasets. More than 100 datasets have been identified and are described in the INSPIRE compliant metadata catalogue used within Activity 1 (see **D1.1 Catalogue of data sources and tools**).
- Matching dataset available (i.e., listed in the catalogue) with data items necessary for compiling the three required **SEEA-Water** tables (physical use and supply tables and asset accounts). An inventory table was designed for that task (see details in **Annex 1**). As the list of data items is rather long, it was decided to focus only to significant water flows for the three pilot sub-basins. These flow diagrams were defined for each sub-basin and validated with stakeholders during the **2nd Stakeholder Workshop** held in Florence (IT) on 2 July 2014. In this inventory table an assessment of physical scale, temporal scale and extend have also been performed
- The results of this matching exercise were discussed with local stakeholders (see **2nd Stakeholder Workshop**) to identify alternative source of information when the quality of datasets was not sufficient (e.g., monthly breakdown not available).

2 Flow diagrams and SEEA-Water tables

This chapter presents the water flow diagrams for the three pilot catchments. Both, the natural water cycle diagram and the water cycle within the economy are represented. Arrows identifying the existing water flows come along with the standard codes given by the International Recommendations for Water Statistics (IRWS). **Annex 1** presents a list of the water flows definitions identified by their codes.

2.1 Chiana sub-basin

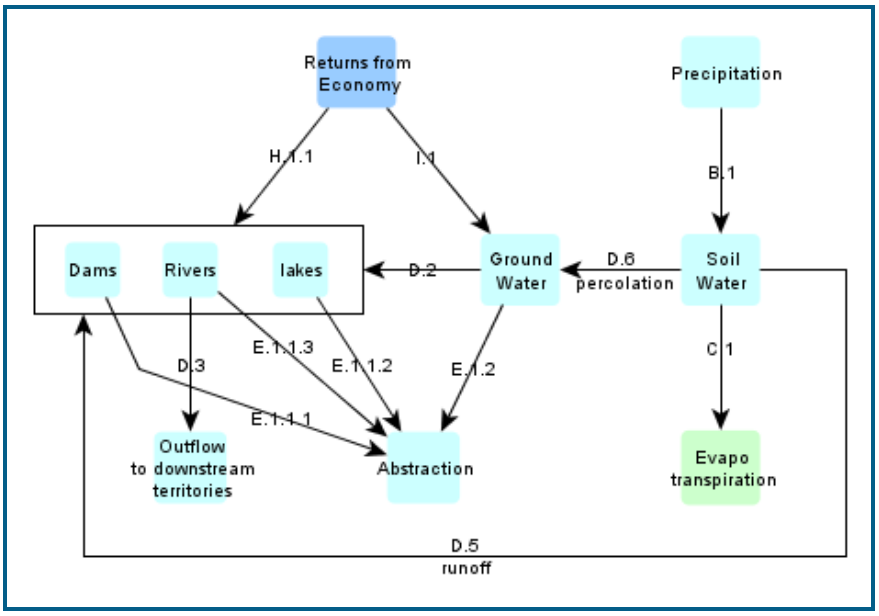

Figure 2 – Natural water cycle for Chiana.

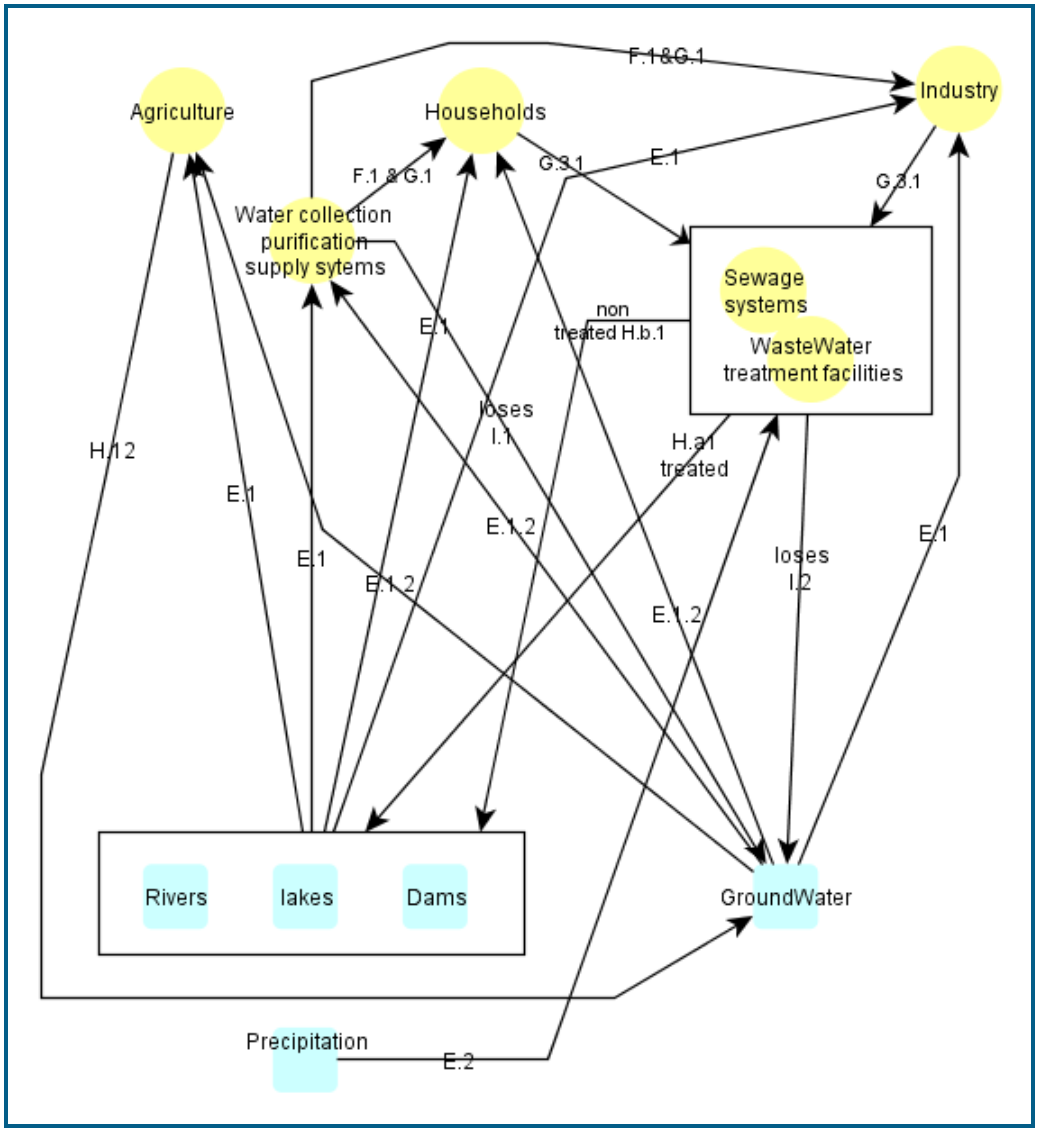

Figure 3 – Water cycle within the economy for Chiana.

2.2 Bisenzio sub-basin

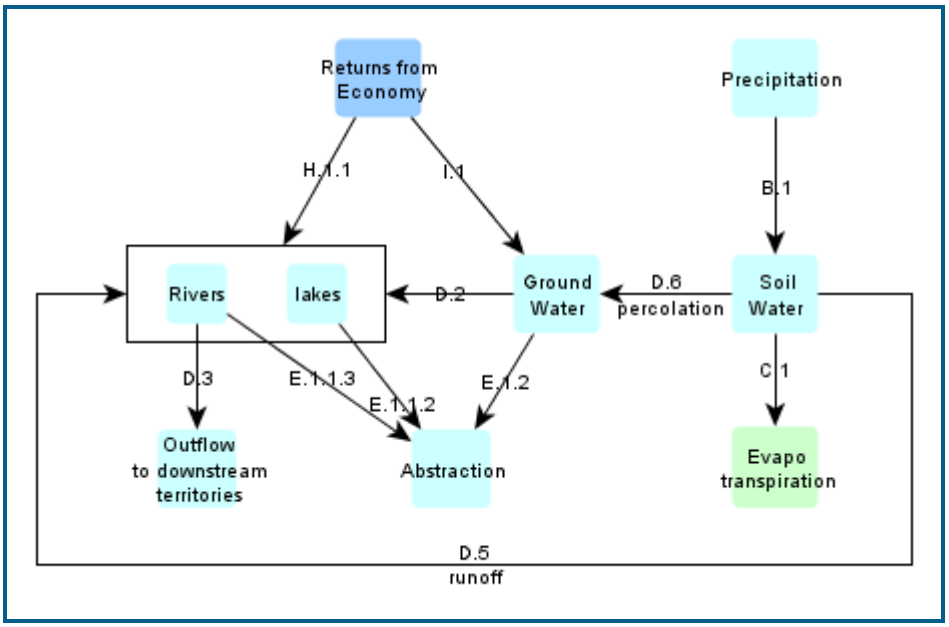

Figure 4 – Natural water cycle for Bisenzio.

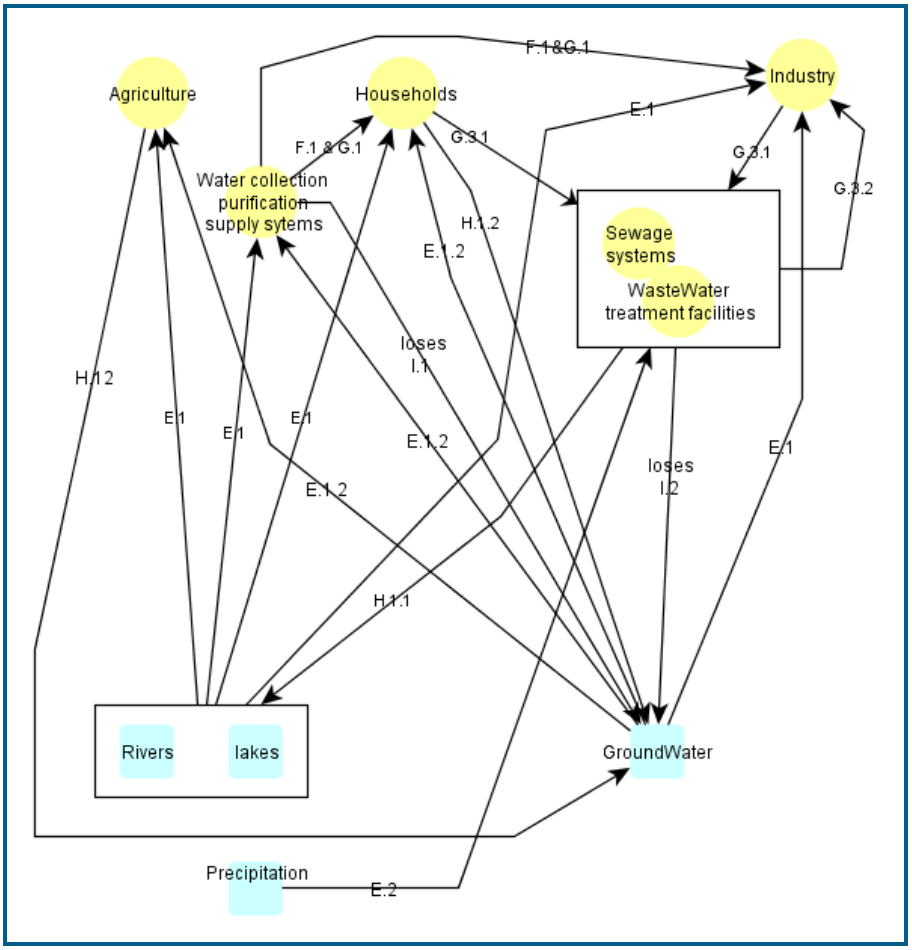

Figure 5 - Water cycle within the economy for Bisenzio

2.3 Pisa area

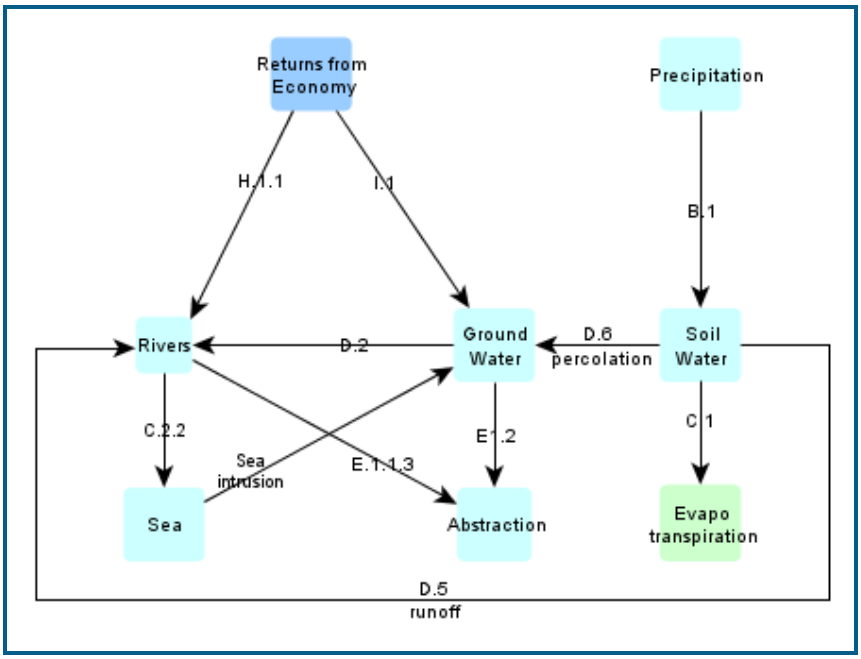

Figure 6 – Natural water cycle for Pisa area.

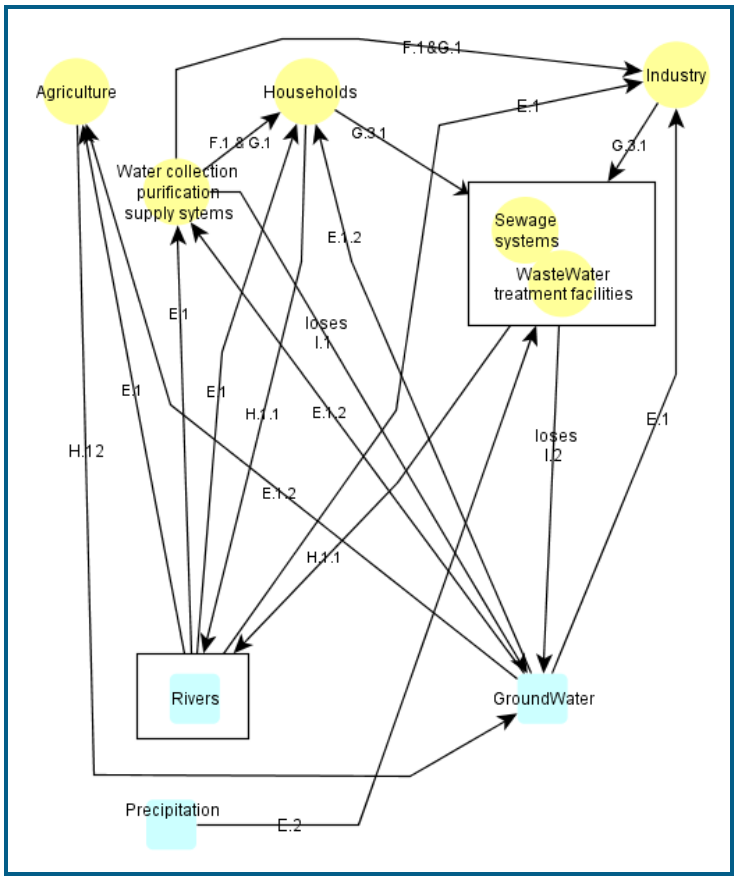

Figure 7 - Water cycle within the economy for Pisa area.

2.4 SEEA-Water tables

Based on the relevant flows for the three sub-basins, the data items necessary for compiling the physical use table (Table 1), physical supply table (Table 2) and asset accounts table (Table 3) were reduced. The non-relevant data items appear in grey in the following tables.

Table 1 – Physical water use table.

Physical water use table [Mm3]		Agri, Forest, fishing 1-3	Industries and services 5-33, 41-43, 45-99	elec-tricity 35	Water supply 36	Sewerage, WWT 37,38,39	Households
From the environment	1.a Abstraction for own use						
	1.b Abstraction for distribution						
	1.i From inland water resources	0.00	0.00		0.00		0.00
	Surface water						
	Groundwater						
	Soil water						
	1.ii Collection of precipitation						
	1.iii Abstraction from the sea						
	1. Total abstraction (1.a+1.b(=1.i+1.ii+1.iii))	0.00	0.00		0.00		0.00
Within the economy	2. From other economic units		0		0	0	0
	Water services						
	Reused water						
	Wastewater to sewerage						
	Desalinated water						

It has been agreed with stakeholders that:

- The use of soil water for rain fed agriculture could be neglected;
- Rain water harvested could be neglected;
- There is no raw water supply for agriculture, that is, water for irrigation is directly abstracted by farmers from the environment;
- Water utilities mainly supply water to households (water services in **Table 1**). Therefore the water supplied by water services to industry could be neglected. In addition, there is no suitable data management system to extract this information from water utilities billing system.

Table 2 – Physical water supply table.

Physical supply table [Mm3]		Agri, Forest, fishing 1-3	Industries and services 5-33, 41-43, 45-99	elect rcity 35	Water supply 36	Sewerage, WWT 37,38,39	Households
Within the economy	4. To other economic units	0			0	0	0
	4.a Reused water		0				
	4.b Wasterwater to sewerage						
	4.c Desalinated water						
Into the environment	5. Total returns (=5a+5b)				0	0	0
	Other					0	
	5.a To inland water resources (=5a.1+5a.2+5a	0	0		0	0	0
	5a.1 Surface water						
	5a.2 Groundwater						
	5a.3 Soil water						
	5b To other resources						
	6. TotalB (4+5)	0	0		0	0	0
	7. Consumption (3-6)	0	0		0		0.00
	7a Loses in distribution (evap. Or malfunctioning meters)						

It has been agreed with stakeholders that:

- Sewerage network leakages will be neglected (sewerage to groundwater);
- Losses within water supply networks are limited to leakages (to groundwater).

Table 3 – Asset account table.

	EA.131.Surface water						
Asset accounts [Mm3]	EA.1311 Artificial reservoir	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, ice and glaciers	EA.132 Ground water	EA.133 Soil water	Total
1. Opening stocks						0	0
Increases in stocks	0	0	0		0	0	0
2. Returns							0
3. Precipitation							0
4. Inflows	0	0	0		0	0	0
4.a From upstream territories							
4.b From other resources in the territory (sea)							
Decreases in stocks	0	0	0		0	0	0
5. Abstraction							
6.Evaporation/actual evapotranspiration							0
7. Outflows	0	0	0		0	0	0
7.a To dowsntream territories							
7.b To the sea							
7.c To other resources in the territory							
8. Other changes in volume							0
9. Closing stocks	0	0			0		0

For the water asset account (representing the natural water cycle), it was agreed that:

- All precipitations is going to soil water and then transferred to surface and ground water
- Snow is neglected

3 Typology of datasets used and main sources

The datasets used can be categorised as follow:

- Direct measurements, for instance river discharge from gauging stations;
- Data from model, for instance ground water balance (using modflow). Two main models are used by the Arno River Basin Authority: Mobidic (for water balance) and modflow (for ground water);
- Data from water rights and waste water discharge permits;
- Estimates based on expert judgement;
- Statistical results from survey mainly provided by the Italian National Institute of Statistic (ISTAT);
- Reference datasets, mainly geographical information (i.e., GIS layers) such as hydrographic network, catchment areas, land cover and land use, ground water bodies, etc.

The main data sources used are:

Provider	**Main activity**	**Type of data sets**
Nuove Acque S.p.A. Publiacqua S.p.A. Acque S.p.A. Gida SpA, etc.	Water Supply systems and wastewater management	Water abstraction Water supply Wastewater discharge Treated Wastewater supplied for reused
Provincia di Firenze, Arezzo, Prato, Pistoia, Pisa, Siena, Livorno, Lucca	Local government	Water abstraction Water levels (surface and groundwater)
Autorità Idrica Toscana	Water supply government	Water demand data
ARBA	River basin organisation	River discharge Surface and ground water balance Results from models
Regione Toscana	Local government	Climatic data
ISTAT	National Institute of Statistics	Water supply networks leakages Population / GDP (not yet exploited)

Additional dataset could be considered by the PAWA project for further analysis and improvement using SEEA-Water:

- Irrigation methods and efficiency data from Confagricoltori (Organisation representing Italian farmer);
- Service costs that could be provided by Regione Toscana and Autorità Idrica Toscana.

4 Data availability assessment

For each water account table, we are providing a quick overview of data items that can be calculated with the datasets compiled up to now. The following colour codes have been used:

- Not relevant for the pilot sub-basins or neglected
- No data available
- Data set available, but limited accuracy
- Data set available with sufficient accuracy

4.1 Physical use table

The physical use table is related to water abstraction for economic activities. The **Table 4** provides a quick overview of data availability for processing the physical water use table.

Table 4 – Data availability for processing the physical water use table.

Physical water use table [Mm3]		Agri, Forest, fishing 1-3	Industries and services 5-33, 41-43, 45-99	elect rcity 35	Water supply 36	Sewerage, WWT 37,38,39	Households
From the environment	1.a Abstraction for own use						
	1.b Abstraction for distribution						
	1.i From inland water resources	0.00	0.00		0.00		0.00
	Surface water						
	Groundwater						
	Soil water						
	1.ii Collection of precipitation						
	1.iii Abstraction from the sea						
	1. Total abstraction (1.a+1.b(=1.i+1.ii+1.iii))	0.00	0.00		0.00		0.00
Within the economy	2. From other economic units		0		0	0	0
	Water services						
	Reused water						
	Wastewater to sewerage						
	Desalinated water						

For the different data items, the data providers and source are commented in **Table 5**.

Table 5 – Information on data used for processing the physical water use table.

Water abstraction data items	Data providers	Comments	Status
From **surface and ground water** for agriculture/manufacturing, mining, construction/households	Provinces based on water abstraction permits delivered	+ Geolocalised point datasets - Maximum abstraction by year - Monthly distribution estimated by provinces - No breakdown by type of industry nor type of agriculture - abstraction from GW only available from 2006 or 2007	😐

Water abstraction data items	Data providers	Comments	Status
From **surface and ground water** For distribution (drinking water)	Water utilities based on declarations for water abstraction permits	+ real yearly values - Monthly distribution estimated - No breakdown by type of use i.e. industries and household	☺
From **precipitation** to sewerage	ARBA	- estimated by expert based on rainfall + Monthly - only a few years	☺
From **treated waste water** for industry	Water utility (GIDA SpA)	+ real metered data on monthly basis from 2007	☺
From **water services** (water distribution network) to households	Water utilities	Water supplied by utilities is neglected	☺
From **waste water** (**Industries and households)** to sewerage and WWTP	Water utilities	Estimated percentages of water uses	😐
From **soil water** to agriculture	N.A.	-	-

Potential improvement:

- Abstraction from surface and ground water for distribution (drinking water supply):
  - Water utilities can provide monthly breakdown for recent years;
- Abstraction from soil water for rain fed agriculture could be estimated if the type of crops cultivated is provided for each concerned area.

Table 6 provides the detailed status of data available for each sub-basin (✓ : means that datasets are provided on monthly basis for all the time range).

Table 6 – Status of data on water use available for each sub-basin

Water Use. Parameters.		Comments/Data source		
		CHIANA	**BISENZIO**	**PISA**
Abstraction from surface water	Own use. Agriculture, farming.	✓	✓	✓
	Own use. Industry:	✓	✓	✓
	Distribution use. Water collection, purification and supply.	✓	✓	-
	Households	✓	✓	✓
Abstraction from groundwater	Own use. Agriculture, farming	Yearly values and constant 2006-2012	Montlhy values 2007-2012 From Prato shared aquifer for Bisenzio uses	Monthly values 2007-20012
	Own use. Industry			
	Distribution use. Water collection, purification and supply.			
	Households			
Abstraction from soil water for own use	Agriculture rain fed	-	-	-
Collection from precipitation	Sewerage i.e. urban runoff,	✓	✓	✓
Reuse treated waste water	Mining quarrying, manufacturing and construction.	Not applicable	✓ 2007-2013	Not applicable

4.2 Physical water supply table

Water supply is related to water returned from the economy (including households) to the environment and water flows between economical activities. A quick overview of data availability is provided in **Table 7**.

Table 7 – Overview of data availability on water supply.

Physical supply table [Mm3]		Agri, Forest, fishing 1-3	Industries and services 5-33, 41-43, 45-99	electricity 35	Water supply 36	Sewerage, WWT 37,38,39	Households
Within the economy	4. To other economic units	0			0	0	0
	4.a Reused water		0				
	4.b Wasterwater to sewerage						
	4.c Desalinated water						
Into the environment	5. Total returns (=5a+5b)	0	0		0	0	0
	5.a To inland water resources (=5a.1+5a.2+5a	0			0	0	
	5a.1 Surface water						
	5a.2 Groundwater						
	5a.3 Soil water						
	5b To other resources						
	6. TotalB (4+5)	0	0		0	0	0
	7. Consumption (3-6)	0	0		0		0.00
	7a Loses in distribution (evap. Or malfunctioning meters)						

For the different data items, the data providers and source are commented in **Table 8**.

Table 8 – Information on water supply data items.

Water supply data items	Data providers	Comments	Status
From **waste water treatment plant** for reuse	Water utility (GIDA SpA)	+ real metered data on monthly basis from 2007 (same dataset as for water use)	☺
From **Industries and services** to sewerage / waste water treatment plant	Water Utilities	Estimated percentages of water use	😐
From **households** to sewerage / waste water treatment plant	Water utilities	Estimated percentages of water use	😐
Returns **from industry & households** waste water to SW and GW	Municipalities, provinces	Estimated percentages of water use agreed with all stakeholders	😐
From **waste water treatment plant** to the SW	Water utilities	Yearly data, Not covering the whole period	☺
From **agriculture** (irrigation) to GW	ARBA	Estimated percentages of water abstracted for agriculture	😐
From **water supply networks** to GW (leakages)	Water utilities and ISTAT	Rough estimates for some years	😐
Losses from agriculture (evapotranspiration)	ARBA	Estimated percentages of water abstracted for agriculture	😐

The critical aspects on these datasets are concerning:

- The breakdown of waste water collected by water utilities from industries and households is roughly estimated on the basis of used water;
- Waste water discharged by industry and households was roughly estimated in cooperation with municipalities and provinces;
- Returns from irrigation to groundwater were estimated on the basis of abstracted water in cooperation with provinces;
- Evapotranspiration could be estimated if the type of crops and irrigation techniques by area were provided;
- Breakdown of water supply to industry and households is not available.

Table 9 illustrates the detailed status of available data for each sub-basin (✓ : it means that datasets are provided on a monthly basis for the time range).

Table 9 – Detailed status of available data for each sub-basin.

Water Supply. Parameters.		Comments/Data source		
		CHIANA	**BISENZIO**	**PISA**
Supply of water to other economic units	Industry, service returns water as wastewater to sewerage	✓	✓	✓
	Households returns water as wastewater to sewerage	✓.		
Returns water to surface water	Treated wastewater.	✓ 2006 and 2011-2013	✓ 2006-2012	✓ 2006-2012
	Households	Estimation provided by provinces and municipalities		
	Industry			
Returns water to: groundwater	Agriculture, farming. Coming from, Ex: irrigation water, etc.	✓ Estimation	✓ Estimation	✓ Estimation
	Waste distribution systems loses	I.1, loses in water distribution systems. Do not cover the whole period of study. 2005 and 2008		
	Sewerage systems loses	Not available		

4.3 Asset accounts (natural water cycle)

Water asset account is related to the natural water cycle. It represents the water balance usually calculated in hydrology. A quick overview of data availability is provided in **Table 10**.

Table 10 – Overview of data availability for water asset account

Asset accounts [Mm3]	EA.131.Surface water				EA.132 Ground water	EA.133 Soil water	Total
	EA.1311 Artificial reservoir	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, ice and glaciers			
1. Opening stocks						0	0
Increases in stocks	0	0	0		0	0	0
2. Returns							0
3. Precipitation							0
4. Inflows	0	0	0		0	0	0
4.a From upstream territories							
4.b From other resources in the territory (sea)							
Decreases in stocks	0	0	0		0	0	0
5. Abstraction							
6.Evaporation/actual evapotranspiration							0
7. Outflows	0	0	0		0	0	0
7.a To dowsntream territories							
7.b To the sea							
7.c To other resources in the territory							
8. Other changes in volume							0
9. Closing stocks	0	0			0		0

It must be noticed that:

- River discharges from upstream (4a) and to the sea (7b) only concern the Pisa area;
- Flows between water resources (4b and 7c) are not considered in the first approach to get a simplified view of the overall balance for the territory. Exchanges between water resources are analysed in the SEEA-W matrix of flows. The data sources are mainly results from models.

For the different data items, the data providers and sources are commented in **Table 11**.

Table 11 – Information on water supply data.

Water supply data items	Data providers	Comments	Status
Opening stocks surface water	Provinces ARBA (processing)	Not available Can be estimated (concerns only one lake)	☹
Opening stocks ground water	ARBA (modflow)	Monthly values	☺
Returns	Water utilities ISTAT (leakages) Provinces Municipalities	From the water supply table From WWTP only a few years, Not complete (direct discharge missing from households and industries)	😐
Precipitation	Regione Toscana ARBA (model)	Daily values for precipitation	☺
River discharge from upstream territory	Regione Toscana ARBA	Real measured data	☺
Ground water inflow from upstream territories	ARBA (modflow)	Simulation from model monthly data	😐
Water abstraction	Provinces Water utilities	From water use table (mainly from water abstraction permits)	😐
Evaporation + Evapotranspiration	ARBA (mobidic)	Calculated from Mobidic model on all ARNO river basin for the full period on monthly basis	☺
Discharge to downstream territory	ARBA	Gauging stations, monthly – 1993/2013 but a few years are missing	☺
River discharge to the sea	ARBA	Estimated	😐
Groundwater discharge to the sea	ARBA (modflow)	Not available	☹

Estimations made and potential improvements concern:

- Estimation of ground water inflows and outflows on monthly basis were estimated and verified by provinces thanks to ground water level;
- Estimation of opening stocks for:
  - Ground water: were obtained from groundwater balance by Mobidic/ModFlow verified with monthly water levels datasets from provinces.
  - soil water: could be estimated using the soil storage capacity defined in a geological research done on Arno River Basin (used as input for running Mobidic and Hec-Hms models to define percolation and run-off).

Table 12 provides the detailed status of data available for each sub-basin (✓ : means that datasets are provided on monthly basis for all the time range).

Table 12 – Detailed status of available data for each sub-basin.

Water flows/Items		Comments/Data source		
		CHIANA	BISENZIO	PISA
From/to artificial reservoir:	Returns	Enclosed on surface water returns data series.		
	Precipitation	No applicable		
	Inflow from other resources	*D.5 runoff and lateral flow		
	Abstraction	Enclosed on surface water abs data series.		
From/to lakes:	Returns	Enclosed on surface water returns data series.	-	
	Precipitation	No applicable	No applicable	
	Inflow from other resources	*D.5 runoff and lateral flow		
	Abstraction	Enclosed on surface water abs data series.		
From/to rivers:	Returns	Yearly Constant value for all years 2006, 2011-2013.	Yearly Constant value for all years 2006-2012	Yearly Constant value for all years 2006-2013
	Inflows from upstream territories	-	-	
	Inflow from other resources	*D.5 runoff and lateral flow	*D.5 runoff and lateral flow	*D.5 runoff and lateral flow
	Abstraction	Water use table: ✓		✓
	Outflow to downstream territories	Monthly and daily ✓		✓ Monthly
	Outflow to the sea	-	-	✓ Monthly
	Outflow to other resources in the territory	-	-	-
From/To groundwater:	Returns	Loses in water distribution systems. Do not cover the whole period of study. 2005 and 2008		

Water flows/Items		Comments/Data source		
		CHIANA	BISENZIO	PISA
	Inflows from upstream territories	Yearly ✓		
	From other resources (Ex: Rivers feeding groundwater)	**D.6 soil percolation		
	Abstraction	Yearly Constant values from 2007-2012.	Quarterly from 2007-2012.	Monthly Constant values from 2007-2012.
	Outflow to the sea	-	-	Monthly
	Outflow to other resources in the territory (Ex. Groundwater feeding rivers)	Lateral Flow: output from Hec-HMS model		
From/To soil water	Returns	No applicable	No applicable	No applicable
	Precipitation	✓	✓	✓
	Evaporation	Monthly and daily ✓	Monthly ✓	✓
	Outflow to other resources in the territory	**D.6 (percolation) and D.5 (runoff) -	**D.6 (percolation) and D.5 (runoff)	**D.6 (percolation) and D.5 (runoff) -

*D.5 runoff, this data series will not be disaggregated by dams; lakes or rivers. It will be extracted from HEC-HMS simulation. Runoff will be directly computed for each sub-basin and the total basin runoff is the addition of runoff at the outlet of each sub-basin.

**D.6 and lateral flow items are expected from HEC-HMS and to be contrasted with Mobidic results. This data series will not be disaggregated by dams; lakes or rivers.

5 First steps towards a data reliability assessment

In the previous chapters, we have reviewed the data availability to compute the SEEA-Water tables foreseen by the project for the three pilot areas selected. In order to get an idea of the level of confidence that we can get from these water accounts, it will also be necessary to assess the data reliability.

Data reliability assessment undoubtedly draws from subjective evaluations; therefore to conduct the most objective assessment possible, it has been decided to analyze data on the basis of a closed list of probable cases taking into account the lineage phase. Such assessment is usually based on a series of step-by-step appraisals that allows a multiple characterization of datasets with the aim of producing a synthesis scale of data quality (Braca et al., 2013; WMO, 2013).

The procedure can be based on a step-by-step evaluation of:

- data availability/unavailability
  - data temporal extension
  - data availability at the most detailed temporal scale possible
- geographical factors
  - data geographical extension
  - data availability at the most detailed spatial scale possible

- data reliability: assessment that depends from data sources and characteristics based on the following factors:
  - lineage
    - direct measurements
    - data from a calibrated model
    - data from a uncalibrated model
    - estimates based on expert judgement
  - temporal data continuity in the available interval
    - continuous data
    - data partially absent(<5% fraction of missing steps)
    - data consistently absent(>5% fraction of missing steps)
  - spatial data continuity in the investigated area (punctual data in the reference area)
    - spatial data available homogenously (homogeneous data density)
    - data unavailable in limited portions of the area
    - data unavailable in extended portions of the area
  - clear presence of outliers
    - absence of outliers
    - outliers partially present (<5%)
    - outliers consistently present (>5%)

Based on this approach, a preliminary reliability assessment of the datasets used is proposed in **Annex 2**. This assessment will have to be reviewed when modeling data and filling in the SEEA-Water tables as they will result in additional test-beds for data validation.

6 Conclusions and way forward

The most important data sets have been collected or estimated with local stakeholders in order to compute the water account tables. When processing these data sets to calculate the accounts, it is expected that additional improvements will be identified through cross validation, modelling and simulation. Most probably, the water accounts will not be processed for the whole time period, that is, 1993-2013 as data sets are not homogenous over this period.

7 References

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Annex 1 – Data items codes from International Recommendations for water statistics[1]

Data item	Definition
Physical data items for inland water stocks	
A. Inland water stocks	The volume of water contained in surface water, groundwater and soil water within the territory of reference at a particular point in time. This includes freshwater, brackish water and saline water and all types of water quality.
A.1. Surface water stocks	The volume of water that flows over or rests on the ground's surface within the territory of reference at a particular point in time. This includes water contained in artificial reservoirs, lakes, rivers, wetlands, snow, ice and glaciers.
A.1.1. In artificial reservoirs	The volume of water contained in man-made surface water bodies used for storage, regulation and control of water within the territory of reference at a particular point in time.
A.1.2. In lakes	The volume of water contained in generally large bodies of standing water occupying a depression in the Earth's surface within the territory of reference at a particular point in time.
A.1.3. In rivers and streams	The volume of water contained in bodies of water flowing continuously or periodically in channels within the territory of reference at a particular point in time. This includes water flowing through artificial watercourses, such as canals for irrigation, drainage or navigation.
A.1.4. In wetlands	The volume of water found in transitional areas where soils are frequently saturated or flooded, including swamps, marshes, playas and bogs, within the territory of reference at a particular point in time.
A.1.5. In snow, ice and glaciers	The volume of water found in a naturally frozen state (ice and ice crystals), measured in water equivalent, within the territory of reference at a particular point in time. This includes seasonal layers of snow and ice on the ground surface and accumulations of ice (i.e., glaciers) that move slowly over land.
A.2. Groundwater stocks	The volume of water in porous and permeable underground layers, known as aquifers, that can yield significant quantities of water to wells and springs within the territory of reference at a particular point in time.

Physical data items for flows into and out of the territory	
B. Inflow of water to a territory's inland water resources	The volume of water that flows into a territory's inland water resources, consisting of precipitation and inflows from upstream territories, per year.
B.1. Precipitation	The volume of water that flows from the atmosphere to inland water resources via rain, snow, sleet, hail, dew, mist, etc., per year.
B.2. Inflow of water from neighbouring territories	The volume of surface water and groundwater that moves into a territory of reference from other territories, per year. This includes all water crossing into a territory and a portion of the water moving into artificial reservoirs, lakes, rivers or aquifers that lie along the territory's border.
B.2.1. Secured through treaties	The volume of surface water and groundwater that moves into a territory of reference from other territories, or along its border, that is protected by formal agreements with upstream territories, per year.
B.2.2. Not secured through treaties	The volume of surface water and groundwater that moves into a territory of reference that is not protected by formal agreements with upstream territories, per year.
C. Outflow of water from a territory's inland water resources	The volume of water that flows out of a territory's inland water resources, consisting of evapotranspiration from inland water resources and the outflow of surface water and groundwater to downstream territories and the sea, per year. This excludes water and sewage exported (K) since these are flows between economic units and the rest of the world, after being abstracted from the environment.
C.1. Evapotranspiration from inland water resources	The volume of water from land and water surfaces that enters the atmosphere by vaporization of water into a gas and through evaporation and transpiration from plants, per year.
C.1.1. Evaporation	The volume of water that enters the atmosphere by vaporization of liquid and solid water to a gas from water and land surfaces, per year. This includes sublimation, which is water that goes from being ice, snow or part of a glacier directly to a water vapour, without going through a liquid phase, i.e., without melting. Evaporation of water consists of water that evaporates directly from surface water and water that evaporates from soil water.
C.1.2. Transpiration from plants	The volume of water that enters the atmosphere by vaporization of liquid water to a gas from plant surfaces when the ground is at its natural moisture content, determined by precipitation, per year. If data are available, then transpiration from animals and people can be recorded as supplementary data item C.1.3.
C.2. Outflow of water to neighbouring territories and the sea	The volume of surface water and groundwater that moves from a territory's inland water resources to other territories and the sea, per year. This includes all water flowing out of a territory or land area and a portion of the water flowing out of artificial reservoirs, lakes, rivers or aquifers that lie along the territory's border.
C.2.1. To neighbouring territories	The volume of surface water and groundwater that flows from within a territory to another territory or territories, per year. This includes water flowing out of artificial reservoirs, lakes, rivers or aquifers that lie along the territory's border.
C.2.1.1. Secured by treaties	The volume of surface water and groundwater that moves out of a territory of reference and is made available to downstream territories by formal agreement, per year.
C.2.1.2. Not secured by treaties	The volume of surface water and groundwater that moves out of a territory of reference and is not guaranteed to downstream territories by formal agreement, per year.
C.2.2. To the sea	The volume of surface water and groundwater that moves from a territory's inland water resources into sea(s) and ocean(s), per year.

Natural transfers of water between inland water resources	
D. Natural transfers with other resources in the territory	The volume of water that moves between inland water resources of a territory, per year.
D.1. From surface water to groundwater	The volume of water that infiltrates into aquifers from artificial reservoirs, lakes, rivers, wetlands, snow, ice and glaciers, per year.
D.2. From groundwater to surface water	The volume of water that moves from aquifers into artificial reservoirs, lakes, rivers, wetlands, snow, ice and glaciers, per year.
D.3. Between surface water resources	The volume of water that moves from one surface water body to another, per year.
D.4. Between groundwater resources	The volume of water that moves from one aquifer to another, per year.
Physical data items for flows from the environment to the economy	
E. Abstraction of water	The volume of water that is removed or collected by economic units directly from the environment within the territory of reference, per year.
E.1. From inland water resources	The volume of water that is removed by economic units from surface water, groundwater and soil water within the territory of reference, per year. This includes the abstraction of inland waters that are fresh, brackish, saline or polluted. This excludes abstraction of water from the sea or ocean, since these are not inland water resources.
E.1.1. From surface water	The volume of water removed by economic units from artificial reservoirs, lakes, rivers, wetlands and snow, ice and glaciers within the territory of reference, per year. Bank filtration is considered an abstraction of surface water.
E.1.1.1. From artificial reservoirs	The volume of water removed by economic units from man-made surface water bodies, used for storage, regulation and control of water within the territory of reference, per year.
E.1.1.2. From lakes	The volume of water removed by economic units from generally large bodies of standing water occupying a depression in the Earth's surface within the territory of reference, per year.
E.1.1.3. From rivers	The volume of water removed by economic units from bodies of water flowing continuously or periodically in channels within the territory of reference, per year.
E.1.1.4. From wetlands	The volume of water removed by economic units from transitional areas where soils are frequently saturated or flooded, including swamps, marshes, playas and bogs, within the territory of reference, per year.
E.1.1.5. From snow, ice and glaciers	The volume of water removed by economic units from water found in a naturally frozen state (ice and ice crystals), measured in water equivalent, within the territory of reference, per year.
E.1.2. From groundwater	The volume of water removed by economic units from aquifers and springs within the territory of reference, per year.
E.1.3. From soil water	The volume of water used by economic units in rain-fed or non-irrigated agriculture and forestry within the territory of reference, per year. This is the volume of precipitation that falls onto agricultural fields and is transpired by the crops, plantations, orchards, etc. This is broadly equivalent to the concept of green water.
E.2. Collection of precipitation	The volume of water collected by economic units directly from falling rain, snow, sleet and hail or collected by contact with dew and mist within the territory of reference, per year. A typical example of collection of precipitation is roof rain harvesting by households. The collection of precipitation includes urban run-off.
E.3. Abstraction from the sea	The volume of saline water removed by economic units from the sea and ocean within the territory of reference, per year.
Alternative breakdown	
E.a. For own use	The volume of water abstracted and used by the same economic units within the territory of reference, per year.
E.b. For distribution	The volume of water abstracted by an economic unit for the purpose of being supplied to other economic units, often after treatment, within the territory of reference, per year.

Physical data items for flows of water within the economy	
F. Water supplied to economic units	The volume of water that is provided by one economic unit to another economic unit through mains, artificial open channels, sewers, drains, trucks or other means, per year. This excludes the losses of water in distribution which are included in data item I and the supply of bottled water (CPC, Ver. 2, 9410), which is one of the supplementary data items.
F.1. Water supplied by resident economic units to resident economic units	The volume of water (CPC 18000) that is provided by resident economic units, typically of the water supply industry (ISIC 36), to other resident economic units through mains, artificial open channels, sewers, drains, trucks or other means, per year.
F.2. Water exported to the rest of the world (water exports)	The volume of water (CPC 18000) that is provided by resident economic units, typically of the water supply industry (ISIC 36), to other non-resident economic units (rest of world) through mains, artificial open channels, drains, trucks or other means, per year.
F.3. Wastewater supplied by resident economic units to resident economic units	The volume of water discharged by resident economic units into drains or sewers for treatment or disposal by other resident economic units, and water supplied by resident economic units to other resident economic units which have to treat this water before it can be used (by the same units), per year. All water discharged into drains or sewers is considered wastewater for treatment or disposal, regardless of the quality of water discharged.
F.3.1. For treatment or disposal	The volume of water discharged into drains or sewers by resident economic units for treatment or disposal by other resident economic units, per year.
F.3.2. For further use	The volume of water supplied by resident economic units which has to be treated by the resident economic units receiving the water before the water can be used (by the same units), per year.
F.4. Wastewater exported to the rest of the world (wastewater exports)	The volume of water discharged into drains or sewers by resident economic units for treatment or disposal by non-resident economic units, and water supplied by resident economic units to non-resident economic units which has to be treated by these units before the water can be used (by the same units), per year.
F.4.1. For treatment or disposal	The volume of water discharged into drains or sewers for treatment or disposal by other non-resident economic units, per year.
F.4.2. For further use	The volume of water supplied to non-resident economic units which has to be treated by the economic units receiving the water before the water can be used (by the same units), per year.
G. Water received by economic units	The volume of water that has been delivered from one economic unit to another economic unit through mains, artificial open channels, sewers, drains, trucks or other means, per year. Water received from other economic units (G) excludes water abstracted directly from the environment (included in data item E) and bottled water (CPC 9410), which is included as a supplementary data item.
G.1. Water received by resident economic units from resident economic units	The volume of water (CPC 18000) that has been delivered to resident economic units by other resident economic units through mains, artificial open channels, drains, trucks or other means, per year.
G.2. Water imported by resident economic units from the rest of the world (water imports)	The volume of water (CPC 18000) that has been delivered to resident economic units by non-resident economic units (rest of world) through mains, artificial open channels, drains, trucks or other means, per year. This excludes water abstracted directly from the environment (included in data item E) and bottled water (CPC, Ver. 2, 9410), which is included as a supplementary data item.
G.3. Wastewater received by resident economic units from resident economic units	The volume of water removed by resident economic units, usually via drains or sewers, from other resident economic units that requires either treatment or disposal, per year.
G.3.1. For treatment or disposal	The volume of water removed by resident economic units from resident economic units, usually via drains or sewers, to be purified (i.e., treated) or removed (i.e., disposed of), per year.
G.3.2. For further use	The volume of water removed by resident economic units, often by pipe, artificial channel or truck, that requires some degree of purification (i.e., treatment) by the economic unit receiving the water before the water is used, per year.

G.4. Wastewater received from the rest of the world (wastewater imports)	The volume of water removed by resident economic units, usually via drains or sewers, from non-resident economic units, that requires some degree of purification (i.e., treatment) and disposal, per year. This excludes water abstracted directly from the environment (included in data item E); and bottled water (CPC, Ver. 2, 9410), which is included as a supplementary data item.
G.4.1. For treatment or disposal	The volume of water removed by resident economic units from non-resident economic units, usually via drains or sewers, to be purified (i.e., treated) or disposed of, per year.
G.4.2. For further use	The volume of water removed by resident economic units from non-resident economic units, usually via pipe, artificial channel or by truck, that requires some degree of purification (i.e., treatment) by the economic unit receiving the water before the water is used, per year. This water may be imported through pipes, artificial open channels, trucks or other means.
Physical data items for flows from the economy to the environment	
H. Returns of water to the environment by economic units	The volume of water that flows from economic units directly to inland water resources, to the sea or to land, within the territory of reference, per year. This includes urban storm water, losses due to leakage and burst pipes, irrigation water that infiltrates into groundwater or ends up in surface water, and the discharges of cooling water and water used for hydroelectricity generation. It excludes evaporation because evaporation is consumption.
H.1. To inland water resources	The volume of water that flows from economic units directly to surface water or groundwater within the territory of reference, per year.
H.1.1. To surface water	The volume of water that flows from economic units directly into artificial reservoirs, lakes, and rivers and wetlands, within the territory of reference, per year. Discharges of water to surface water include discharges of cooling water, urban run-off (including storm water) and run-off from agricultural land. It may also include the discharges of water used for hydroelectricity power generation.
H.1.1.1. To artificial reservoirs	The volume of water that flows from economic units directly into man-made surface water bodies used for storage, regulation and control of water, within the territory of reference, per year.
H.1.1.2. To lakes	The volume of water that flows from economic units directly into generally large bodies of standing water occupying a depression in the Earth's surface, within the territory of reference, per year.
H.1.1.3. To rivers	The volume of water that flows from economic units directly into bodies of water flowing continuously or periodically in channels, within the territory of reference, per year.
H.1.1.4. To wetlands	The volume of water that flows from economic units directly to transitional areas where soils are frequently saturated or flooded, including swamps, marshes, playas and bogs, within the territory of reference, per year.
H.1.1.5. To snow, ice and glaciers	The volume of water that flows from economic units directly onto naturally frozen water (ice and ice crystals), within the territory of reference, per year.
H.1.2. To groundwater	The volume of water that flows from economic units directly into aquifers, within the territory of reference, per year. Discharges of water to groundwater include the artificial recharge of aquifers, urban run-off (and storm water) that is collected and allowed to infiltrate into groundwater and water from agriculture that infiltrates into groundwater. Discharge to soil water is water discharged from economic units onto land surfaces where the water seeps rapidly into soil.
H.2. To the sea	The volume of water that flows from economic units directly into the sea or ocean, within the territory of reference, per year. These discharges may occur near the coast or further offshore.
H.3. To land	The volume of water that flows from economic units directly to transitional areas where soils are frequently saturated or flooded, including swamps, marshes, playas and bogs, within the territory of reference, per year.
Alternative breakdown	
H.a. Returns of water to the environment after treatment by economic units	The volume of water discharged into the environment by economic units after some pollutants have been removed, within the territory of reference, per year. This includes wastewater discharged by the sewerage industry (ISIC 37) and other industries after undergoing on-site treatment.
H.b. Returns of water to the environment without treatment	The volume of water that is discharged into the environment by economic units where pollutants have not been removed, within the territory of reference, per year.

Physical data items for losses from distribution networks and sewerage systems	
I. Losses of water	The volume of water that is lost in distribution or lost when sent for treatment and disposal, within the territory of reference, per year. This includes water (CPC 18000) and wastewater.
I.1. Losses of water (CPC, Ver. 2, 18000) in distribution	The volume of water (CPC 18000) that is lost during distribution and transportation, between the point of abstraction and the point of use, or between the points of use and reuse (e.g., from mains, artificial open channels and trucks), within the territory of reference, per year.
I.2. Losses of water sent for treatment or disposal in collection	The volume of wastewater lost from sewerage systems, artificial open channels and trucks used to collect wastewater, within the territory of reference, per year.

[1] For the full version of the IRWM data code, follow the link: http://unstats.un.org/unsd/envaccounting/irws/irwswebversion.pdf

Annex 2 – Preliminary data quality assessment

For each dataset a report table was filled in, detailing:

- dataset name;
- temporal features: extension, scale;
- spatial features: extension, density;
- data reliability: assessment scale from 1 (bad) to 10 (very good).

Data items reliability assessment is carried out, at the proposed scale, on the basis of the aforementioned features assigning a score to each data item.

Data features	Assessment	Score
Lineage	direct measurements	10
	data from a calibrated model	6
	data from an uncalibrated model	4
	estimates based on expert judgment	2
Temporal data continuity	continous data	10
	data partially absent	6
	data consistently absent	2
Spatial data continuity	spatial data available homogenously	10
	data unavailable in limited portions of the area	6
	data unavailable in vast portions of the area	2
Outliers	absent	10
	outliers partially present	6
	outliers consistently present	2

The total score is compared to a 0 to 10 scale dividing by 40 (maximum score) and rounding the sum up. In cases where one of the data features cannot be evaluated the total score is compared to the maximum score.

The following table illustrates the results for the stored datasets. As said the results will be reviewed during the PAWA project implementation; the resulting data assessment updates will be illustrated in the project future deliverables and in the metadata generated files.

The table only describes available data.

Data item	Temporal features	Spatial features	Data item reliability
Precipitation amounts over the investigated basins	Daily 1993-2013 Monthly 1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	10
Rain gauges location	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	10
Temperature	Daily 1993-2013 Monthly 1993-2013	Basin 01 - medium density Basin 02 - medium density Area 03 - medium density	9
Termometers location	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	10
Humidity	Daily 1993-2013 Monthly 1993-2013	Basin 01 - medium density Basin 02 - medium density Area 03 - medium density	8
Hygrometers location	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	10
Wind velocity	Daily 1993-2013 Monthly 1993-2013	Basin 01 - low density Basin 02 - low density Area 03 - low density	8
Anemometers location	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	10
Radiation	Daily 1993-2013 Monthly 1993-2013	Basin 01 - low density Basin 02 - low density Area 03 - low density	8
Radiometers location	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	10

Data item	Temporal features	Spatial features	Data item reliability
Discharge	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	9
River stage gauges location	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	10
Potential evapotranspiration	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	9
Real Evapotranspiration	1993-2013	Basin 01 - high density Basin 02 - high density Area 03 - high density	9
Areal Extension	-	Basin 01 - high definition Basin 02 - high definition Area 03 - high definition	10
Main Channel	-	Basin 01 - high definition Basin 02 - high definition Area 03 - high definition	10
Digital Elevation Model	-	Basin 01 - high definition Basin 02 - high definition Area 03 - high definition	10
Slope	-	Basin 01 - high definition Basin 02 - high definition Area 03 - high definition	10
Lag Time	-	Basin 01 - high definition Basin 02 - high definition Area 03 - high definition	10
Soil Properties	-	Basin 01 - high	10

Data item	Temporal features	Spatial features	Data item reliability
		definition Basin 02 - high definition Area 03 - high definition	
Soil Use	2007-2012	Basin 01 - high definition Basin 02 - high definition Area 03 - high definition	10
Surface Waterbodies Definition	2010-2013	Basin 01 - high definition Basin 02 - high definition Area 03 - high definition	10
Groundwaterbodies definition	2010-2013	Basin 01 - high definition Basin 02 - high definition Area 03 - high definition	10
Abstraction from SW for Agricultural use	Basin 01: 2007-2013 Basin 02: 2007-2013 Area 03: 2007-2010	Basin 01: high density Basin 02: high density Area 03: high density	Basin 01: 5 Basin 02: 5 Area 03: 5
Abstraction from SW for Industrial use	Basin 01: 2007-2013 Basin 02: 2007-2013 Area 03: 2007-2010	Basin 01 - high density Basin 02 - high density Area 03 - high density	Basin 01 - 5 Basin 02 - 9 Area 03 - 5
Abstraction from SW for Water supply	Basin 01: 2007-2013 Basin 02: 2007-2013 Area 03: 2007-2010	Basin 01 - high density Basin 02 - high density Area 03 - high density	Basin 01 - 5 Basin 02 - 7 Area 03 - 5
Abstraction from SW for Households	Basin 01: 2007-2013 Basin 02: 2007-2013 Area 03: 2007-2010	Basin 01 - high density Basin 02 - high density Area 03 - high density	Basin 01 - 5 Basin 02 - 5 Area 03 - 5
Abstraction from GW for Agricultural use	Basin 01: 2007-2010 Basin 02: 2007-2013 Area 03: 2007-2010	Basin 01 - high density Basin 02 - high density Area 03 - high density	Basin 01 - 5 Basin 02 - 5 Area 03 - 5
Abstraction from GW for Industrial use	Basin 01: 2007-2013 Basin 02: 2007-2013 Area 03: 2007-2010	Basin 01 - high density Basin 02 - high density Area 03 - high density	Basin 01 - 6 Basin 02 - 9 Area 03 - 5
Abstraction from GW	Basin 01: 2007-2013	Basin 01 - high density	Basin 01 - 5

Data item	Temporal features	Spatial features	Data item reliability
for Water supply	Basin 02: 2007-2013 Area 03: 2007-2010	Basin 02 - high density Area 03 - high density	Basin 02 - 8 Area 03 - 5
Abstraction from GW for Households	Basin 01: 2007-2010 Basin 02: 2007-2013 Area 03: 2007-2010	Basin 01 - high density Basin 02 - high density Area 03 - high density	Basin 01 - 5 Basin 02 - 5 Area 03 - 5
Returns to SW	Basin 01:2006, 2011-2013 Basin 02: 2006-2012 Area 03: 2010	Basin 01 - high density Basin 02 - high density Area 03 - high density	7
Reused water for Industrial use	Basin 02: 2007-2012	-	7
Water Supply leakages	Basin 01: 2010-2013 Basin 02: 2010-2013 Area 03: 2010-2013	Basin 01 - low density Basin 02 - low density Area 03 - low density	5
GW water balance components	Basin 01: LTA (1993-2010) Basin 02: 2007-2012 Area 03: LTA (1993-2012)		6