Physical water flow accounts with Supply and Use and water asset / water balance assessment NL

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Acknowledgements

In this study for Eurostat we have tried to compile the Physical Water Flow Accounts with Physical Supply and Use tables (PSUT) for water and the physical water asset accounts / water balance sheet for 2014 for the Netherlands.

First, we would like to thank Eurostat for provision of the Grant to conduct this study and to obtain the remote sensing data from eLEAF and perform the GIS processing. The resources from the Grant enabled to develop the methodologies and collect and process the water data.
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Finally, we would like to thank our colleagues at Statistics Netherlands (CBS) who have reflected on the project and report.

Summary

In this Eurostat study project we have tried to compile the Physical Water Flow Accounts with Physical Supply and Use tables (PSUT) for water and the physical water asset accounts / water balance sheet for 2014 for the Netherlands. Methods and data collections have been developed to compile the Water PSUT and asset tables at the national scale. Further we managed to compile basic regionalized water balances, for which the most important quantifications could be made.
The data sources are described and the cooperation with the National Water Authority, Water Research, the Meteorological Institute, and the National Groundwater Register is further developed and structured for future data use.

Instead of applying the so-called 'reference crop evaporation', in the water balance table of the international OECD-ES-Joint Questionnaire on Inland Water, we now again tried to work with the 'actual evapotranspiration' (actual ET). For assessment of the actual ET for the National territory and in a spatial explicit manner, allowing making overlays with whatever aggregation, as with the land use categories, data was obtained from eLEAF. This organisation calculates the evapotranspiration, both actual and reference in a spatial and temporal explicit manner based upon remote sensing data, satellite data, besides monitoring precipitation spatially and with monthly data.
These spatial types of data were processed in a way that could be used for compilation of the relevant tables, including the PSUT and the water asset account / water balance sheet.

The results and patterns on reference ET, actual ET, and precipitation for 2014 are compared with the results of the 2009 Eurostat Grant study (Graveland & Baas, 2012). With the temporal resolution of monthly data, the patterns of these variables can be assessed and insight in water provisioning to economic use and the role of renewable water resources are nicely illustrated; this adds information and increases the use ability of these statistics & accounts. These newer technologies and type of data opens up new opportunity and really add detail and quality to the existing methods and observation methodologies for compilation of the accounts. Showing changes in climate and weather and impact on supply and resource use.
The data on precipitation, reference and actual ET were processed and will be used in further analyses describing water scarcity and water productivity. The spatial explicit data opens up list of opportunity to combine with other spatial data and to progress and contribute to the assessment of ecosystem services, natural capital.

It was the objective to combine the different methods for a single or eventually few years with different climatic circumstances, with figures on reference ET ('potential ET'), to derive ratios in order to have a rough estimate for actual ET for years where only reference ET is known. Unfortunately, the processing of the GIS data on actual ET and precipitation took more time than was foreseen, so this action could not be executed. However, the production and processing system of the GIS based data of actual ET is now in place, which will speed up the processing of future data deliveries. Also related projects that try to assess ecosystem services in a spatial explicit manner may benefit from this work and compilation effort. This may include efforts for quantification of the water provisioning services as provided by the natural environment and already determined and illustrated by the different tables and graphs in this report.

To test the feasibility for calculation/assessment of the actual evapotranspiration by use of possible alternative methods was one of the aims of the project. Because a lot of time and resources dedicated to the project were needed for the data processing for the compilation of the PSUT as well as for the GIS-based actual ET data, this objective could not be met.

1. Introduction

This project has focused on the compilation of physical supply and use tables for water and on water asset accounts and balance sheet. Further it attempts to improve the figure for actual evapotranspiration.

1.1 Background of the project

In Statistics Netherlands water statistics has developed since the early 70-ties and SEEA – type water accounts since the early 90-ties, respectively close to 50-years and over 25 years. Although, in some periods at limited speed. The institute thus gained experience in water statistics and SEEA – water accounts compilation and the alignment in between. Statistics and accounts has been developed step by step, including emissions to water, physical water flow accounts and statistics and water balance and water asset account, next to water quality accounts as a pilot. With the support provided by the Eurostat water statistics program, several elements of the Dutch water statistics and water accounts has been developed and improved in the last decade.

As National Statistical Institute (NSI) we participated in the CREEA project (Compiling and Refining Environmental and Economic Accounts), and in one working package did a pilot for a PSUT for physical water flows. Statistics Netherlands participated in the Eurostat Joint Task Force on water statistics and accounts. In this Task-Force several issues to bridge between existing Water statistics and SEEA – type Water Accounts were addressed with the aim at further establishment and alignment of the definitions, concepts, and classifications. The ultimate aim is to create a comprehensive system of physical water statistics and physical water flow accounts with the right aggregates and following Eurostat's formats. As part of that the relation with the joint reporting vehicle was tested and one tried to align on the data structure definitions (DSD's), developed by the Joint Task Force. This was preparatory work to a possible legal basis. This isn't there yet.

More recently on request of the ministry of economic affairs, various questions on water use in economic activity were systematically addressed in context of a larger national project focusing on the further development of the existing material flow monitor (MFM) as well as studying on prospect on recovery of particular rare metals and materials from waste water. This combined work on the different (environmental) statistics and SEEA - accounts, allow for enhanced alignment and integrated analysis between the accounts, statistics and monetary information in the National Accounts (SNA). Some experimental work is done on water resources valuation (Edens and Graveland, 2014) and recently as part of projects dedicated to ecosystem accounts development, also the water related ecosystem services were accounted for.

Since these statistics in scope, quality and exposure has been progressing in the last decade, the application and active use is growing in parallel. In a variety of publications both national and international, the results for a variety of water figures are presented on a regular basis. Examples are the use in our annual / biennial *Environmental Accounts of the Netherlands (Statistics Netherlands, 2014c)*, the mostly biennial publication *Green Growth of the Netherlands* implementing the OECD Green Growth formats (Statistics Netherlands, 2015c). Moreover use of the established water figures is made in recent publications on monitoring the progress on the SDG's, particular indicators under SDG 6.4 and in more customised ad-hoc publications requested by several ministries.

In this study we tried to build upon experience and used both existing data sources and some new sources, like remote sensing based data. We benefit from previous work and develop in the direction of a comprehensive system of physical water statistics and Physical water flow accounts with the preferred aggregates and following the formats provided by Eurostat and also to check on the relation with the earlier designed ‘joint reporting vehicle’ and try to align with the data structure definitions DSD’s, both established in the Joint Task Force on water statistics and accounts with Eurostat.

1.2 Objectives of the project

The first objective of the project is, starting from existing data, to compile the Physical water flow accounts (PWFA) with physical supply and use tables (PSUT) for reporting year 2014 according the known international formats as from the Water Taskforce ran by Eurostat a few years ago. For that purpose, missing parts compared to the existing simple water tables were compiled and shown for 2014.
Another element of this first project objective is to compile the physical water asset account / water balance for the national territory (ref. to table 1 of the OECD-Eurostat Joint Questionnaire - Inland Waters (OECD-ES JQ-IW). As part of that data are collected for compiling the asset accounts at the national level and for the four river basins as well. This is done both testing the feasibility of getting actually the data and to execute the required compilation process.
The prime focus is on the compilation of water flow and asset accounts for a recent year, here 2014, for which the required data largely were available and developed.

Second objective of the project is assessment, gaining insight and further improve the water asset accounts / water balance, in particular the item of evapotranspiration (ET) towards a sound figure for actual evapotranspiration (Act-ET). As the actual ET figure, in contrast to the normally substantial higher figure of potential ET (or reference (crop) ET), will produce a much more realistic figure for ET in the water asset accounts / water balance sheet and the lined Joint-Questionnaire. Although done before for just a single year (2009), thus not representative for a complete time series, we aim with data for another year with different climatic circumstances. This shows differences and similarities and provides input for a possible future method able to derive actual ET from potential ET for other years too.
For that purpose external data were bought, based upon raw satellite / remote sensing data and interpretation. Actual ET data for a recent year, 2014 were obtained with quite different climatic conditions compared to the satellites data previously obtained for reporting year 2009. The remote sensing data obtained are geo-referenced data, which allow to combine with other data sources, such as for land use, compile overlays and present functional maps.

Finally we aimed to test the feasibility for application of (an) alternative method(s) for compiling a sound figure for actual ET in contrast to potential ET for other years. This didn’t work out in this project, as there were too many surprises to deal with the obtained remote sensing data in the project. It showed different years can show very different outcomes.

1.3 Project activities

The following activities are executed:

a. Compile a full set of PSUT tables for water for 2014, following the international SEEA-W format and compared to Eurostat format (from ES-Taskforce and update);
b. Compile physical water asset accounts (water balance) for the Netherlands, with special attention to actual external inflow from upstream and actual outflows. Break down to River Basin was done as far it was possible;
c. Description of the data sources used for compilation of the water asset accounts, set-up of structural cooperation with National Water Authority and the Meteorological Institute;
d. Instead of using current available data on the so-called “reference crop evaporation”, as a substantial improvement, data on ‘actual evapotranspiration’ (actual ET) are compiled and included in the relevant tables (incl. the PSUT), which is a major improvement of the water asset account / water balance. For this purpose assessment of the actual ET for the National territory and spatially explicit level, the relevant data was obtained from eLEAF. This company calculates actual ET in a spatial and temporal explicit manner based upon remote sensing;
e. The feasibility for calculation/assessment of the actual ET by use of an alternative method is tested. The quality of the results is uncertain, the results will be confronted with the result derived from the remote sensing data (eLEAF) and conclusions drawn for possible use in future;
f. Results on actual ET from the two methods for 2014 and 2009 were compared and checked with data on the climatic circumstances;
g. Writing of the report;
h. Publication on Statistics Netherlands (CBS) website.

The following actions were originally planned, but could not be executed within the resources and timeframe of the project:

a. The feasibility for calculation/assessment of the actual ET by use of an alternative method could not be tested;
b. It was also the objective to combine the actual ET figures with figures on potential ET, to derive ratios between potential and actual ET. These ratios then could be applied for years where only data on potential ET are available, to have a rough estimate for actual ET over time.

2. Physical Supply and Use Table 2014 – water types and water flows

2.1 Introduction

The different water types play an important role in economic activity. To reduce the burden to the (water) environment, the abstraction from water resources that are more or less scarce and the water used by economic activities including households and return flows are monitored. The tables we will discuss, show the use and reliance on the water resources from the inland water system. Industries could use the different water resources more efficiently, for example via recycling of water.

The Physical water flow accounts (PWFA) that follow SEEA-W format are based upon the water statistics and additional sources and consists of physical supply and use tables (PSUT). In this physical SUT, 'water' is categorised into various types of water in the conceptual division of main flows in supply and use, namely, A. water volumes extracted from the environment (water abstracted from the environment by economic entities), B. physical water flows within the economy including transactions and C. water return flows from the economy to the environment. In the project, for reporting year 2014 the water PSUT is compiled. The data, data processing, applied procedures for compilation, some main results and findings are dealt with in this chapter.

2.2 Data sources

Before we describe the methodology applied for compilation of the PWFA – PSUT tables and the water asset tables in some detail in paragraph 2.3, we first will present and discuss the main sources. These sources subsequently will be referred to when dealing with the methodology. Here we discuss the data and the major studies and reports used. These data description is in line with previous work.

2.2.1 Data and statistics

Data on agriculture:

- Wageningen Economic Research (WER), of Wageningen University & Research (formerly 'Agriculture Economics Institute, LEI) has a long functioning business information network ('Bedrijven-Informatienet', BIN) which supplies data on water extraction and use by agriculture, both arable farming and animal husbandry, and horticulture. Data are available on the total quantity of water abstraction – the extraction from the environment and use of tap (drinking) water - for the various sectors in agriculture and horticulture and for several years (time series). BIN uses a limited sample survey of over 1,000 holdings in agriculture and horticulture that have been followed intensively for several years. The sample survey is in line with European formats through the Farm Accountancy Data Network (FADN). The sample is drawn from the population of agricultural holdings that are included in the agricultural census. Wageningen Economic Research (LEI) has supplied rough data to Statistics Netherlands on commission for several years. Each year Statistics Netherlands examines whether an update is required. Some 'processing' of the WER (LEI) data is needed to get the desired aggregates for the extraction of surface water as well as for groundwater.

- Agricultural census, or 'Farm Structure Survey', FSS, this also known as the Survey on the structure of agricultural holdings, and executed by all European Union (EU) Member States. The legal basis for the FSS is Regulation (EC) No 1166/2008 of the European Parliament and of the Council of 19 November 2008 on farm structure surveys. This is an integral observation of all agricultural holdings in the Netherlands, using a lower threshold that is based on the holding's economic size. The Standard Output is used as the measure of economic size. Once every three years or so questions are included about farms' water use, particularly about irrigation. There are some minor criticisms about this source: it does not provide an overall picture of all water use because various years are missing and the questions have changed over time. For this reason, the source is only used as a control tool.

Data on manufacturing industry:

- Electronic annual environmental reports (e-AER; in Dutch: e-MJV)[1]: through the e-AERs returned by companies we gather data about waste materials and emissions to air and water of about 500 companies in manufacturing and in the energy (NACE 35) and the environment sector (NACE E36 – E39). Only companies engaged in activities described in annex 1 of the EC-Regulation Pollutant Release and Transfer Register, PRTR are under obligation to report, but only when they exceed the threshold for one or more substances in the distinguished list of substances or for waste. The industrial classification of the companies is known from the International Standard Industrial Classification of all economic activities, either NACE rev.2 or ISIC rev 4 [2]:
    - The e-AER also contains a 'water module'. This module is used to collect data about the extraction of surface water and of groundwater, as well as the use of tap (mains) water. That data is made available from the key companies in the industrial sector. Statistics Netherlands extrapolates the individual water data of this selection of companies to the total population and to the populations per (group of) industry (following the International Standard Industrial Classification, NACE or ISIC) by using the data per company and per NACE class (see 'PRODCOM data' below). Not all NACE classes (3 of 4-digit level) in manufacturing are sufficiently covered by the data from the e-AER. In those cases we made estimates based on other sources, including old figures from the National Water Survey on water use by industry (see National Water Survey on water use by industry, NWS below).
    - PRODCOM data: these data are used in calculations that determine the extraction of fresh surface water and groundwater as well as tap (mains) water use by companies in SBI2008 (3-digit) categories 15-37 that are not present in the e-AER register. For the NACE 3-digit categories that are represented by a sufficient number of individual companies, the data on water production and tap water are extrapolated to national totals. Raising is done with the physical and/or monetary production data from the PRODCOM statistics and in part done with labour figures. The summed water data of the individual companies with an e-AER are raised based on the ratio of the production of the individually registered companies and the total production of the industry (NACE).

- National Water Survey on water use by industry (NWS; CBS, 2004). This NWS survey was executed every five years. In this survey, questions were asked about the water use by companies and for example a distinction was made for the water use for cooling. Electricity

[1] http://www.e-mjv.nl/ .

[2] International Standard Industrial Classifications (ISIC, NACE or Dutch SBI 2008). The Dutch Standaard Bedrijfsindeling (SBI 2008) is based on the activity classification of the European Union (Nomenclature statistique des activités économiques dans la Communauté Européenne, NACE) and on the classification of the United Nations (International Standard Industrial Classification of All Economic Activities, ISIC).

plants and large companies in manufacturing were observed in full. Smaller companies were included in a sample survey. The last time the survey was conducted on reporting year 2001. Due to cuts in the budget at that time this Survey had been abandoned. In total the NWS survey covered some 7,500 business units:

- For industries (NACE Rev.2) at the 3-digit level in manufacturing that were not represented with an e-AER, water extraction and water use are estimated on the basis of historical data from this survey on water in: a. Mining and quarrying (NACE 11), b. manufacturing (NACE 15 to 37), c. 'Public utilities' with Electricity, gas, steam and warm water (NACE 35). For a full description of the method used, see Graveland, 2006.
- The survey data were also used to distinguish water used for cooling within process water.

- Labour accounts (LA)[3]. The Labour accounts are another satellite account with the national accounts, compiled by Statistics Netherlands based on registrations and surveys on employment. They provide information about the number of fulltime equivalents by industry (regkol). This is used for compilation of several parts of the PSUT Water Accounts. For some missing parts where there is missing observation data, use is assessed by combining employment figures (employed persons) with water coefficients, the water use per worker. This combination was used to derive the quantity of tap water per industry for household purposes (personal care).

- National Groundwater Register ('Landelijk Grondwater Register', LGR)[4]. This register was a result of the introduction of the Water Act, came about in 2009 and has been established since. In here one aims to integrate the 12 existing provincial groundwater registers and more recently also the groundwater registers from the 23 Dutch water boards that remained in 2016. In this Act the legal tasks and powers pertaining to groundwater in the Netherlands were laid down. The Interprovincial consultation body (IPO), together with the Province of Overijssel and TNO DINO (for underground registrations) made sure that the provinces and water boards have access to this central groundwater register (LGR), so they can perform these tasks. The National Groundwater Register contains data on:
  - All extractions for which registration or notification is obligatory;
  - All permits for extracting groundwater and/or infiltrating water;
  - The administrative data including the purpose for which water is extracted etc.[5];
  - Technical information, including water quantities abstracted;
  - Geographical information.

  The National Groundwater Register is still being developed. The data on reporting years 2008-2012 that we analysed in previous study for the ministry of Economic Affairs (Statistics Netherlands, 2016g) showed that it does not fully reflect all groundwater extractions. The LGR data we wanted to use for reporting year 2014, after thorough analysis, appeared less complete. We therefore based this, particularly for compilation of abstractions data for use in the on the 2008 – 2012 time series and checked on possible missing observations and extrapolated to 2014.

- Integral survey on the design and functioning of all urban wastewater treatment plants (UWWTP) in the Netherlands. Statistics Netherlands carries out this survey among the Water boards on behalf of various other government bodies such as Rijkswaterstaat and

[3] http://www.cbs.nl/nl-NL/menu/methoden/dataverzameling/2008-ar.htm
[4] https://www-new.lgronline.nl/lgr-webclient/
[5] This includes the part of the abstractions dedicated to cold and heat storage.

RIVM.[6] The results are published in seven StatLine publications, including process data on wastewater treatment[7]. These publications provide insight in the total volume of influent and the return flows of treated wastewater to the environment (effluent).

- Materials Monitor. For the Materials Flow Monitor we made calculations for the plausibility of the balancing items on the loss/inclusion of water in product and water 'included' in the extraction of raw materials/products. Based on the supply and use of products/waste by industry and the quantities of water it contains, we calculated the volume of water flows coming with products into and flowing out of the different industries. Based on this we made an estimate of the net water intake and the water loss (e.g. through evapotranspiration). This is a rough estimate which nevertheless gives a fair indication of the water flows through products.

- VEWIN. This is the Association of Dutch Water Companies. The VEWIN registers are a key data source for the figures on total tap (mains) water supply, e.g. for household use. Statistics Netherlands uses these figures[8]. VEWIN is also the main source for the substantial groundwater and fresh surface water abstraction by the water companies.

2.2.2 Literature

The data described above were supplemented by a desk study. This was needed for identification of the purposes the different water types are used for in economic activity and for 'Confrontation with wastewater treatment data'. Below we highlight the most important reports and studies for this.

Distinctions in process water

- EIM - Industriewater in Nederland (2009)[9]*; It is a report on the competition in the different market segments of the industrial water sector in the Netherlands. It maps industrial water use by purpose.*
- RIVM - Toepassing WAPRO; Versie 1999 (2000)[10]*; This report addresses water consumption within the target groups; consumers, industries (14 sectors), agriculture, trade and services and government. There is a distinction made in surface, ground and tap water used for cooling and for other purposes. It also includes a forecast based on economic and demographic scenarios.*
- Wageningen Economic Research (former LEI) - Watergebruik in de agrarische sector 2009-2010 and 2011-2014, naar stroomgebied in Nederland (2013; Meer van der, R., 2013a; 2014; 2016)[11]; Wageningen Economic Research (LEI) calculated figures on water use in agriculture for the annual publications by Statistics Netherlands *Environmental accounts of the Netherlands* and *Compendium voor de Leefomgeving (Environmental Data Compendium, English site has less detail)*. In these calculations, different types of water and purposes are a distinguished.

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[6] Rijkswaterstaat is the executive agency of the Ministry of Infrastructure and the Environment, responsible for the Dutch main road network, the main waterway network, the main water systems, and the environment in which they are embedded. RIVM is the National Institute for Public Health and the Environment. In Dutch: 'Rijksinstituut voor volksgezondheid en milieu').

[7] http://statline.cbs.nl/Statweb/publication/?VW=T&DM=SLNL&PA=70152NED&D1=0,18&D2=0&D3=0&D4=a&HD=150616-0902&HDR=T&STB=G1,G2,G3

[8] http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82883NED&D1=0&D2=1&D3=4-9&HDR=T&STB=G1,G2&VW=T

[9] http://www.vemw.nl/~/media/VEMW/Downloads/Public/Water/Rapport%20Industriewater%20in%20Nederland.ashx

[10] http://rivm.openrepository.com/rivm/bitstream/10029/9647/1/703717007.pdf

[11] http://edepot.wur.nl/256293

Confrontation with data from urban wastewater treatment plants (UWWTP)

- *TNS-Nipo*[12] *- Watergebruik Thuis 2013*; VEWIN commissions TNS-Nipo a study every three year about water use at home among over 1,000 respondents. The report shows in detail what tap water is used for and developments in this over the years.
- *DELTARES & TNO - Effluenten RWZI's, regenwaterriolen, niet aangesloten riolen, overstorten en IBA's (2015)*[13]*;* This factsheet includes a calculation method for the emissions resulting from effluents of urban wastewater treatment plants (UWWTP), rain water sewers and storm drains. Ratios are calculated for each source (precipitation and dry weather household effluent and other) about the quantities of materials/emissions in rain water and spillage sewers. We used those ratios in our current study to determine the volumes of water.
- *STOWA-HAAS - Hemelwaterafvoer; analyse systematiekonderzoek naar kwantificering van hemelwaterafvoer naar de riolering en de RWZI.*[14]*;* It has become routine in recent years to make more calculations in the wastewater chain, including measuring precipitation, supply to the urban wastewater treatment plants and storm drains. In the report by STOWA these data are applied in order to analyse more closely how the sewage system functions.
- STOWA - Rioolvreemd water; onderzoek naar hoeveelheden en oorsprong water (2003)[15]*; This study was conducted because there were differences between the theoretical wastewater flow rate and the actual influent at urban wastewater treatment plants. The difference is explained by unintended dilution of sewage (via unintentional infiltration / drainage of groundwater and/or inflow of storm water etc. via inappropriate connections including yard drains, roof drains, etc.) entering the sewage system (often by leaks). STOWA has developed a methodology for quantifying this unintended dilution of sewage, which is called the DroogWeerAfvoer Analyse Systematiek (DWAAS).*

2.3 Methods

Now that we discussed the data sources, we can work out the method for compiling the PSUT in some detail. The various aspects are used to structure this. In a physical water SUT three main flows are thus distinguished: flows from the environment to the economy, from the economy to the economy (or within economy) and from the economy to the environment.
Figure 2.1 gives schematic representation of the relation between the water assets (stocks/resources) and water flows in terms of supply and use that are elementary for a PSUT. The figure shows the relationship between the assets in the inland water system together with the salt surface water (Sea) and the flows to the economy, within the economy and the return flows to the environment again.

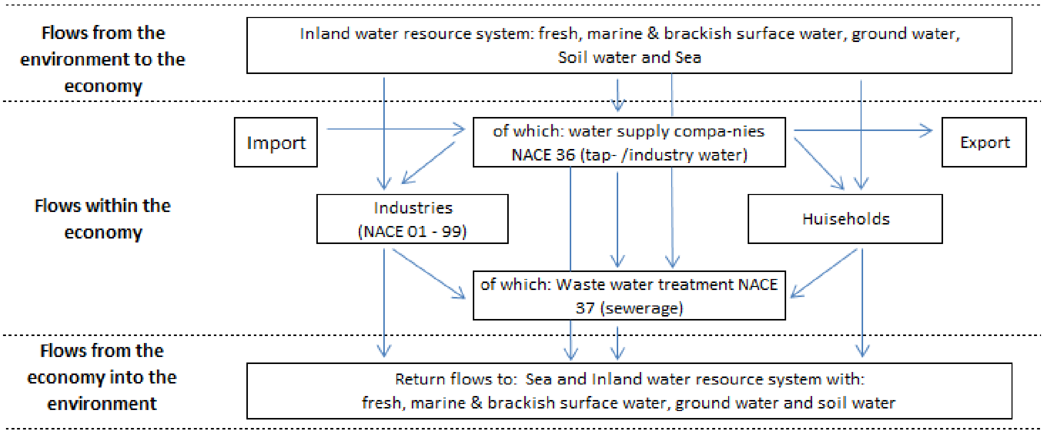
[12] http://www.vewin.nl/SiteCollectionDocuments/Publicaties/Watergebruik_Thuis_2013.pdf

[13] http://www.emissieregistratie.nl/ERPUBLIEK/documenten/Water/Factsheets/Nederlands/Effluenten%20RWZI%20(berekend).pdf

[14] http://stedelijkwaterbeheer.stowa.nl/Upload/publicaties/STOWA%202009-24.pdf

[15] http://stedelijkwaterbeheer.stowa.nl/Upload/publicaties2/2003_08.pdf

Figure 2.1 Illustration of the physical water flows between the environment and the economy and within



Source: SEEA-Water, 2012, Figure III.2 Detailed description of physical water flows within the economy. Statistics Netherlands, figure adjusted for this study.

2.3.1 Flows from the Environment to the Economy

The inland water system has three main fresh water sources, namely fresh surface water, groundwater and soil water[16]. Furthermore water is extracted from salt and brackish surface water (marine) at the sea shore often for cooling purposes. All this water is used to serve for production and consumption activity. The water types distinguished by the PSUT are explained later in this chapter. In the Physical Supply table the abstraction of water is recorded as supplied by the environment. The same quantity of water is registered in the use tables as water for intermediate consumption by the range of industries that performs the actual abstraction. In most cases the water is used by the entity that abstracts the water. This we call ‘abstraction for own use’ (self-supply). The various purposes the water is actually used for are combined and presented in some main categories. Water from precipitation that becomes soil water (and from other sources like groundwater) and gained for by plants/crops to serve transpiration and that benefit economic activity is also included. Rain water gathered in the storm sewers is excluded.

2.3.2 Flows within the Economy

This category represent the flows between different economic entities and will also referred to as ‘From the economy to the economy’ in the report. Water abstracted from the environment by a particular economic entity can be distributed to other economic actors, after treatment or even untreated. The water goes from one to the other economic actor, but for this category it remains in the economy. Besides the water use by enterprises, the use table also shows the final consumption by households and the use by the rest of the world (exports). In the supply table these items come back as supplied by ‘water companies’ (NACE 36) and as ‘the rest of the world’ (imports). The Netherlands shows a small negative trade balance for drinking water, or net imports, for a series of years.

Apart from the larger and often ‘visible’ physical water flows, water in products is also taken into account. There is also water in the raw materials and contained by auxiliary products that are transacted among economic actors, while water can be added to raw materials and

[16] Soil water is also a main source in the inland fresh water system. Soil water as a flow from the environment to the economy is part of the SUT or PSUT in the standard water accounts.

products during the production phase. These quantities are shown in the use table, as 'water in product'. Finally a given quantity of water remains in the products that are supplied, either in finished or semi-manufactured products. These quantities are presented by the supply table as supplied by the industry under 'water from products'.

In the sequence of starting with abstraction from the natural water resource and ending up with using it in production and consumption activities, there will be water that is no longer or not fully used by the (intermediate or final) user. Some of this used water will flow from the economy (production activity) to the economy via wastewater treatment facilities and is called wastewater. That water can be discharged in the sewerage system, the Urban Waste Water Treatment Plants (UWWTP) or resupplied, sometimes after some form of wastewater treatment in dedicated waste water treatment facilities, often in manufacturing on industrial sites, or to other economic entities for reuse. This reuse is presumably not for the full 100% observed and available from the source data.
The wastewater category is part of the 'Flows within the Economy' but continues and is also part of the third main category of 'Flows from Economy to Environment', as it interacts with both. Wastewater supplied by wastewater treatment plants or other economic entities are recorded in the supply table with the correct industry (NACE; 'regkol') under the item to 'wastewater collection and –treatment' and the item to 'Industry (re-used water)'. In the use tables these quantities are included in wastewater treatment under 'wastewater collection and treatment' and allocated to the receiving industry (regkol) under 'industry (reuse of water)'.

2.3.3 Flows from the Economy to the Environment

The last and third category determines what happens to the water after its use by economic activity and return to the environment again, either to the atmosphere or to the inland water system or outside like the Sea or neighbouring countries, these are the 'return flows'. The return flows originate directly from either the economic entity, households and/or from wastewater treatment facilities. In the supply table, these water flows are shown as water supplied by the industry (regkol) or households involved under 'wastewater collection and treatment' or 'to the environment', while a distinction is made between fresh and salt surface water and the soil under land. Per industry the discharge (supply table) has to correspond with the total water intake (use table), and corrected for the flows of 'water in product' and 'water losses'.

To get to a complete 'balancing system' for all the water volumes described and being part of the three main flow categories, one needs to take the water losses into account. Water losses represent those water flows that do not reach their desired destination, or disappear from the inland water stock or from products. Water is mainly 'lost' in large volumes through evapotranspiration (ET), e.g. from crops or during distribution e.g. through leaking or theft[17]. Loss is registered as such in the supply table for the concerned industry. Corresponding volumes are recorded in the use table as 'return flows' for the entity environment under 'water losses'. This excludes evaporation from crops based on extractions of soil water in agriculture that originally stem from precipitation.

[17] Here again the large flows of water to the atmosphere by crops via Transpiration are excluded from the tables as a loss.

In summary, the rows in the SUT consist of 'economic entities'; that are five items: the various industries (regkols), households, imports, exports and the environment. The columns are made up from various sections that provide information about:

- Abstraction of water from the environment, including abstractions / crop absorption;
- Distribution and use of water by the various industries (regkols) and households in the economy, including water in products;
- Production and flows of wastewater (often via wastewater collection facilities towards processing) and reused water (between households and businesses);
- 'Return flows', in which a distinction is made for the destination of the return flows into either fresh surface water, salt surface water and into soil. Also, water losses due to vaporizing (including evapotranspiration from sprinkling and irrigation) are considered 'return flows'.

A few key elements of the PSUT, carrying concepts and definitions, are relevant in the design and thus also in the interpretation of the PSUTs. These key elements relate to the concepts of Water Supply versus Water Use, the different types of water that are distinguished and the (direction of) flows and supplying resource and/or receiving water body, as part of the bigger inland water system and connection with the sea, neighbouring countries, and atmosphere. A number of these key elements of the PSUT are defined and explained in Annex III – Glossary.

To get a full functional monitoring system with a fully balanced and integrated PSUT requires a few additional routines. The main ones will be discussed briefly here. On industrial wastewater, for the various industries and households we estimated the released wastewater flows, divided into wastewater collection and treatment (sewer), industry (reuse water), soil water, salt surface water, fresh surface water and the atmosphere (water loss). A further routine during compilation of the PSUT is the confrontation with urban wastewater treatment plant (UWWTP) data. For example, it is needed to confront the dry weather discharge by households and companies with the influent of urban wastewater treatment plants (UWWTP). This aims to account for rainwater and unintended dilution of sewage that flows into the urban wastewater treatment plants as well as the combined sewer overflow and leaks in the sewer system. The entire return flow needs to be assessed and analysed, the water flowing from the economy via the sewerage system and urban wastewater treatment plants back into the environment. The possible reuse of waste water after treatment in its own wastewater treatment facilities often on site or neighbouring sites is not included because this is not well known. Similar the water supplied to other economic entities for use or reuse, is also not fully observed.

Finally, to get a functional PSUT, the integration and balancing of water, wastewater with balancing items is required. The various figures and inputs were confronted in the end. To achieve such fully balanced physical SUT tables for water, we balanced: 1.water abstraction, 2.water use, 3.wastewater production, 4.water in products and 5.discharge into the environment with other return flows. The final item we deal with in balancing the table is 6.water loss during the production process.
The first four steps are more or less explained elsewhere, together with the description of the data sources and methods used. The last step of integration and balancing is a technical process that is not described in detail in this report, but is included in the results of the PSUT tables. This is mainly a matter of checking after the data is confronted in the PSUT and discover the items that do not balance yet. These need to be adjusted, changed in a way that is both plausible and helps to get the relevant items 'balanced'. Some expert knowledge on both hydrological system

and economic data integration (i.e. like National Accounts) or other environmental accounts is needed.

On the PSUT tables compilation, the applied methods and in interpretation of results we would like to emphasise that this is a pilot study, testing the feasibility of compiling a complete as possible PSUT. We observed some smaller remaining imbalances in the end. The results are partly based on estimates, supported by expert knowledge, but largely based on already available statistics and previous studies on water.

2.3.4 Distinction in types of water

The three main elements that constitute the water PSUT, with 1.origination from the environment, 2.throughput with exchange within economy and 3.destination environment again, for each a number of different water types are characteristic.
We distinguish four water types from the environment, four flows within the economy, and three flows that return to the environment. The eleven water types altogether are discussed in some more detail here.
For the ***first main water flow in the PSUT*** we look into the flow of water from the environment to the economy. This includes four water types / flows: **a. groundwater, b. fresh surface water, c. marine surface water, d. soil water (abstraction to ET and in product)**. A single category of physical water flows important for production and consumption is exempted from this study. That is the limited volumes of water collected from 'precipitation'. This is particularly important in horticulture where precipitation is collected at the glasshouses and stored in basins or reservoirs above ground and on site. This water is often used for irrigating the plants in horticulture, eventual in combination with other water sources. Furthermore part of the households collect rain water in small quantities.

In the ***second main water flow*** *of the PSUT*, flows within the economy, again four water types / water flows in the PSUT are distinguished: **a. Tap(mains) water**, the water of drinking water quality**; b. Industrial water**, also referred to as 'other water', but often similarly transported like drinking water via mains, **c. Water in products** and **d. Waste water**. 'Water in products' is the flow that enters the economy bound in the products, and/or the water contained by the products that are traded/consumed within in the economy, or that may end up in products leaving the country via export. Water in products plays a role in the manufacture of for example dairy products, which uses a great deal of raw milk, which contains over 85 percent of water. The fourth water flow category and that is still within the economy, is category d. Wastewater (untreated). This constitutes a flow from companies and households transported via the sewer system to the urban wastewater treatment plants (UWWTP's). After the waste water treatment this water returns to the environment, usually to surface water. Those (manufacturing) companies that treat and/or reuse their own wastewater as well as the wastewater of other companies are also included in this category, this because wastewater is exchanged within the economy with a relevant monetary transaction. This flow is not fully observed though. The wastewater of companies that treat themselves, and may reuse themselves, and which they subsequently return to the environment does not come in this category but in the third category, 'from the economy to the environment'. This study excludes a possible (but limited) fifth flow within the economy, the water supply between companies as warm water / hot steam. However, sufficient data are not available on this.

The ***third main water flow of the PSUT*** consists of the return flows from the economy to the environment. Return flows of water after use in economic production or consumption activity can flow into either fresh surface water bodies, salt surface water bodies or back into the soil / land (mainly relevant in agriculture). Three types of water are distinguished in the third main flow: **a. Wastewater** that, after treatment in the urban wastewater treatment plants (NACE 37), returns to the environment, in a quality that meets the requirements to get releases into the surface water again. A considerable amount of the wastewater generated in the country is treated by the companies themselves with a wastewater treatment facility on site. Moreover, this is often subsequently reused (recycled) or returns to the environment, via mainly discharge to surface water bodies or else. **b. A considerable return flow is the large volume of cooling water** used in power plants or in manufacturing that returns to the environment, either to inland water or to the sea. **c. Then another major category is the return flow to the environment that relates to the evaporation by cooling towers and crops (transpiration).** This flow is recorded as a 'loss'. In agriculture, this is the water absorbed by the crop and then largely evaporates into the atmosphere. Evaporation of water from wet soil surfaces, hard surface, and surface water and not explained by economic activity is outside the scope of the study. These are merely flows from one environmental compartment to another, possibly within the inland water system.

2.4 Results

This paragraph illustrates and discusses some main results on the SEEA – Water Accounts with Physical Supply and Use tables (PSUT). The Supply and Use tables distinguish three main water flows. The abstraction 'From the Environment to economy', the flows between entities, including households within the economy and the return flows, the water flow 'From Economy to Environment'. These return flows show returns to the inland water system and the atmosphere. For quantification of these return flows, detailed analysis is needed to track the flows after its use in production and consumption such as waste water, its processing and destination. This is compiled by detailed industry, water type, and main purpose of the water use. The detailed PSUT tables as well as the aggregated tables for 2014 are available and will accompany this report in an Excel file. These will be published together.

2.4.1 Physical Water Supply and Use table 2014

The aggregated PSUT for water flows in the Netherlands in 2014, both Use table and Supply table, are shown in annexes I and II. These supply and use tables (or the accompanying detailed PSUT tables) can be linked to the National Accounts and other environmental accounts, i.e. with similar industry aggregation as to the Energy accounts (EA), material flow accounts (MFA) and so on, allowing for detailed environmental economic analysis.

On the dimensions of the aggregated water Supply- and Use tables (PSUT) as shown in the Annexes: The columns show the grouped 'economic entities' following NACE / ISIC – categories, that is the various industries ('regkols'), households, imports, exports and the environment. The rows are made up from the various sections that provide information about origin, throughput and destination of the different water types:

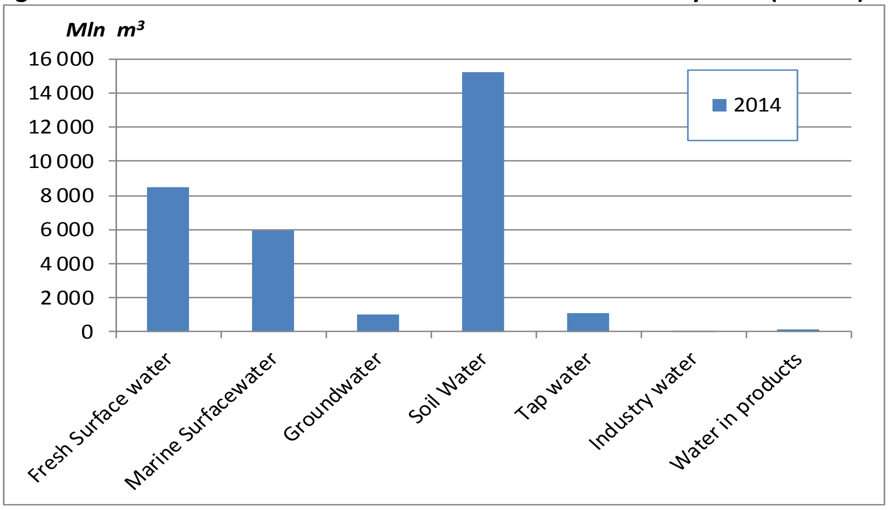
- Abstraction of water from the environment, including plant uptake /crop absorption;
- Use of water by the various industries (regkols) and households in the economy, possibly after distribution and including water in products;

- The generation and flows of wastewater (often towards wastewater collection) and reused water (between households and businesses) and;
- ‘Return flows’ back to the environment, in which a distinction is made in the return flows into fresh surface water, salt surface water and soil / land;
- Also ‘water losses’ due to vaporizing, including evapotranspiration from (agricultural) land (also as a consequence of sprinkling and irrigation) are considered a loss from the inland water system as it flows to the atmosphere.

For the detailed PSUTs, underlying the aggregated PSUT shown in the Annexes and presented in the Excel tables accompanying the report, the tables are transposed. This with changing the orientation of rows and columns, there the columns have various sections with information on origin and destination of the different water types and rows showing the grouped ‘economic entities’ with detailed NACE/ISIC – Industries.

Figure 2.2 show the kind of data that can be derived from the accounting tables. It shows that in 2014 large flows of both marine and fresh water are abstracted from the surface water bodies. Large part of these flows returns to its origin, either the inland water system or to the marine water, like for facilities situated near the coast. This includes ‘in-stream use’ which implies it can be used more often. It further shows the relative importance of abstractions from (fresh) groundwater, the scarcer resource at some locations and season throughout the year. Also, it shows the large uptake by plants / crops, from soil water, mainly in agriculture and forestry and in few other sectors. Further, it shows the water abstracted as part of other products (i.e. crops) and some relevant flows within the economy.

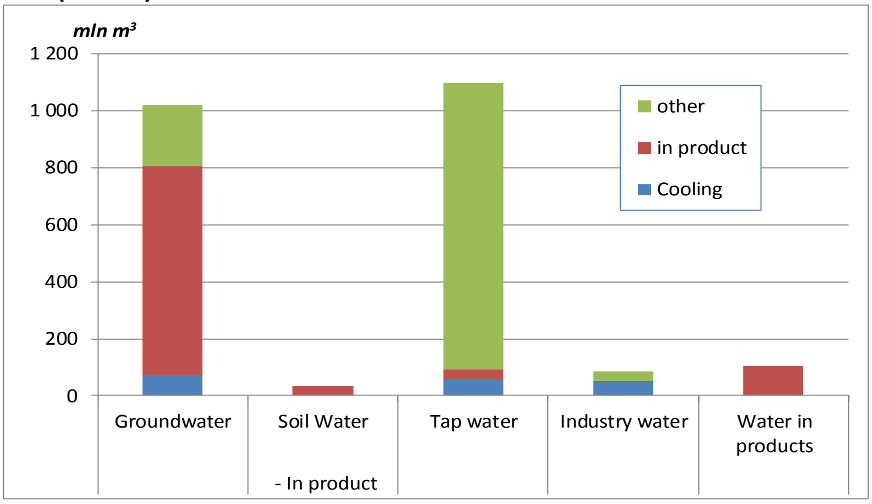
Figure 2.2 Water abstraction and use in Dutch Economic activity 2014 (mio m^3) [1)]



[1)] These flows may not all add up, some show the same water.

Figure 2.3 shows the different flows without the large surface water flows and without the large soil water flows towards the atmosphere via Evapotranspiration (ET), largely from agricultural land by crops and forest. As information is available at detailed industry level, the figure can also be made for uptake and use by the different industries and for other analysis of water in its economic use.

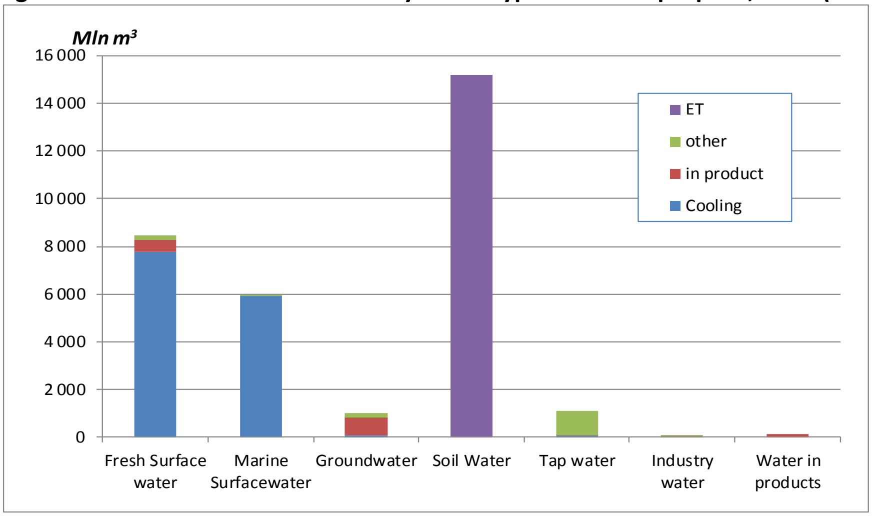
Figure 2.3 Water abstraction and use in Dutch Economic activity, excluding the large flows, 2014 (mio m^3) 1)



1) This figure tries to provide additional insight in the smaller water flows, by excluding the large surface water flows and the large soil water flow to the atmosphere via Evapotranspiration (ET).

Figure 2.4 shows the different water flows, again abstraction and use combined, for some flows thus at least double counted. It distinguishes the different water types and a selection of the (main) purposes that are served by the physical water flows for which the supply and use are monitored by the PSUTs. As information is available at detailed industry level, the figure can also be made for uptake and use by the different industries and other analysis of water in its economic use.

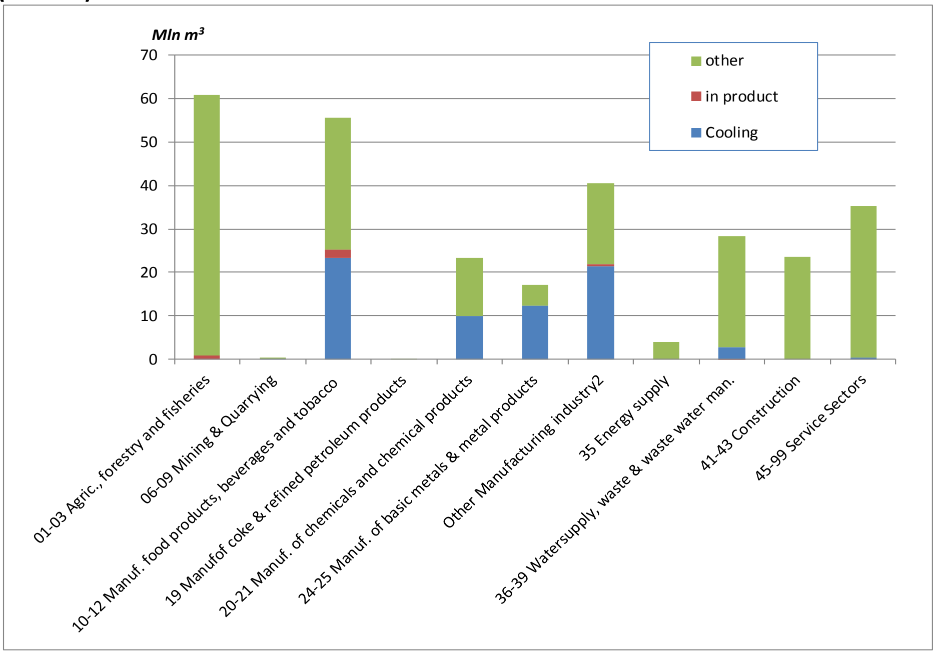
Figure 2.4 Water use & abstraction by water type and main purpose, 2014 (mio m^3) 1)



1) From soil water, as limited (not visible) part end-up 'In product'.

Figure 2.5 gives an example of water flows from the environment, here the abstraction of groundwater and with a breakdown by industry (groups) and purpose of the use. This is a result from the aggregated table for industry groups. The detailed data is also available. The industry groups agriculture (NACE 01-03) and the 'Manufacturing of food products, beverages and tobacco products' abstract most groundwater. The manufacturing industries abstract most groundwater for cooling purposes.

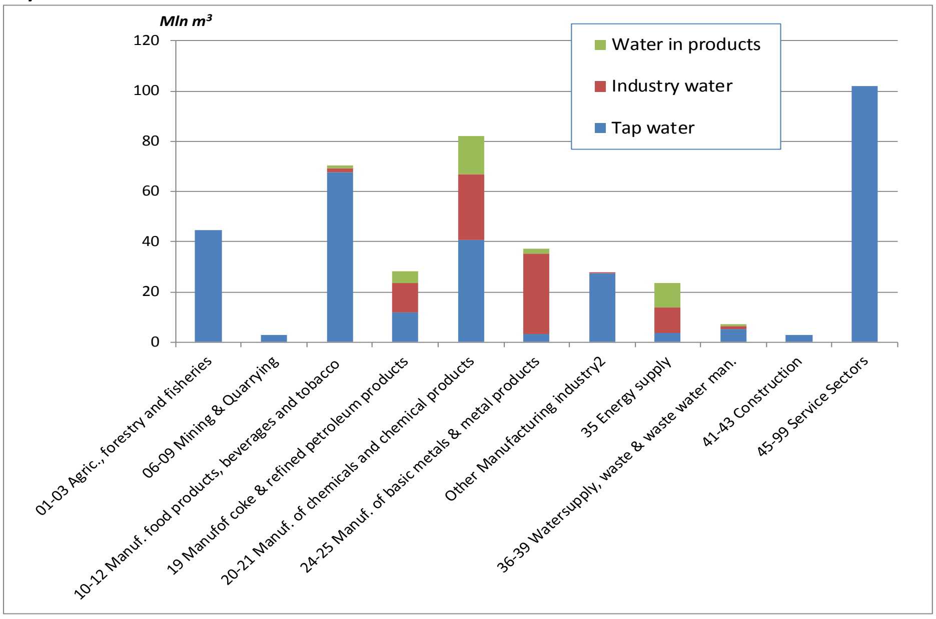
Figure 2.5 Groundwater abstraction by Economic activity (industry) and by purpose, 2014 (mio m³) [1)]



[1)] Water supply industry obviously abstracts by far the most and therefore excluded from this figure, as this water is distributed and actually used by the industries and households, not for just own use.

Figure 2.6 gives an example of water flows from the environment, here the distribution and supply of tap water (drinking water), the supply of industry water, with different quality and water accompanying products. Clearly altogether the services sectors, agricultural sectors, the manufacture of food products, beverages and tobacco, and chemical industry use most of the tap water supplied. Moreover industry water is used mainly in chemical and metal fabrication and less in petrochemical industry and energy supply. The industry breakdown allows for further analysis with economic information from industries in National Accounts.

Figure 2.6 Water use 'within the economy', by NACE industry and by water type, 2014 (mio m³) [1)]



2.5 Conclusions

Here some conclusions that relate to this chapter are drawn:

1. The large intake of fresh and also of Marine water to large extent become return flows of almost the same volume, apart from some (smaller) water losses and relatively limited volumes ending up in products, and sometimes water as a commodity;
2. This can be applied as an identity for example for some of the bigger items in the tables, allowing to check as part of compilation and plausibility check procedure and to see if the balancing goes right;
3. Abstractions of groundwater were relatively limited, once compared to the large abstractions from fresh and marine surface water and from soil water, but still are very important as a quality and alternative resource;
4. Abstractions in large volumes from surface water, particularly from marine water are often for cooling purposes. These flows after use often return to the surface water bodies again either sea, or inland water system, this is referred to as in-stream use, showing the abstracted water earlier on can be used once more;
5. The large flows of ET to the atmosphere from soil water via land and crops are shown in the use tables, as a flow from the environment to economy by industry, in the context of the new SEEA-EEA, the Experimental Ecosystem Accounts one can refer to as provisioning service, but an intermediate provisioning service as this is facilitating the production process, it doesn't end up in the product that enters the economy. Still it is an elementary provisioning service flow;
6. The PSUT also shows that one should first focus on the big flows. In terms of compilation effort it also allows to prevent from dedicating too much time to the (sometimes relatively really) small items;
7. The quantifications in the tables can support decisions and policy decisions, starting from the main flows, not the small (possibly less relevant) ones.

3. Return flows and waste water

3.1 Introduction

The last main flow in the PSUT is the water flow after use from the economy to environment. After water is used one gets wastewater. These wastewater flows are estimated for the range of industries (133 regkols) and for the households. Not all the water that was used and was determined earlier on is discharged. Part of the water is included in products; another part is released into the atmosphere, as in the case of evapotranspiration, a 'water loss' from the inland water system. The remaining water, if it is not reused, is discharged. Discharges flow into the environment again (direct discharges to surface water or to land/soil), these flows are called 'return flows'. Alternatively, the 'waste water' can also be discharged onto the sewer system that is what we call part of 'the economy', as a monetary transaction is involved. Here the wastewaters flow via the Urban Waste Water Treatment Plants (UWWTPs) and after treatment it gets released into the environment.

3.2 Method

The procedures and methods for estimating wastewater and return flows from households, manufacturing sectors and other sectors differ, although, the water intake for each economic entity as starting point is common. The compilation procedure is to try to estimate the volume of water that leaves an economic entity, i.e. each company. We tried to account for water losses and the water in products.

For the ***Industrial (manufacturing) sectors*** with respect of the discharges, we make distinction between direct discharges/'return flows', and the indirect discharges. In the SUT Water, indirect discharges are considered 'wastewater'. Direct discharges by industry (manufacturing) are almost completely observed by the electronic annual environmental reports (e-AERs) that cover the bigger manufacturing companies. To calculate the indirect discharges it is not sufficient to subtract direct discharges from total water intake. After intake, water losses occur and water partly will end up in products, this need to be considered during compilation. For assessing water losses, different methods were proposed and checked.
After testing and comparison, also with previous work in order to come up with plausible findings, we have chosen an alternative with which it was assumed that all surface water flows, both fresh and salt (marine) and industrial water flows are fully discharged into the environment (direct discharge). This is not always the case and equally not all tap water and groundwater is discharged into the sewer system.
In a next step, we started from the assumption that the underestimates and overestimates balance each other out, also by considering the water in products and water losses. Further, in applying this method, customising at the detailed industry-level (balancing) proved necessary. For which we relied upon individual e-AERs that showed that some companies in a given industry discharge a significant amount of tap water and/or groundwater directly onto fresh surface water bodies.

The assumption is that all direct discharges are done on fresh surface water bodies, except for intakes of salt (marine) surface water and groundwater abstractions for well point drainage. Intakes of marine surface water are also fully discharged on the marine surface water, mainly the North sea. The ratio for discharging groundwater from well point dewatering is taken as

20/40/40 percent for sewer/fresh surface water/soil respectively. This is the best expert guess we could make, considering this discharge is not the most relevant water flow, both in terms of depleting water resources and enhancing water management. It is often only a local and temporarily abstraction (mostly in construction activity). This 20/40/40 distribution is also because there is a preferred sequence for discharging groundwater from well point dewatering by Rijkswaterstaat, water boards and municipalities: 1. soil, 2. fresh surface water, 3. sewage system[18]. However, discharge into land/soil or fresh surface water bodies is not always possible. With the groundwater register LGR we further determined for which industries groundwater is mainly used in well point dewatering. From the use table, we learn that the water supply companies abstract the biggest volumes of groundwater and surface water. Big part of this water goes into the supplied product. The supply table shows this as tap water (and partly industry water) supplied by the Water industry ('regkol'; NACE 36).

The ***Non-industrial sectors*** primarily use tap water, particularly for personal care, also referred to as 'non-process water'. In several cases groundwater is abstracted for well point dewatering as shown by the National Groundwater Register (LGR). Agriculture uses a variety of water sources, including tap water, groundwater, and large volumes of soil water but also fresh surface water for irrigation and for watering cattle. Water 'loss' plays a big role in agriculture - primarily due to transpiration from crops (ET) and cattle - and to less extent in construction. For the non-industrial sectors, we assumed that all tap water is discharged into the sewer, obviously excluding water losses and the water that was included in the product during the production process. There are a few exceptions, such as agriculture and construction, but also sports clubs. In these cases, we determined per industry the tap water share discharged onto land/soil and to fresh surface water. This is based on the purposes for which the tap water is used, taken from the literature and some expert findings.
In agriculture water loss and flows related to water in products and water send to the atmosphere by plants after uptake from soil water, tend to play a major role, as in crop growing. Although one can search for efficiency improvement in soil water use, it is not possible to grow crops without these large volumes of transpiration from crops (part of ET). This is clearly not a future avoidable flow, as it is a requirement to crop growth. Although with adequate farm management the loss of water from the soil via evaporation can be reduced in favour of the transpiration benefitting the crops. We further leave it out from this wastewater chapter, it is a flow to the atmosphere and become part of the hydrological cycle again where it may end up in precipitation in or outside the national territory or elsewhere one day.
The soil water, including the small part in soil water that stem from irrigation, is taken up by crop roots and transpires or evaporates from the ground and < 1 percent end up in the crop for plant growth and in the resulting products. As said evapotranspiration (ET) is considered 'water loss' as it leaves from the inland water system. These flows appear outside the waste water flows from 'industry'.

Water loss for non-manufacturing industries is originally estimated at a 5 percent ratio. Following our calculations, households have water losses of close to 10 percent of the tap water used (see households). We estimate the water loss among non-manufacturing industries to be low because water is used for purposes in which relatively little water is lost (flushing, washing, etc.). There are exceptions. In industries where relatively much water is used for preparing food/drinks and/or cleaning, water loss tends to be greater (about 10 percent). Further, a few industries show very small shares of tap water with discharge to the sewer. We base the

[18] See for example http://www.bronbemalen.nl/16

estimate for these industries mainly on the purposes for which the tap water is used, e.g. sports clubs (sprinkling) and farms, mainly used for watering cattle and cleaning.

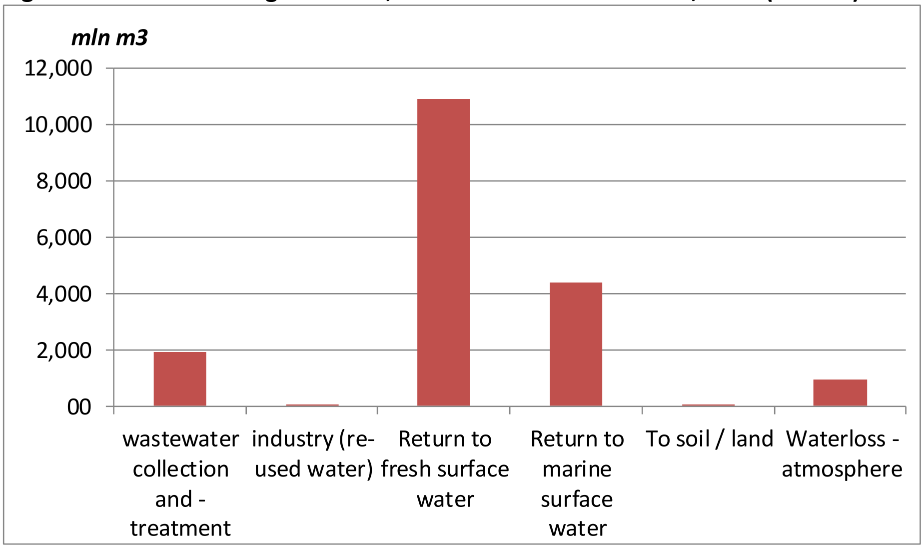
For determining groundwater intake, the LGR groundwater register is used to get an indication of the purposes for which the groundwater is used, and whether this is combined with (balancing) infiltration or not. On the basis of this information and expert knowledge we made estimates for the discharges of groundwater into surface water, the soil and the sewer. Non-manufacturing industries (regkols) mainly extract groundwater in well point drainage and to a lesser degree for irrigation (only few industries). In well point drainage, we used the same ratio (share) as with manufacturing industries. In some cases, the LGR provide indication to deviate from this ratio, for instance for groundwater mainly used for other purposes such as irrigation. In such cases we did some customising. For groundwater, just like for tap water purpose we assumed a water loss of some 5 percent, unless there was a reason to deviate from this found in the literature, LGR and e-AER or from expertise.
In the intake of fresh surface water, observed only in agriculture among the non- manufacturing industries, we assumed that nothing is discharged into the sewer. Fresh surface water, excluding water losses and water in product is mostly discharged into the soil (possible become part of manure storage, handling, and application on agricultural land) and for small part onto fresh surface water bodies.
There are several industries, like maritime shipping and fishing, for which we assumed that they discharge part of their wastewater into marine surface water.

As ***Households*** primarily use tap water, the total volume of drinking water use is taken from the existing water statistics (CBS – StatLine). Not all of the total water use by private households is discharged into the sewer system, as not all households, but almost all (>99 percent) are connected to the sewer system in the country. Moreover, part of the water is 'lost' through evapotranspiration.
We estimated the share of drinking/mains water discharged into the sewer based on the VEWIN-report (2014). We estimated the water loss depending on the purpose of the water use (category). For example, small part of the water destined for cleaning ends up in the sewer, like water for drinking water, and coffee / tea preparation. Some water use categories are added like 'wash basin in the toilet' and 'rinsing the bath'.
The final estimate is that slightly over 90 percent of drinking water used by households ends up in the sewer. The rest is mainly taken through evapotranspiration and categorised as 'water loss'. From the households not connected to the sewer (< 1 percent), two third discharges into fresh surface water and the rest into the soil. We assumed that the water loss of these households does not differ from that of the households that are connected (Statistics Netherlands, 2016).

3.3 Results

After processing the data, we started compiling the tables and attempted to balance it, through which the supply and use tables were further completed. Here we thus focused on the third main flow from the 'economy to the environment', via either waste water collection combined with treatment and via direct discharge, which allows to quantify the return flows to the inland water system and the losses. Although we face slight difficulty in balancing it properly, the main items were assessed. Results again are shown via the supply and use tables in the Annexes I and II. Here we show results for some key element in figures. Figure 3.1 show the volumes of waste water generated and return flows to the environment.

Figure 3.1 Waste water generation, return flow and water loss, 2014 (mio m^3) [1); 2)]

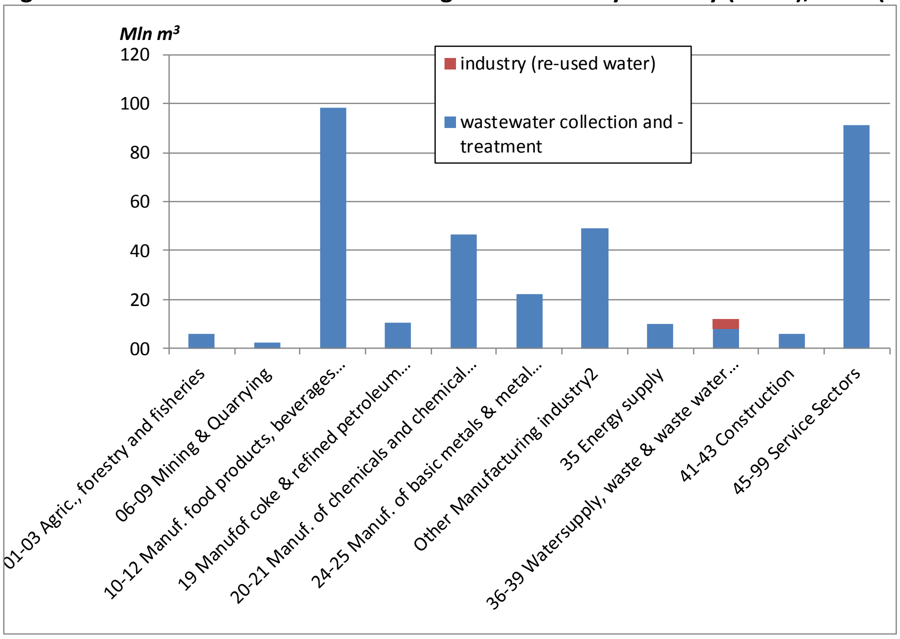


[1)] The large water flow to the atmosphere by ET from crop is excluded from this figure.

[2)] Industry (re-used water) is 4.0 mio m^3, while 'To soil / land' is 67.2 mio m^3.

Figure 3.2 further shows a cross-section of the 'Waste Water' part, in itself part of the 'within economy' section of the aggregated Supply table also shown in Annex II. Several more selections can be derived from the two aligned tables of the PSUT. It shows the distribution of the Waste water flow to Urban Waste Water facilities (UWWTPs) grouped by industry, showing the food industry (NACE 10—12) and a range of Service industries (NACE 45-99) are the biggest contributors. Re-use by these industries is hardly noticed, only in waste and wastewater management (NACE 36-39) some re-use is observed, showing that re-use of water is still not common in NL. However, we also expect that not all re-use is completely observed.

Figure 3.2 Waste water flows to sewerage and re-use by industry (NACE), 2014 (mio m^3) [1)]



[1)] Contribution by households is excluded from this figure, while this is large flow of > 700 mio m^3.

We learned, for the total flow from environment to economy, the largest part is discharged directly to the environment, as these mainly consists of cooling water flows. Further quantification of the return flows is based on many assumptions, differentiated per industry and purpose of the use. This needs further development and cross-checking with other sources.

3.4 Conclusions

Here some conclusions that relate to this chapter are drawn:

1. The previously discussed large flows of ET to the atmosphere, in principle also imply a loss from the inland water resources. We choose to not take these into account in the calculations of the water losses in the PSUT tables, because these flows would dominate these figures completely. Moreover the soil water has hardly other options or competing uses as groundwater and surface water may have, although via enhanced farm management the water loss via evaporation from the soil can partly be transferred to transpiration from crops, supporting crop growth. Moreover the abstraction from the soil water throughout the year on a regular basis is replenished via precipitation. The annual precipitation exceeds the annual ET, but patterns clearly differ over the season and regions. An option is to include the loss via ET in the loss calculation, to show its effect;
2. The return flows to land/groundwater appeared to be very limited, with only a fraction of the abstraction of groundwater, causing a substantial deficit of the water from these flows. This also shows the relevance of the contribution from other sources. It also shows the importance of the replenishment of groundwater by sufficient precipitation throughout the year;
3. The tables are a strong instrument in creating a good and detailed feel for the bigger and smaller flows in the supply and use relations, and in the reliance of the country upon the different water resources. This supports insight and can be a gain for decision making;
4. In compilation of some parts of the supply and use tables, choices were to be made. Other choices would have resulted in different outcomes.

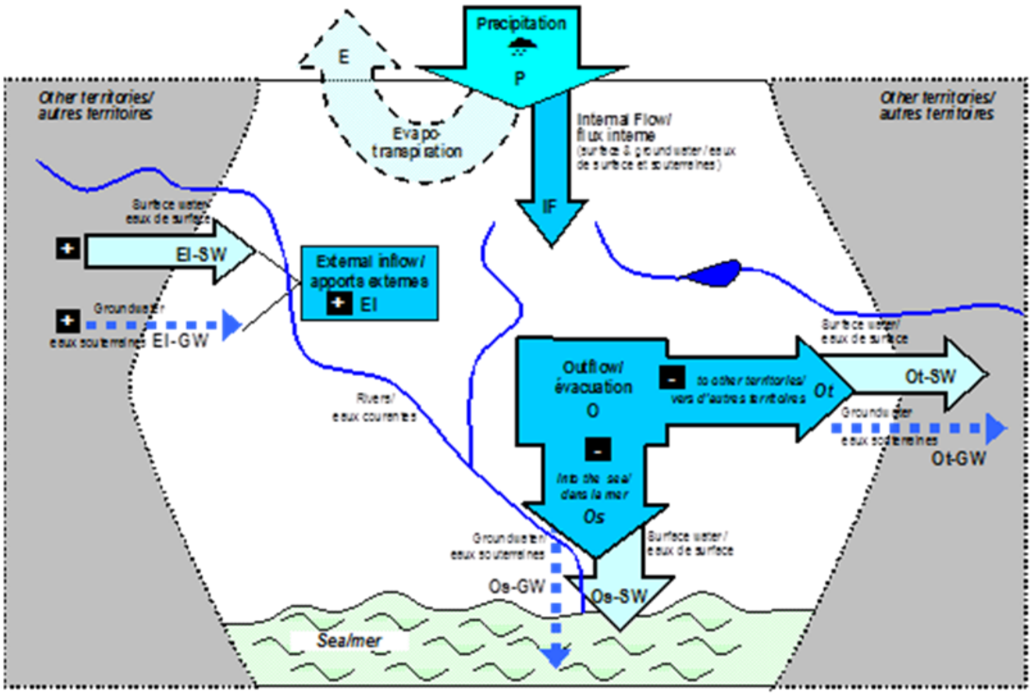
4. Physical asset accounts / water balance

4.1 Introduction

The Physical asset accounts following SEEA-W format and for majority relying upon water balance type of data is compiled for reporting year 2014. Data, its processing, and the applied procedures for compilation are dealt with in this chapter.
The water asset account /water balance as presented in this chapter consists of several elements, based on a variety of stream flow data, satellite data and modelling, and meteorological data. Data are compiled for the country as a whole as well as per River Basin District. In a previous study (Graveland & Baas, 2012), done as a Eurostat Grant, several major improvements of the methods for compiling the water balance were done and documented already. The methods thus not will be described extensively in this report. From the available data we compiled the water balance according to table 1 format of the Joint Questionnaire on Inland Waters. We further aimed to fill a simplified water asset account table, based on the SEEAW standards.

Figure 4.1 shows the different elements of the water balance, in connection with table 1 of the Joint Questionnaire (JQ).

Figure 4.1 Simplified hydrological cycle



Source: OECD/ Eurostat – Joint Questionnaire on Inland Waters, the JQ-IW (2010).

The actual evapotranspiration (actual ET) is one of the major elements of the water balance. The method and plain results for this parameter for 2014 are described only in brief in this chapter, as part of the water balance description for 2014. In chapter 5, an in-depth analysis is given of the results of the actual ET. This in-depth analysis will contain (i) a comparison with data on the reference Crop Evapotranspiration (ET-REF), which is in fact a proxy for the potential Evapotranspiration, (ii) a comparison with the ET-actual of 2009 (see Graveland & Baas, 2012), (iii) explanation of the observed data on basis of the weather situation, temperature and precipitation data and (iv) an overlay of ET-actual data with Land use data, which can provide data on soil water use of agriculture and other sectors, to be incorporated in the PSUT tables.

Paragraph 4.2 gives a comprehensive description of the data sources and methods used for compilation of each separate element of the JQ table 1 water balance and the water asset account. In paragraph 4.3, first, the results of all the elements of the water balance are given. Then the national water balance and the basic water balances per River Basin are given. Finally, also the water asset account is presented.

4.2 Data and Methods

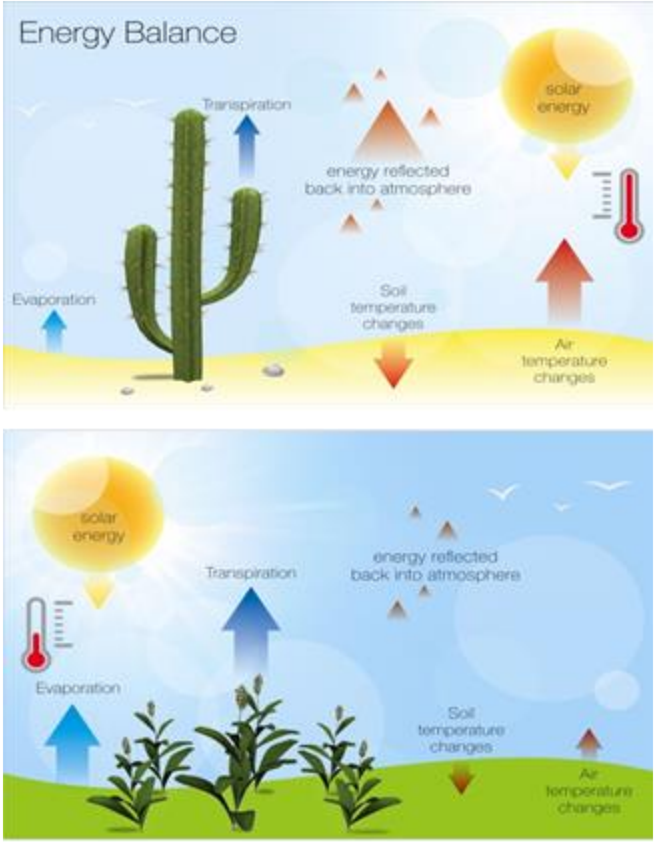
4.2.1 Precipitation and actual evapotranspiration

In this project, the assessment of actual evapotranspiration and precipitation was done for the country as a whole and for the River basins districts. This assessment is based upon spatial and temporal explicit data that has been obtained from eLEAF, a third party.

For precipitation (rainfall), eLEAF processed data of 325 gauging stations across the country. The raw data were obtained from the Dutch Meteorological Institute (KNMI). The density of this precipitation network is high enough to identify spatial differences in precipitation patterns. The daily measurements of the 325 stations were converted to a grid of 250 by 250 meter, covering the whole country, using the Kriging interpolation technique. Daily precipitation maps were aggregated to monthly grid-based maps. Statistics Netherlands received the monthly grid-based data as well as some graphs with the seasonal (winter versus summer) values. For a more elaborated overview of the GIS processing as well as more results, see Chapter 5.

The Actual Evapotranspiration rate depends on the available solar energy, weather conditions (air temperature, humidity and wind speed), and the moisture content in the soil. A number of algorithms have been developed by eLEAF to calculate the Actual ET based on remote sensing data. These algorithms use the surface energy balance, which is based on the principle that the incoming radiation, if not reflected, heats the ground, the air, or is used for ET. Figure 4.1 shows a schematic diagram of the surface energy balance, with the arrows indicating the different energy fluxes. Remote sensing data is used to solve the energy balance. The algorithms behind these calculations are not explained here; additional information on the related models SEBAL and ETLook can be found in Bastiaanssen et al. (1998, 2012).
Statistics Netherlands received data files with the monthly aggregates of the actual ET per grid cell (250 * 250 m) as well as graphs with the seasonal (winter versus summer) values. For a more elaborated overview of the GIS processing as well as more detailed results, see Chapter 5.

Figure 4.2 Energy fluxes within the surface energy balance



Source: Graveland, Baas, et.al., 2016.

4.2.2 Internal flow

The internal flow represents the total volume of river runoff and groundwater generated, in natural conditions, exclusively by precipitation into a territory. To be more precise, the internal flow is equal to the amount from precipitation less actual evapotranspiration and can either be calculated or measured. If the river runoff and groundwater generation are measured separately, transfers between surface and groundwater have to be netted out to avoid double counting in the calculation.

In this project the figure of 'Internal Flow', will be calculated as the volume of water that stem from precipitation, less the actual evapotranspiration. The available data facilitate calculation of internal flow per River Basin District.

4.2.3 Actual external inflow

External inflow consists of two flows: external inflow of surface water and external inflow of groundwater. External inflow of fresh surface water is calculated on basis of stream flow data of gauging stations at or near the border. External inflow of groundwater is not calculated in this study, but we use estimates from literature. Methods and data sources to determine actual inflow are described in brief only; for more detail is referred to Graveland & Baas (2012) and Graveland et al. (2016).

Data on external inflow are obtained from the National Water Authority (on the large rivers like Rhine and Meuse) and from the regional water boards (on small streams), in total 26 stations. Data were transmitted and stored per gauging station, as daily values (m^3/day), thus allowing aggregation to each desired spatial or temporal aggregation.

Actual inflow of groundwater is difficult to measure but can be modelled. Therefore, also in the context of a project on the SDG indicators, connection was made to Deltares, a semi-public consultancy company in waterworks and hydrology. Deltares uses a model that provides the required data: the Netherlands Hydrological Instrument (NHI) (De Lange et al., 2014, www.nhi.nu). In this report the outcomes of this calculation is used, but only for the country as a whole.

4.2.4 Total renewable water resources

The total renewable water resources are calculated as the sum of (a) internal flow and (b) actual inflow. The term 'water resources' is understood here as freshwater resources (excluding the non-fresh).

4.2.5 Actual outflow

Outflow of surface water includes outflow to the sea (North Sea, Wadden Sea, Ems-Dollard and Scheldt estuary) only. As the Netherlands is situated downstream in all the relevant River Basins, the outflow particularly reflects the large quantities of inflow of fresh surface water from the rivers upstream. Outflow of surface water to neighbouring countries does not occur, except for one small river (Dinkel) that crosses the Dutch-German border twice.
Data on outflow were obtained from the National water authority, monitoring the large river mouths and large canals and sluices, as well as from the regional water boards, responsible for monitoring dozens of small polder outlet pumps to the sea. In total, data of 65 monitoring stations were inventoried. Data were transmitted and stored per gauging station, as daily values (m^3/day), thus allowing aggregation to each desired spatial or temporal aggregation.

4.2.6 Other components

For completion of a full, but simplified water asset balance, we also need data on:

1. Abstraction of water. These are derived from the water PSUT as compiled in Chapter 2 of this report.
2. Returns of water. These are also taken from the PSUT table in Chapter 2.
3. Opening stock and closing stock: these two items don't have a large dynamic in the Netherlands, since most of the water levels in the surface water bodies are controlled by sluices, dams, and pumps. Also, the level of the lake Ijsselmeer, the closed off inland bay and by far the largest freshwater body in the country and is kept at constant level in winter. Opening and closing stock for fresh surface water is therefore not re-estimated thoroughly. Values for opening stock and closing stock are taken from an earlier study (Graveland and Baas, 2012) in which rough estimates for stocks of groundwater; soil water and surface water were made and calculation methods described.

4.3 Water Balance / Water Asset Account 2014

4.3.1 Results of the basic elements of the Water Balance

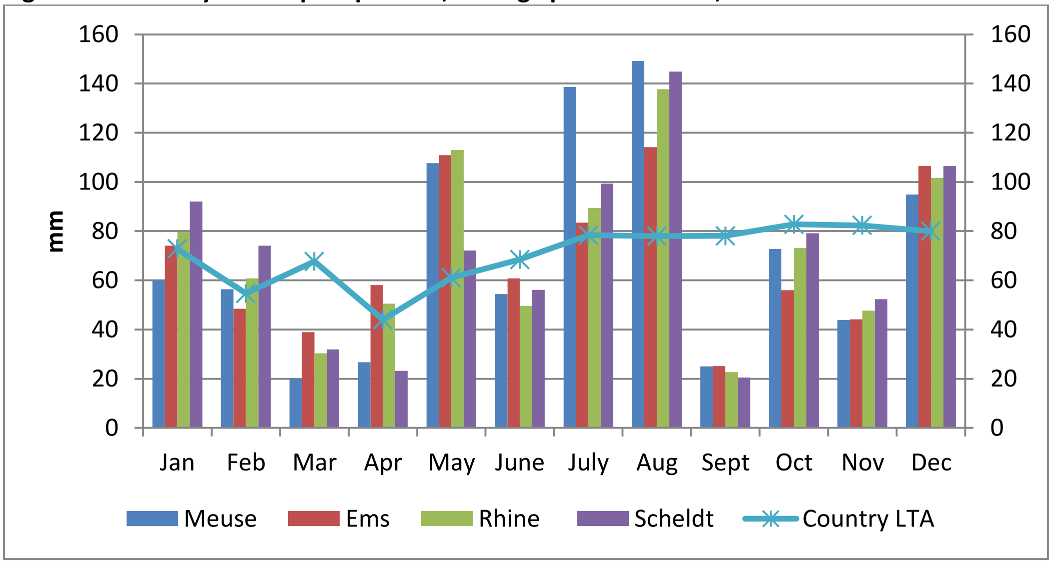
In this paragraph we present the results for the basic elements of the water balance for 2014. For each of the elements of the water balance we present here i) monthly values, ii) a yearly total and ii) seasonal totals, as for the summer season (April-September) as well as the winter season (January-March and October-December). Results are also presented per River Basin (Rhine, Meuse, Scheldt and Ems).

After the results per element, the total water balance is presented (see table 4.4).

Precipitation and Actual ET

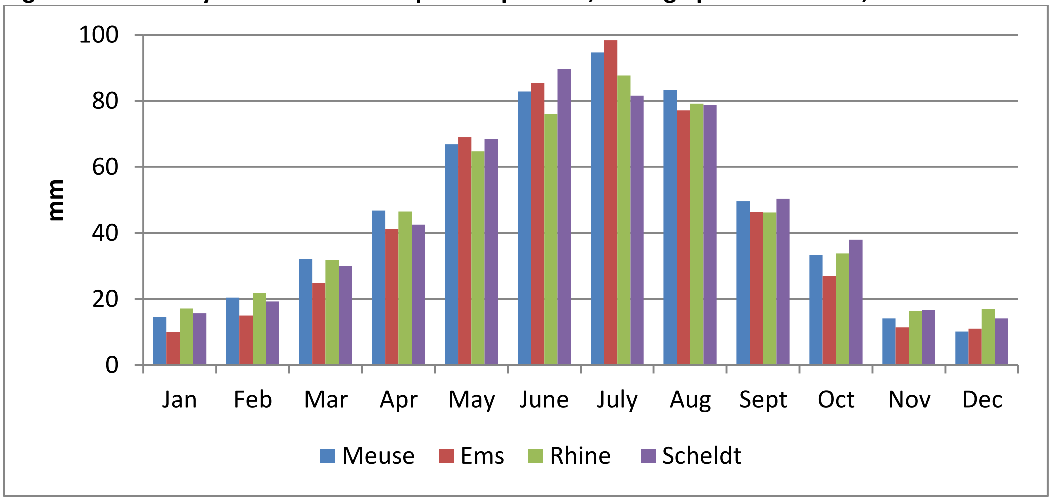
Figure 4.3 and 4.4 show the monthly values for mm of Precipitation and mm Actual ET respectively, per River basin. For Precipitation, also the 30-year monthly Long-Term Average (1981-2010) of the country is plotted. Table 4.1 provides the results on the cumulative mm Precipitation and Actual ET, per season and per River Basin, as well as the precipitation surplus. Table 4.2 presents the aggregated results based on million m^3. The latter values are calculated by multiplying the pixel values (mm) by the pixel surface (250*250 m). In chapter 5, also more spatial results of actual ET, Precipitation and Precipitation surplus are shown in the form of maps per season (summer, winter).

Figure 4.3 Monthly rate of precipitation, average per River Basin, 2014



Source: eLEAF, adapted by Statistics Netherlands

Figure 4.4 Monthly rate of Actual Evapotranspiration, average per River Basin, 2014



Source: eLEAF, adapted by Statistics Netherlands

Table 4.1 Average cumulative rate of Precipitation and Actual ET, per River Basin, 2014

	Precipitation			Actual Evapotranspiration			Precipitation surplus		
	Year	Summer	Winter	Year	Summer	Winter	Year	Summer	Winter
	mm								
The Netherlands	852	467	385	539	406	132	313	61	253
Per River Basin:									
Meuse	850	501	348	548	424	124	301	78	224
Ems	820	452	368	516	417	99	304	35	269
Rhine	856	463	393	538	400	138	318	63	255
Scheldt	852	416	436	544	411	133	308	5	303

Source: eLEAF (2016), adapted by Statistics Netherlands

Table 4.2 Volumes of precipitation and actual ET, per River Basin, 2014

	Total Surface[1)]	Precipitation			Actual Evapotranspiration		
		Year	Summer	Winter	Year	Summer	Winter
	1,000 ha	*mio m³*					
The Netherlands	3,716	31,675	17,366	14,309	20,026	15,103	4,923
Per River Basin:							
Meuse	738	6,269	3,701	2,569	4,046	3,127	919
Ems	232	1,905	1,051	855	1,199	969	230
Rhine	2,544	21,785	11,777	10,007	13,686	10,180	3,506
Scheldt	201	1,716	838	878	1,096	828	269

Source: eLEAF (2016), adapted by Statistics Netherlands

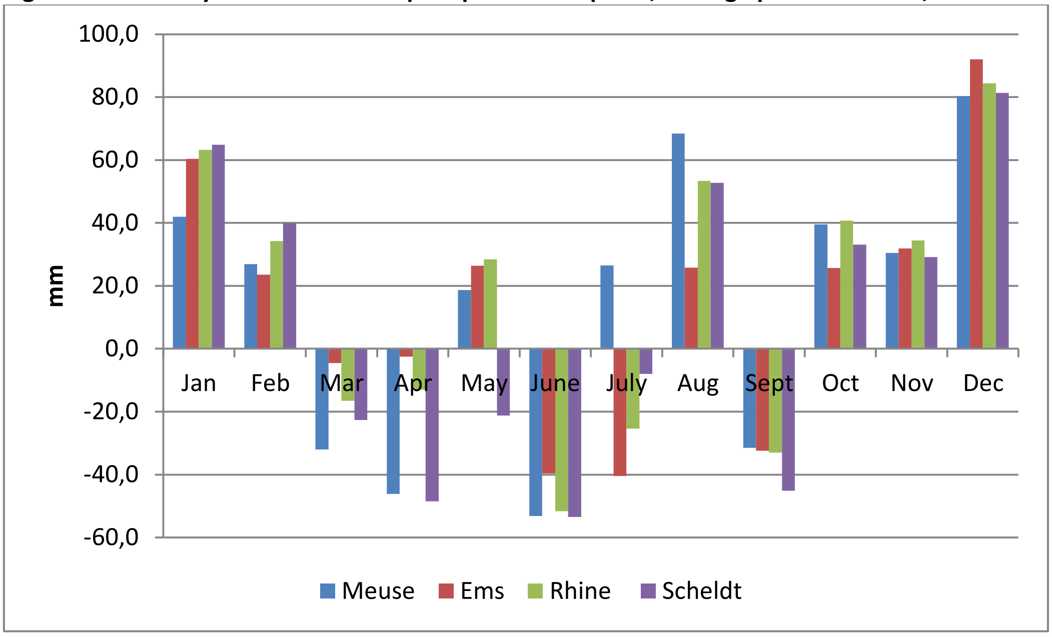
[1)] Surface of land and fresh inland waters for which precipitation and ET volumes are calculated.

From figures 4.3 and 4.4 as well as tables 4.1 and 4.2, the following observations are made:

- Figure 4.3 shows for 2014 that especially in the months March, June, September and November in most River Basins the precipitation was significantly lower than the country LTA. On the other hand, May, August and December were wetter than Normal;
- Especially May and August had much precipitation: almost twice the normal value. The result is that in 2014 total precipitation in the summer season (April-September) is 20% higher than in the winter season. Normally, precipitation in the winter half-year is 10% higher than in summer;
- The monthly values show that there is quite a difference between River Basins. Precipitation in mm differs significantly between the River Basin areas. A few examples:
    - Precipitation during January in the Scheldt Basin is 50% higher than in the Meuse Basin. In February, precipitation in the Scheldt Basin is 50 to 30% higher than in the other three River Basin areas;
    - In July, the precipitation level in the Meuse Basin (south of the Netherlands) is 65% higher than in the Ems Basin (situated in the North of the Netherlands);
- In general, the monthly mm actual ET in the Ems Basin, situated in the North-East of the country, is lower than in the other River Basins. The reason could be lower temperature values but also the lower precipitation rates (mm) can play a role, which allows for less water to evaporate from the soil or surfaces.

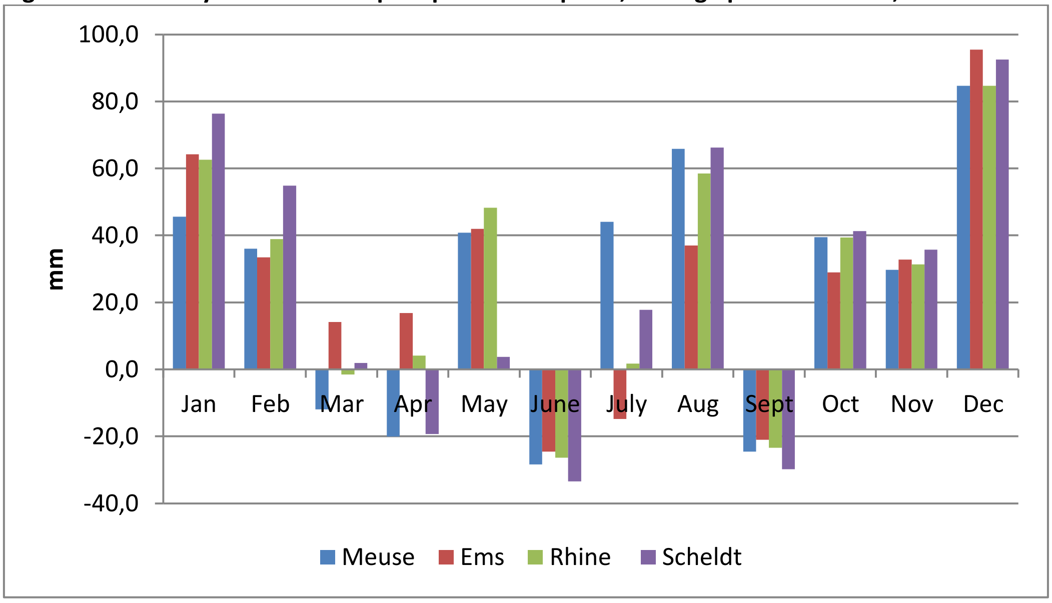
Figure 4.5 shows the monthly rates (mm) of Potential precipitation surplus, per River Basin. This value can indicate potential or even actual drought situations: it shows the monthly rates (mm) of the deficit or either surplus of water when evapotranspiration is at its highest potential value. In figure 4.6 the monthly rates (mm) of actual precipitation surplus are shown. When negative, this rate is an indicator for the net contribution of soil water or surface water (mm) to serve the actual evapotranspiration needs. A positive value (surplus) indicates how much water is net available for recharge of water resources.

Figure 4.5 Monthly rate of Potential precipitation surplus[1], average per River Basin, 2014



[1] Potential precipitation surplus: Precipitation minus Reference crop evapotranspiration. The negative values show the situations with 'precipitation deficit'.

Figure 4.6 Monthly rate of Actual precipitation surplus[1], average per River Basin, 2014



[1] Actual precipitation surplus: Precipitation minus actual evapotranspiration. The negative values already illustrate the situations with 'precipitation deficit', for which soil water provision allows the Actual ET and crop growth to continue. In principle, this figure can also be an estimate for 'Internal Flow'.

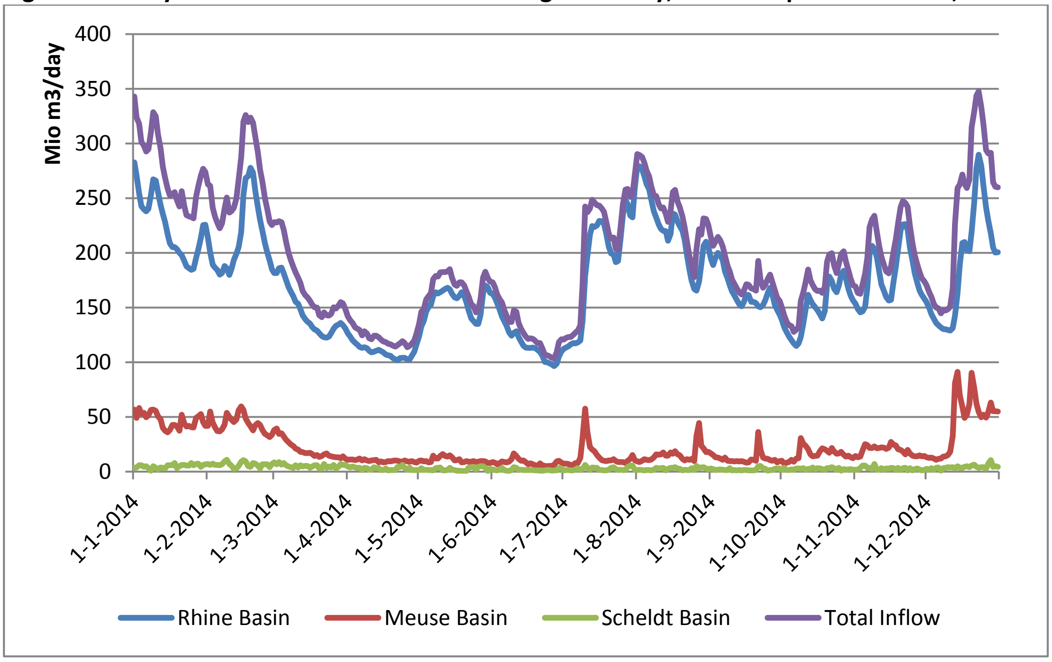
From figure 4.6 it can be concluded that especially in the months of June and September, the monthly precipitation is not sufficient to facilitate the actual ET. In these months, the resources of soil water must supply a part of the water needed for actual ET. In April this is also valid for the Meuse Basin and the Scheldt Basin. On the other hand, in May and August, the precipitation rate (mm) exceeds by far the actual ET.

In all the winter months, precipitation is higher than the actual ET, except in March, where there is a sort of equilibrium, but the picture clearly differs per River Basin.

Actual external Inflow and Actual Outflow

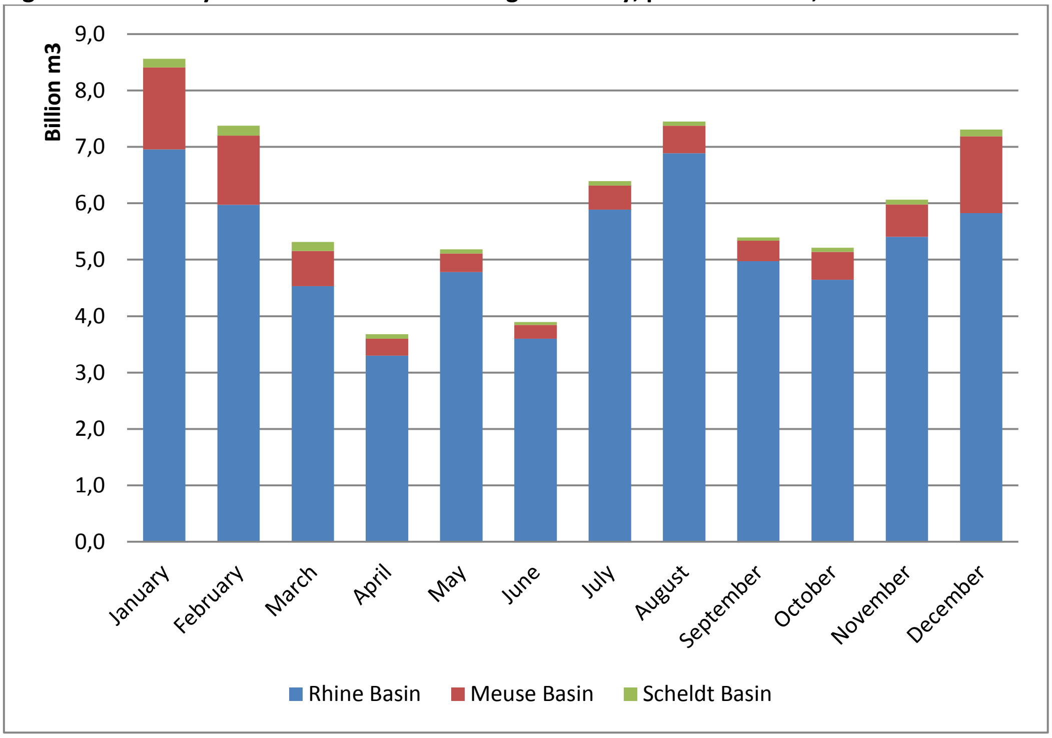
Figure 4.7 shows the total daily inflow volumes for the Netherlands and the River Basins. Figure 4.8 shows the aggregated monthly volumes with a breakdown into River Basin. The two figures show that there is a major difference in flow pattern between the Rhine Basin inflow and Meuse Basin inflow. A big part of the inflow is determined by the river Rhine, which is fed by glaciers and rainwater from the upstream part of the Rhine basin abroad. The Meuse River is primarily rain fed. The inflow from Belgium via the river Scheldt into the Dutch part of the Scheldt basin is not accounted for, since this flow enters the country in the Westerschelde Estuary, which is already a tidal area with brackish and marine water and directly connected to the North Sea. The only inflow into the Scheldt Basin that is accounted for is the inflow via the Kanaal Gent-Terneuzen, but that is just a minor volume. For the River Basin Ems there is no inflow from abroad.

Figure 4.7 Daily actual external inflow from foreign territory, total and per River Basin, 2014



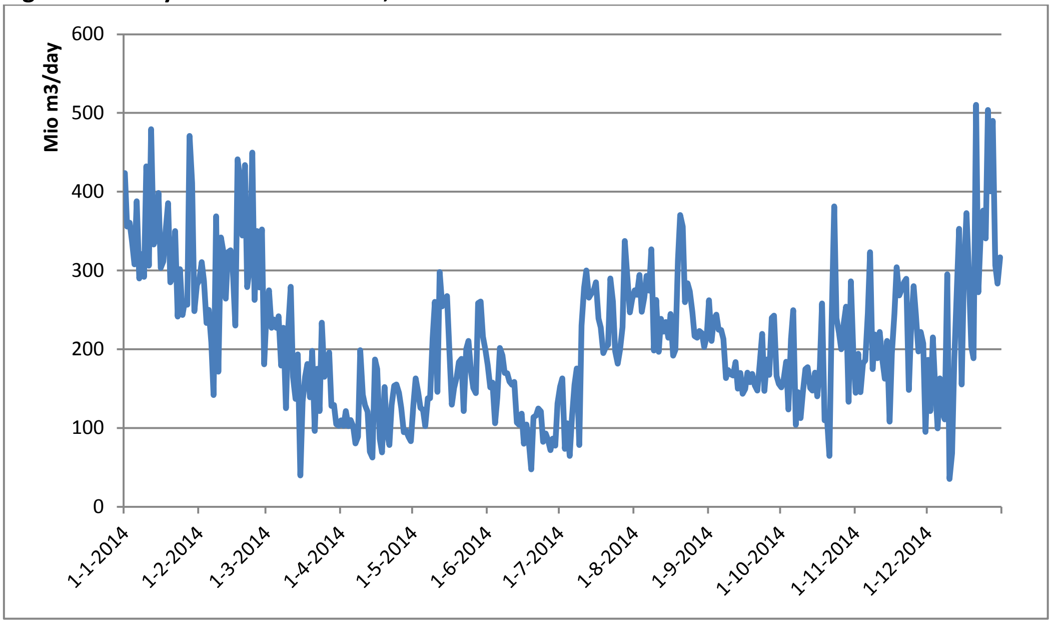
Source: Statistics Netherlands

Figure 4.8 Monthly external inflow from foreign territory, per River Basin, 2014



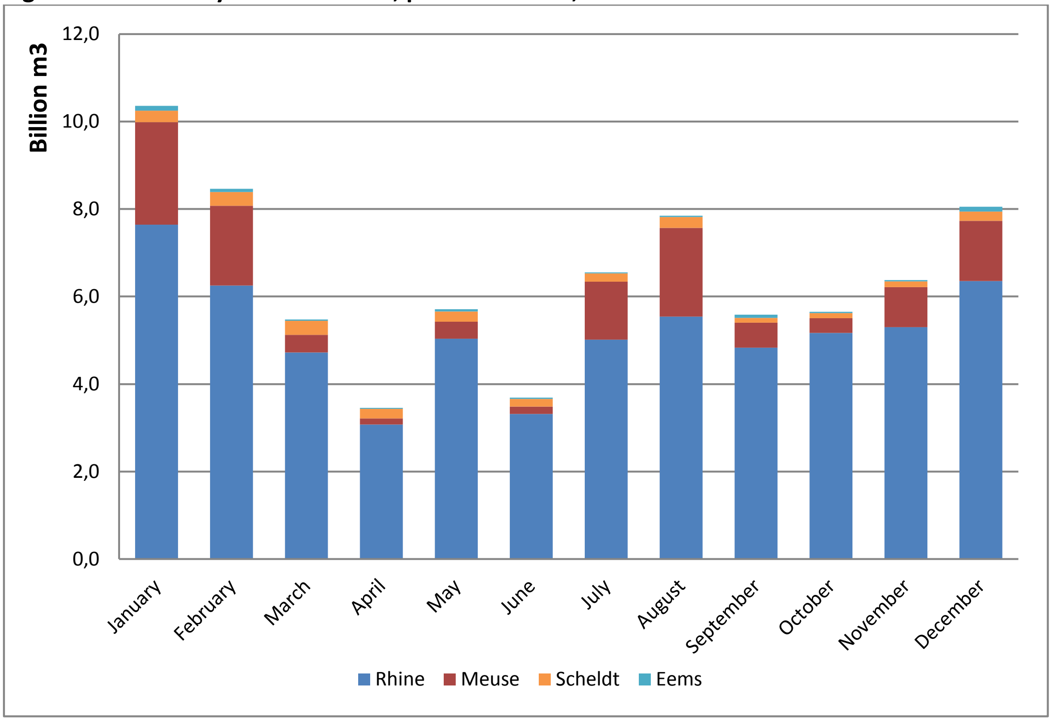
In figure 4.9 the daily outflow volumes for the country are plotted. It is the sum of 65 riverine flows, controlled outlets and polder effluents entering the North Sea and estuarine waters like the Wadden Sea, Westerschelde and Oosterschelde. Figure 4.10 shows the monthly aggregates of actual outflow, per River Basin.

Figure 4.9 Daily outflow to the sea, 2014.



Source: Statistics Netherlands

Figure 4.10 Monthly outflow to sea, per River Basin, 2014



Source: Statistics Netherlands

In table 4.3, the total volumes of inflow and outflow are given for the country and per River Basin, as a yearly total and per season.

Table 4.3 Total external inflow and outflow volumes to sea, 2014

	Actual Inflow			Actual External Outflow		
	Year	Summer	Winter	Year	Summer	Winter
	mio m^3					
The Netherlands	71,835	31,995	39,840	77,225	32,842	44,382
Per River Basin:						
Meuse	7,874	2,143	5,731	11,827	4,615	7,213
Ems	0	0	0	618	230	388
Rhine	62,770	29,438	33,332	62,271	26,829	35,441
Scheldt	1,192	414	777	2,509	1,169	1,340

Source: Statistics Netherlands, this report.

4.3.2 Synthesis of total Water Balance

Table 4.4 represents the water balance according to table 1 of the OECD/Eurostat Joint Questionnaire Inland Waters (JQ-IW). The internal flow is calculated as precipitation less the actual ET. The total renewable freshwater resources are calculated as the sum of the internal flow, generated at the territory and the total external inflow from foreign territory. The (maximum) recharge into the aquifer is calculated straightforward as the result from the available Total renewable freshwater resources minus the total outflow.

As already was concluded in Paragraph 4.3.1, a remarkable result of the Dutch water balance for 2014 is that total precipitation in the summer season (April-September) is higher than in the winter season. This is also illustrated in figure 4.1 and the tables 4.1 and 4.2. Especially in the months of May, July and August, rainfall was high compared to rainfall in the winter months. See also chapter 5.5.1 for a more in-depth analysis of the weather conditions in 2014.

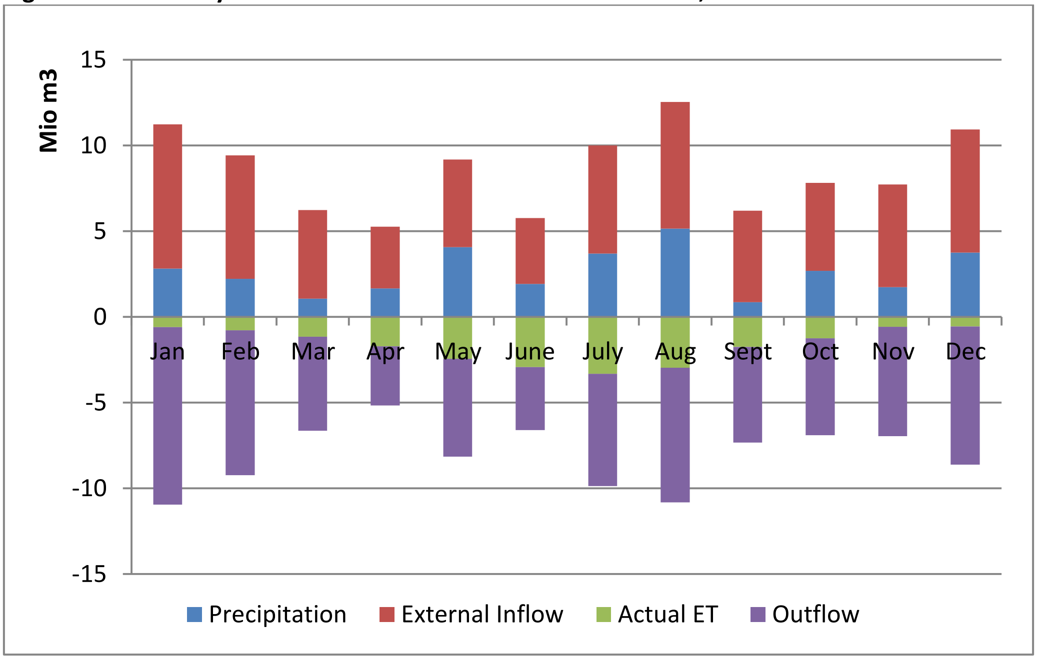
Table 4.4 Water balance (JQ-IW table 1) for the Netherlands, 2014

	Year	Summer	Winter
	mio m^3		
Precipitation (a)	31,675	17,366	14,309
Actual evapotranspiration (b)	20,026	15,103	4,923
Internal Flow (c) = (a)-(b)	11,649	2,263	9,386
External inflow, total (d)	72,343	32,249	40,094
of fresh surface water	71,835	31,995	39,840
of groundwater [1)]	508	254	254
Total renewable freshwater resources (e)=(c)+(d)	83,992	34,513	49,479
Total actual outflow to sea (f)	77,225	32,842	44,382
Recharge into the Aquifer (maximum) (e)-(f)	6,767	1,670	5,097

[1)] Source: Deltares (see: Graveland, Baas, et al, 2016). Seasonal data not available; divided on 50/50 basis.

Figure 4.11 shows the monthly data of the 4 main elements: Precipitation plus Fresh surface water from External Inflow versus Actual ET plus Outflow. This figure shows that in most of the months (except for March, June and September) the incoming flows of (renewable) freshwater via precipitation and external inflow into the country is larger than -or almost equal to- the outgoing flows. Over the year there thus is a (small) net inflow, even without accounting for the relatively small underground flows of (ground-)water. This also suggests there is net recharge of the existing stocks of fresh water in the country, either ground, surface, and/or soil water.

Figure 4.11 Monthly balance of the four main freshwater flows, 2014



Water Balances per River Basin

In principle, most data for compilation of River Basin water balances were available while compiling the report for this study, except for the flows between the River Basins. These will be calculated in a later stage. Already source data for these flows are available but it was not possible to process and evaluate this flow data. Especially the interactions between Rhine, Meuse and Scheldt are very complex and need thorough analysis. Nevertheless we present here the water balances of the four River Basins. See tables 4.5 to 4.8 for the data of Meuse, Ems, Rhine and Scheldt, respectively.

Table 4.5 Draft basic water balance for Meuse River Basin, 2014

	Year	Summer	Winter
	mio m^3		
Precipitation (a)	6,269	3,701	2,569
Actual evapotranspiration (b)	4,046	3,127	919
Internal Flow (c) = (a)-(b)	2,224	573	1,650
External inflow, total (d)	7,874	2,143	5,731
of surface water from abroad	7,874	2,143	5,731
of surface water from other River Basin[1)]	1)	1)	1)
of groundwater	p.m.	p.m.	p.m.
Total renewable freshwater resources (e)=(c)+(d)	10,097	2,716	7,381
Total actual outflow to sea (f)	11,827	4,615	7,213

1) Under construction.

Table 4.6 Draft basic water balance for Ems River Basin, 2014

	Year	Summer	Winter
	mio m^3		
Precipitation (a)	1,905	1,051	855
Actual evapotranspiration (b)	1,199	969	230
Internal Flow (c) = (a)-(b)	707	82	625
External inflow, total (d)	0	0	0
of surface water from abroad	0	0	0
of surface water from other River Basin[1)]	1)	1)	1)
of groundwater	p.m.	p.m.	p.m.
Total renewable freshwater resources (e)=(c)+(d)	707	82	625
Total actual outflow to sea (f)	618	230	388

[1)] Under construction.

Table 4.7 Draft basic water balance for Rhine River Basin, 2014

	Year	Summer	Winter
	mio m^3		
Precipitation (a)	21,785	11,777	10,007
Actual evapotranspiration (b)	13,686	10,180	3,506
Internal Flow (c) = (a)-(b)	8,099	1,598	6,501
External inflow, total (d)	62,770	29,438	33,332
of surface water from abroad	62,770	29,438	33,332
of surface water from other River Basin[1)]	1)	1)	1)
of groundwater	p.m.	p.m.	p.m.
Total renewable freshwater resources (e)=(c)+(d)	70,869	31,036	39,833
Total actual outflow to sea (f)	62,271	26,829	35,441

[1)] Under construction.

Table 4.8 Draft basic water balance for Rhine River Basin, 2014

	Year	Summer	Winter
	mio m^3		
Precipitation (a)	1,716	838	878
Actual evapotranspiration (b)	1,096	828	268
Internal Flow (c) = (a)-(b)	620	10	610
External inflow, total (d)	1,192	414	777
of surface water from abroad	1,192	414	777
of surface water from other River Basin[1)]	1)	1)	1)
of groundwater	p.m.	p.m.	p.m.
Total renewable freshwater resources (e)=(c)+(d)	1,811	425	1,387
Total actual outflow to sea (f)	2,509	1,169	1,340

[1)] Under construction.

4.3.3 Results of the simplified Water Asset Account

In table 4.9 the results of the simplified National Water Asset Account are given for reporting year 2014. The table distinguishes in the water types: fresh surface water, ground water as well as soil water.

The stocks of water as presented in table 4.9 are average values of the estimates of (the ranges of) stocks that were compiled in a previous study (Graveland and Baas, 2012). As explained earlier, the opening and closing stock don’t have a large dynamic in the Netherlands, since most of the water levels in the surface water bodies are controlled by sluices, dams and pumps. Opening stocks therefore are assumed to be equal to the respective closing stocks.

Table 4.9 Simplified water asset account, the Netherlands, 2014

Mio m^3	Fresh surface water	Ground water	Soil water	Total
1. Opening Stocks [1)]	11,300	950,000	27,500	988,800
Increases in stocks, total	85,211	7,275	29,274	121,759
2. Returns	10,907		67	10,974
3. Precipitation [2)]	2,469		29,206	31,675
4. Inflows	71,835	7,275	0	79,110
4.a. from upstream territories	71,835	508		72,343
4.b. from other resources in the territory [3)]	0	6,767	0	6,767
Decreases in stocks, total	94,974	1,019	17,515	113,509
5. Abstraction [4)]	8,471	1,019	15,205	24,695
6. Evaporation/Actual evapotranspiration [5)]	2,512		2,310	4,822
7. Outflows	83,992	0	0	83,992
7.a. to downstream territories	0	0		0
7.b. to the sea	77,225	0		77,225
7.c. to other resources in the territory[3)]	6,767	0	0	6,767
8. Other changes in volume	9,763	-6,256	-11,759	-8,251
9. Closing Stocks [1)]	11,300	950,000	27,500	988,800

Note: Grey cells indicate non relevant or zero entries by definition

[1)] Average values of the earlier assessed range of the stocks are applied. Source: Graveland and Baas (2012).

[2)] Based upon surfaces of surface water versus land.

[3)] Flow from groundwater to soil water and vice versa could not be quantified. Seepage, flow from groundwater to surface water is netted out with infiltration.

[4)] Abstraction from soil water here is equal to ET solely from agricultural land.

[5)] Based upon surfaces of surface water versus area non-agricultural land.

In the water asset account shown in Table 4.9, the total actual ET, as determined from the eLEAF data, has been split up in 3 separate items. On basis of the overlay of the map with actual ET rates with the land use map (see Chapter 5 for more detail) it was possible to determine the volumes of actual ET from agricultural and recreational areas. In fact, this is water extracted from the upper part of the soil (soil water) before it is either used by the crops and other vegetation and subsequently transpired to the atmosphere or directly evaporated from that surface to the atmosphere. This amount of soil water is included in the water asset account in the row ‘Abstraction’, under ‘Soil water’. This workaround is also used in the PSUT, where the use of soil water by agriculture is estimated as the actual ET from areas with agriculture. The second item is evaporation from fresh surface waters (2,512 mio m^3) and the remaining actual ET from other surfaces (2,310 mio m^3) not being agriculture or recreation.

The exchanges between groundwater and surface water, via seepage and infiltration have been netted out in the table. The net amount of exchanged water is represented here as the maximum recharge of the aquifer, calculated as the total renewable freshwater resources less the outflow to the sea (see also table 4.4). This volume equals 6,767 mio m^3, which is accounted as a decrease of surface water (from) and an increase of groundwater (to).

Since there are no clear annual updates available for the opening and closing stocks of each water type, a separate row item called ‘Other changes in volume’ has been added in which the balancing volumes are given. A balancing item was needed anyway, that show the difference between ‘Decreases in stock, total’ and ‘Increases in stock, total’ for each distinct water type and combined. A negative value means that there is a surplus of this water type that is transferred to other water types, for instance from surface water to groundwater or from soil water to ground water. The final result is that there is a balancing volume of 8,251 mio m^3 of freshwater for the country overall. This shows that for 2014 there is net addition to the combined stocks of fresh water (bodies) in the country. This may imply a positive finding for this particular year, although a preliminary finding as not all table items has been assessed with full accuracy.

The table illustrates again that the Netherlands is lying in the delta of 3 major rivers: the enormous inflow of fresh surface water from upstream territories compares to more than 6 times of the stock of surface water.

5. Analysis of data on Actual Evapotranspiration

5.1 Introduction

The Actual Evapotranspiration (ET) provides, in contrast to potential ET or (crop) reference ET, a more realistic (actual) level of ET, depending on the actual situation on the ground. This particularly is relevant in situations with lasting dry conditions. While potential and reference ET show the figures at the higher level of possible ET, under suggested ideal situation on site of constantly sufficient provision of water by from the soil, without shortages.

In an earlier study (Graveland & Baas, 2012), Statistics Netherlands already made an attempt to use data on Actual Evapotranspiration. In that study, we obtained ET data from WaterWatch, a company with experience in the calculation of actual ET on basis of remote sensing. See: WaterWatch (2011) for a description of the methods applied. WaterWatch compiled actual ET data for the year 2009, a relatively dry year. The study clearly confirmed that the national water balance is strongly influenced by which ET value one uses. The actual ET value in 2009 was much lower than the potential ET or crop reference ET, which resulted in a 60 % higher value for the internal flow and a 13% higher value for Total renewable water resources.

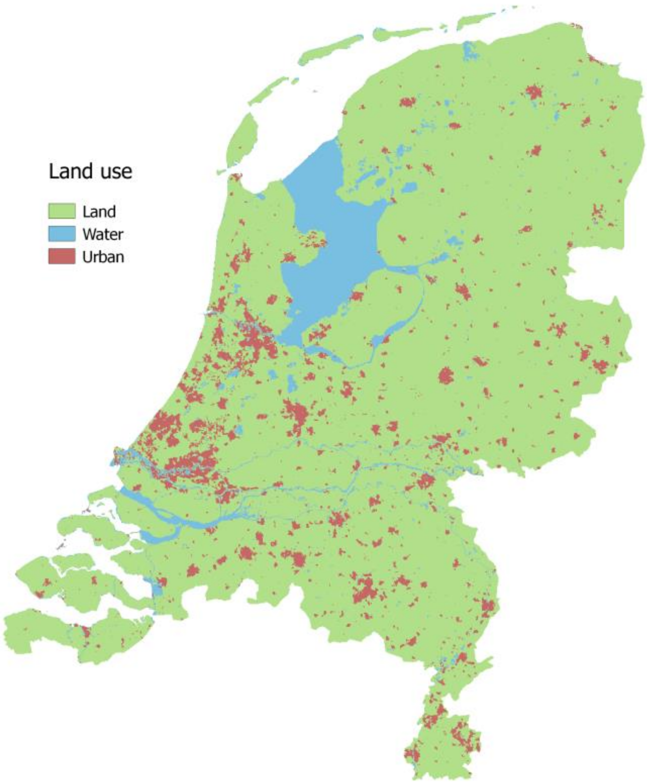
In the current study, Statistics Netherlands again used ET data calculated on basis of remote sensing data. These were obtained from eLEAF, the successor company of Waterwatch and methods and results described (eLEAF; 2016). The difference with the first dataset (used in Graveland & Baas; 2012) was that data were delivered in a spatially explicit manner in GeoTIFF format as per grid cell of 250*250 meters, for actual ET, Precipitation as for the Reference (or potential) ET. This allowed further in-depth analysis of the data in combination or overlay with land use data and River Basins. Also, we received monthly datasets whereas in the first study only seasonal (summer versus winter) data were obtained.

Paragraph 5.2 provides a concise description of the data obtained from eLEAF, and the way this data was processed by Statistics Netherlands, including the overlay with the River Basins map in a shape file and a map on land use. Spatial and temporal results of Precipitation, Reference ET and actual ET for 2014 are given in paragraph 5.3. In Paragraph 5.4, the results of the overlay with the Land Use map are given. In paragraph 5.5 we make a comparison between the data of 2009 and 2014. Finally, in paragraph 5.6 some final conclusions and recommendations are formulated.

5.2 Description of data and GIS analysis

Monthly aggregated data on mm actual ET, mm Reference ET and mm Precipitation were supplied by eLEAF. The dataset contained 36 (3 x 12) files in geoTIFF format, covering the whole land surface as well as the surface of the fresh water bodies, in total nearly 600,000 pixels of 250 by 250 m. Each pixel was already classified by eLEAF as i) Surface water ii) Urban area or iii) Land (not urban) on basis of a land cover map and was also already attributed to a River Basin district. Total Dutch territorial area covered by the pixels is 37,165 km^2. Figure 5.1 shows the land use map that was used by eLEAF.

Figure 5.1 Land use map used in dataset of eLEAF



The monthly GeoTiff files were imported in ArcGIS 10.2.2 for further processing and compiling the maps. Also, the gridded data were aggregated to the River Basins and Land cover category and exported to an Access database in which data were converted from mm to volumes (m^3), using the pixel area of 6.25 ha. The resulting data were exported to Excel for further analysis and compiling graphs, indicators and seasonal data (summer versus winter season).
The ArcGIS system was used to compile different maps showing actual ET, Precipitation, and Precipitation deficit, for the summer season and the winter season. The major spatial and temporal results are given in paragraph 5.3.

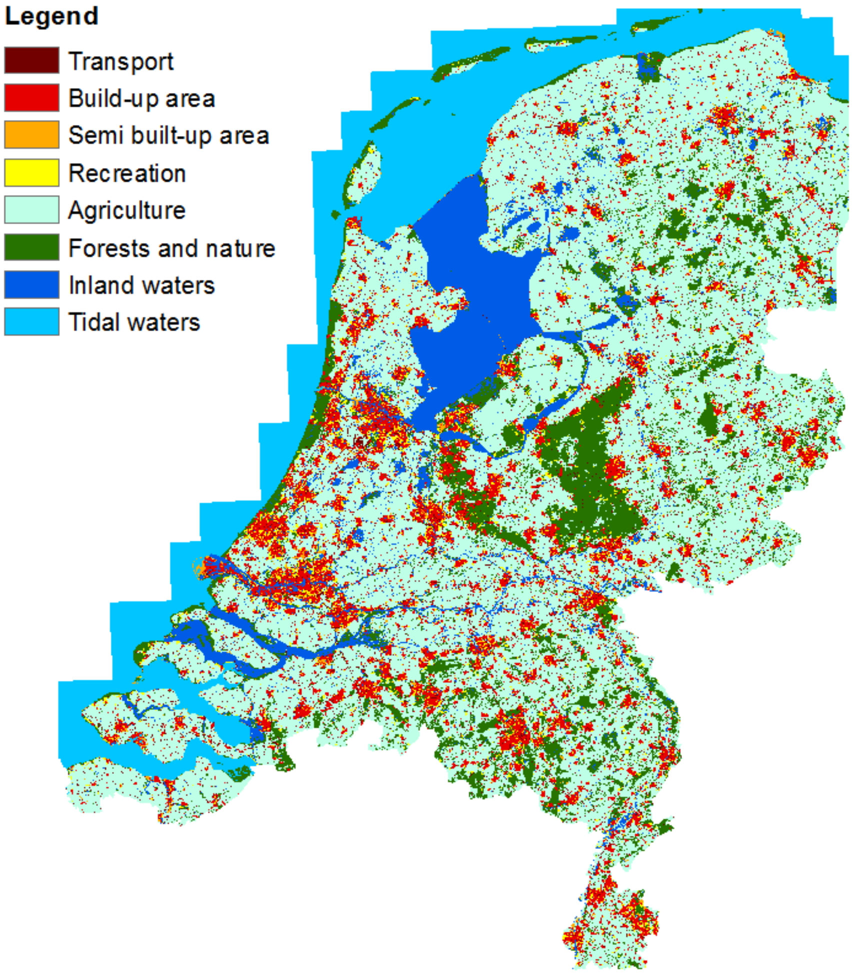
For further analysis on the relation between land use and ET, an overlay was made with a gridded map of the Land Use in the Netherlands (Bestand BodemGebruik BBG (Statistics Netherlands (CBS) (2016i). Because of the limitations in the data processing capacity with ArcGIS, the detailed categories of the BBG map were aggregated to 8 categories. Also, the monthly data on actual ET and Precipitation had to be aggregated to seasonal data. See table 5.1 for the list of BBG categories. Figure 5.2 shows the map of the Netherlands with the distinguished BBG categories. The results of data-processing are given in paragraph 5.4.

Table 5.1 Aggregated categories on Land Use for overlaying with ET data map

BBG category-code	Description	Includes:
1	Transport	Main roads, railways, airfields, airports
2	Built-up area	Areas with houses, offices, factories
3	Semi built-up area	Graveyards, waste disposal sites, construction sites etc.
4	Recreational areas	Parks, lawns, public gardens, sporting fields, recreational parks; camping-sites

5	Agriculture	Pastures, fields, greenhouses
6	Forests and nature	Forests, dry natural area, wetlands
7	Inland waters	Inland surface waters, fresh and partly brackish
8	Tidal waters	Marine and estuarine waters

Figure 5.2 Gridded map of aggregated land use categories according to BBG

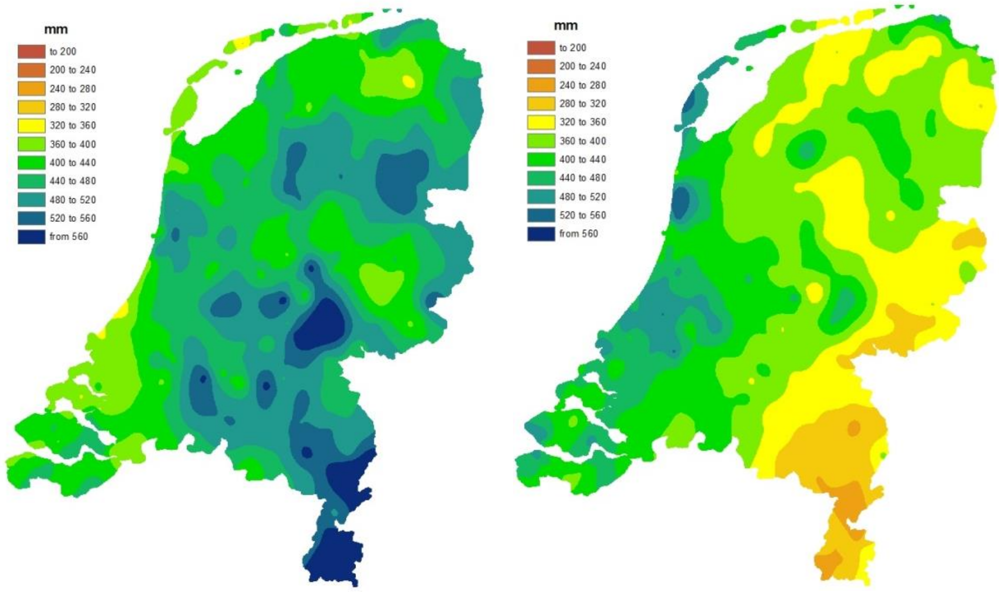


Source: BBG, Bestand Bodemgebruik 2012 (Land Use file, reporting year 2012); Statistics Netherlands (CBS) (2016i).

5.3 Spatial and temporal results of actual ET and Precipitation

In this paragraph results are given of the 2014 data on actual Evapotranspiration (actual ET) as well as precipitation. Figure 5.3 shows the spatial results of the precipitation for summer and winter season. Again, these figures show that in general precipitation in the summer (April-September) was higher than in winter, especially in the centre and in the south of the Netherlands.

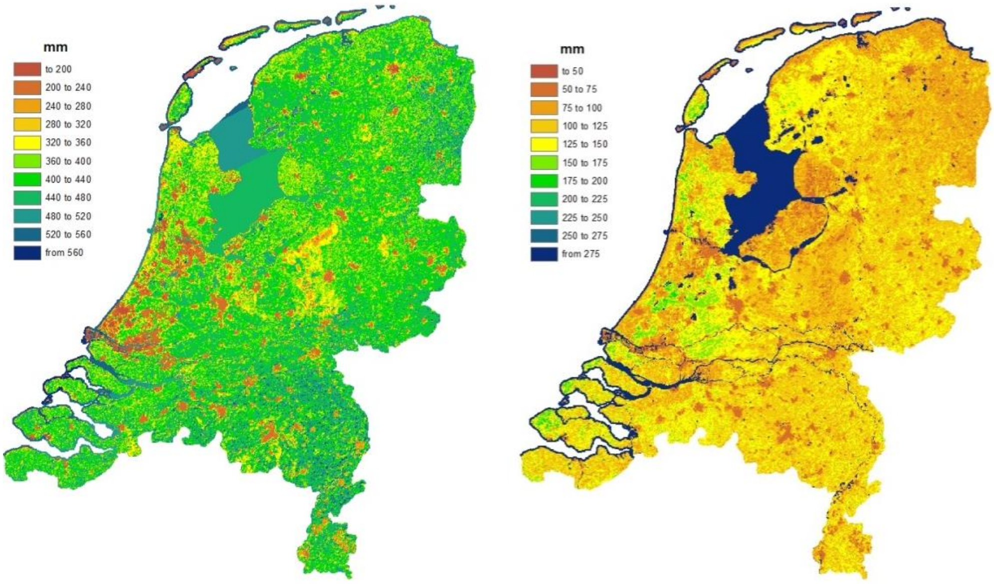
Figure 5.3 Precipitation, summer (left) 2014 and winter (right) 2014



Source: eLEAF, adapted by Statistics Netherlands.

Figure 5.4 shows the spatial results of actual ET for both the summer season as the winter season. In summer, many 250 by 250 m pixels on the land surface show a higher actual ET rate than pixels situated at open inland water surfaces, like the main lake IJsselmeer. That is (partly) explained by the existence of vegetation that has several layers of leaves from which the transpiration can sum up to high values, thus even exceeding the evaporation rate (mm) from open water surfaces.

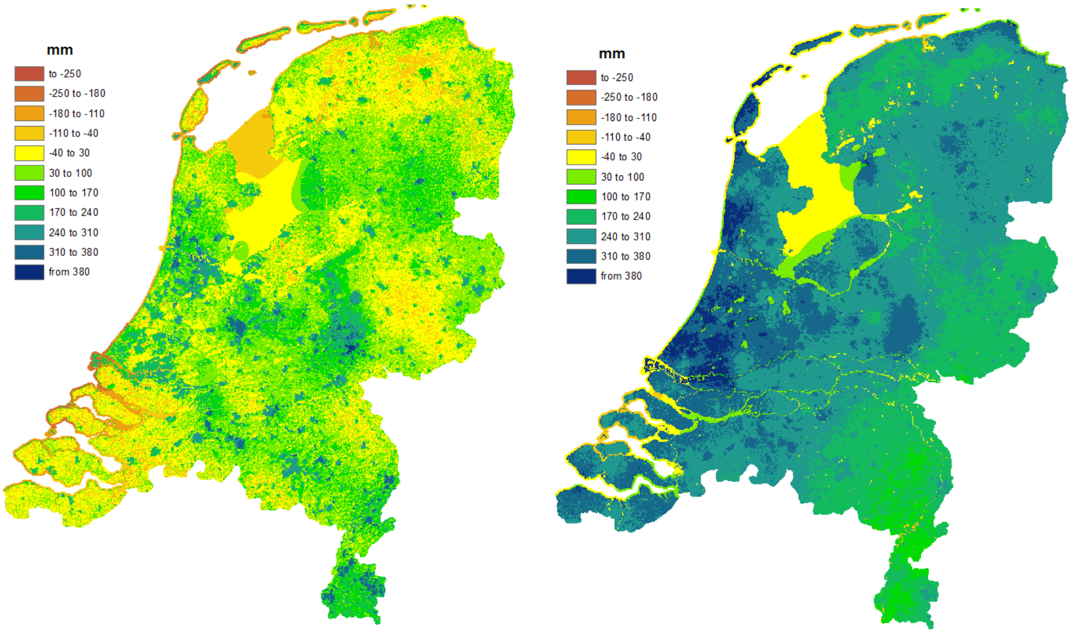
Figure 5.4 Actual Evapotranspiration rates, summer (left) 2014 and winter (right), 2014*)



*) Note the scale of the legend differs between summer and winter.
Source: eLEAF, adapted by Statistics Netherlands.

Figure 5.5 shows the seasonal precipitation surplus, calculated as precipitation rate minus the actual ET rate (mm). During the summer season, in many pixels the rate of the precipitation surplus is in the category between minus 40 to 30 mm and between 30 to 100 mm. In areas with high precipitation (compare with figure 5.3), the surplus can reach rates of 240 mm or higher. In the South-West of the Netherlands, mostly the Scheldt Basin, the rate of the precipitation surplus is the lowest, as already was shown in table 4.1.
The map on precipitation surplus in the winter season shows that for open water areas, like for the IJsselmeer in the centre of the country, the surplus is much smaller than in land and urban areas. That is caused by a higher actual ET rate by evaporation, as is also shown in the map on winter actual ET in figure 5.4.

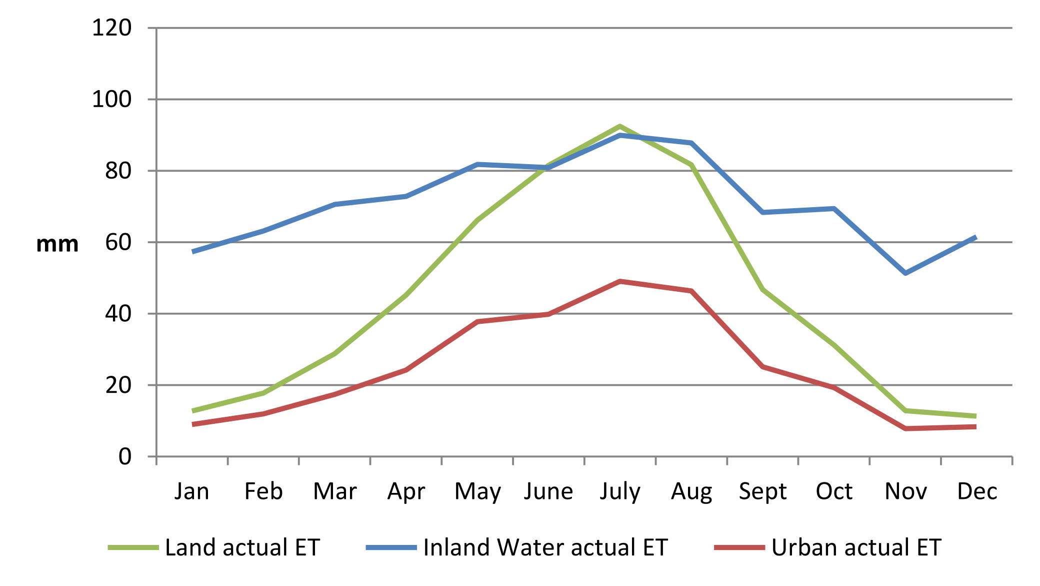
Figure 5.5 Rates of Precipitation surplus, summer (left) 2014 and winter (right), 2014



Source: eLEAF, adapted by Statistics Netherlands.

Figure 5.6 shows the monthly actual ET rates for the three main types of land use that eLEAF distinguish in their results. As expected, the actual ET rate in urban areas is in all months lower than actual ET from Inland Water and Land. In urban areas, often evaporation from paved surface is the main mechanism, which is limited due to quick run-off of the water from precipitation, while area covered by and transpiration from vegetation is low. This phenomenon also limits cooling options by vegetation in urban areas. For open water it holds that only evaporation occurs, while this is not hampered by a low availability of water, so even in the winter months evaporation is still high compared to ET from land surfaces. For land areas, the actual ET is often a combination of evaporation and the transpiration by (multiple) layers of vegetation, resulting in a larger difference between the summer season, when transpiration increases, and the winter season. In June and July the actual ET from land surface is somewhat higher than the evaporation from open water surfaces. This is due to the strong transpiration of multiple layers of vegetation, especially in situations when there is regular and sufficient precipitation and thus sufficient replenishment of the soil water in the upper layers.

Figure 5.6 Monthly Actual ET rate (mm) per main type of land use, 2014



5.4 GIS-overlay with Land Use data

As outlined in paragraph, an overlay of the seasonal aggregates of Precipitation and Actual ET rates (mm) with 7 types of land use was made in the GIS system. Due to limitations in data processing capacity with the installed GIS package, this could only be done per season (summer and winter) and not per month. In table 5.2 the seasonal results for ET rates of the BBG land use overlay are compared with the original ET rates in the eLEAF data, where 3 main categories of land use were distinguished. Also, the total share in total surface area is provided per category.

Table 5.2 Average actual ET rate (mm) and shares per land use category from BBG overlay and eLEAF data, 2014

	actual ET			% of total area
	Year	Summer	Winter	
	mm			
Land use category according to BBG				
Transport	495.2	383.4	111.8	3.1%
Built-up area	391.5	301.3	90.2	9.5%
Semi built-up area	480.2	360.4	119.8	1.4%
Recreational areas	473.2	362.0	111.2	2.8%
Agriculture	541.1	422.3	118.8	60.4%
Forests and nature	510.2	397.1	113.0	13.1%
Inland waters	765.5	454.2	311.3	9.7%
Land use category in eLEAF data				
Urban	296.4	222.5	73.9	6.6%
Land (excl. Urban)	528.5	413.7	114.8	85.5%
Inland waters	854.8	481.6	373.2	7.9%

Originally, the land use map was made up of polygons. In order to make the overlay with the gridded actual ET data, the polygons were gridded to 250 m by 250 m pixels, on basis of the dominant land use category in each pixel. This caused that in many pixels the combination of actual ET value and land use category was not 100% accurate in the sense that differences in actual ET between the land use categories were flattened out by the gridding.

From table 5.2, indeed the conclusion can be drawn that the overlay with the BBG grid leads to different results compared to the original land use categories present in the data of eLEAF.
Nevertheless, the data show that the actual ET rate (mm) differs per land use category, although differences were expected to be larger. One can recognize similarities between the two datasets, like the observation that actual ET from water surfaces is generally higher than from land surface. Also, urban or built-up areas have the lowest actual ET rates, since this is often predominantly explained by evaporation from wet surfaces like from roofs, streets and pavements. For non-urban areas it becomes visible that Agricultural land has the highest actual ET rate, followed by Forest land and Nature. This is what could be expected. Except for the actual ET from Inland Waters and urban (built-up) area, it is also visible that in the winter period there is no large difference in actual ET between the other land use categories.

5.5 Comparison between 2009 data and 2014 data

As explained, in an earlier study (Graveland & Baas, 2012) we also obtained data on actual ET determined by remote sensing. These data were compiled for the calendar year 2009. In this chapter we try to make a comparison of the data on actual ET and precipitation between 2009 and 2014, and try to explain differences on basis of the weather situation.
For 2009, we only have seasonal data for actual ET. This limits opportunity to make a good and complete comparison between those two years 2009 and 2014.

Below are graphs and tables with 2009 and 2014 weather data, as well as Long Term Averages, based on the time-series of 1981 to 2010. Figure 5.7 provides the monthly averages of temperature. Figure 5.8 gives the monthly precipitation rates in mm. Table 5.3 provides the yearly and seasonal (summer and winter) rates for all relevant parameters.

Figure 5.7 Monthly average temperatures for 2009, 2014 and the LTA

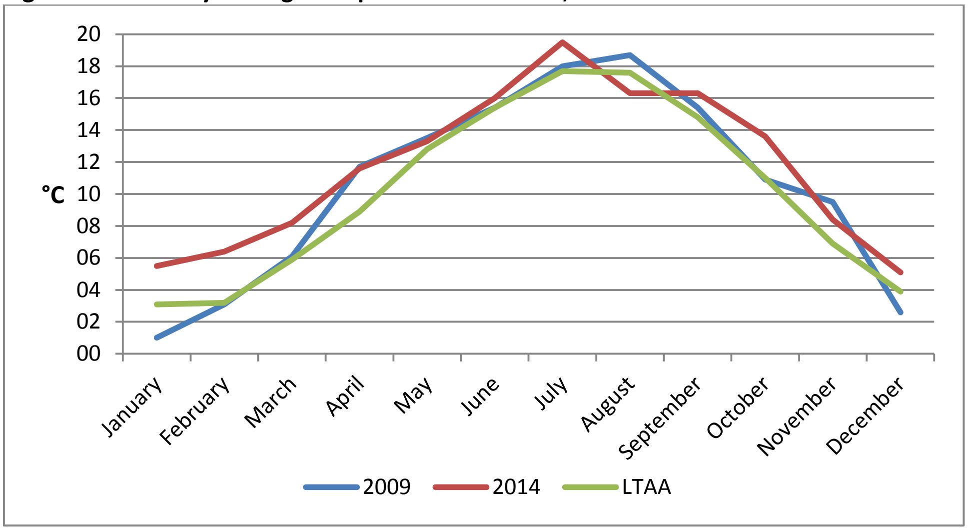


Figure 5.8 Monthly precipitation rates for 2009, 2014 and LTA

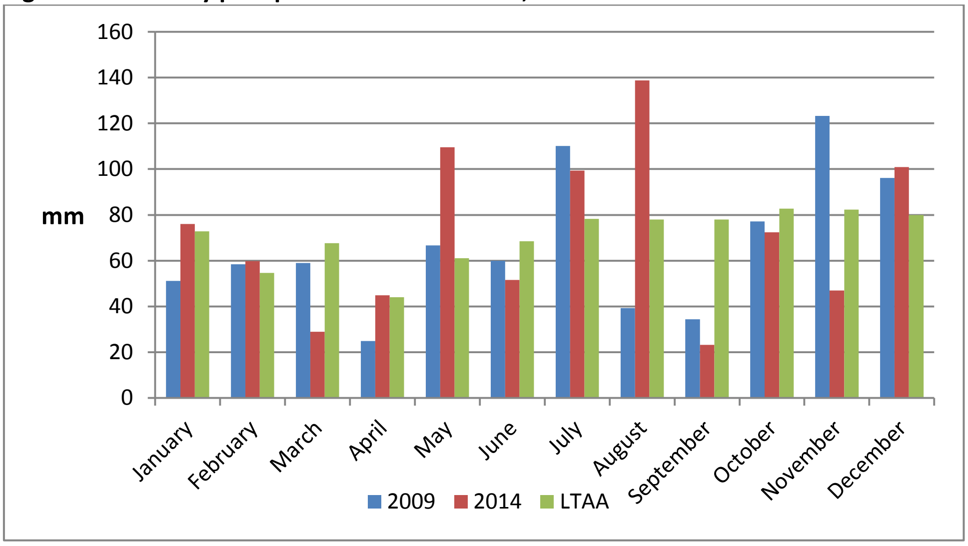


Table 5.3 Annual and seasonal weather data, 2009, 2014 and LTA

	2009	2014	LTA
Temperature	°C		
Annual average	10.5	11.7	10.1
Summer	15.5	15.5	14.5
Winter	5.5	7.9	5.7
Precipitation rate	mm		
Annual sum	800.2	852.4	847.8
Summer	335.2	467.3	407.7
Winter	465.0	385.0	440.1
Actual ET rate	mm		
Annual sum	458.0	538.9	
Summer	383.0	406.4	
Winter	75.0	132.5	
Reference crop ET rate	mm		
Annual sum	622.9	666.4	579.6
Summer	522.4	509.7	475.1
Winter	100.5	156.8	104.5
Precipitation surplus	mm		
Annual average	342.2	313.5	
Summer	-47.8	60.9	
Winter	390.0	252.6	

Sources: www.knmi.nl,, eLEAF (2016), WaterWatch (2012)

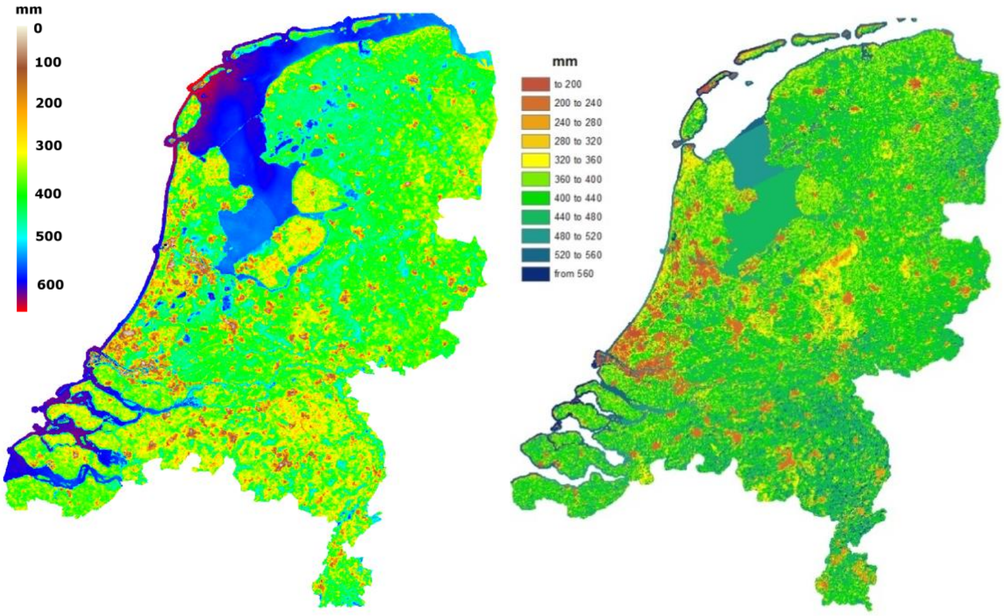
Based on the weather data in table 5.3 and the figures 5.7 and 5.8 the following picture can be drawn:

- Except for August, the monthly average temperatures in 2014 were higher than the monthly Long-Term Average. 2014 overall was a warm year, especially the winter months. These higher temperatures in the winter months resulted in higher Actual ET compared to 2009 and higher than the regular Reference Crop (potential) ET;

- The 2009 summer was relatively warm and dry, especially August. In particular during the period January-March and the month of December the temperatures were lower than normal;
- The summer season of 2014 was relatively wet. Only in September the precipitation rate was much lower than average. On the contrary, total precipitation in the winter months was lower than normal. Cumulative precipitation over the Summer period was higher than in the Winter months;
- In 2009, precipitation rates in the months of January, April, August and September were low. In the Summer period (April-September) therefore the precipitation aggregate was lower than the Actual ET, causing an overall precipitation deficit. In summer, thus provision from the soil water was needed for the Actual ET and crop growth to continue. Since only seasonal ET data are available for 2009 and not monthly ET, we cannot indicate in which months this mechanism is the strongest, but from the monthly temperature and precipitation data it can be predicted that the deficit occurred particularly in April, August and September;
- In the winter season of 2014 higher temperatures resulted in a higher Actual ET rate compared to 2009 as well as a higher than normal Reference Crop (potential) ET.

Figure 5.9 shows the spatial division of cumulative actual ET rates (mm) per grid cell of 250 by 250 m for the summer season of 2009 and 2014. The map of 2009 was prepared by Waterwatch, the 2014 map was compiled by Statistics Netherlands on basis of the data from eLEAF. We tried to make the colours of the categories of ET rates similar as far possible, to facilitate the comparison.

Figure 5.9 Spatial division of actual ET (mm) in summer 2009[1)] (left) and summer 2014[2)] (right)



[1)] Source: Waterwatch (2012).
[2)] Source: eLEAF, adapted by Statistics Netherlands.

In general it appears that in the summer of 2009 the actual ET from land surface was significantly lower than in 2014. Since the average temperature in both years was the same (15.5 degrees Celsius), the differences in actual ET rates from land surface are explained mainly

by the large difference in precipitation, 2009 being relatively dry and 2014 relatively wet. Availability of soilmoisture in 2009 was much lower than in 2014.
In 2009 the evaporation from open water was somewhat higher in 2014.

5.6 Conclusions and remaining issues

Conclusions

1. In this project we managed to set up and develop a system for the processing of GIS-based monthly data on actual ET, Precipitation and Reference (crop) ET. Spatial explicit source data were delivered by eLEAF, a third party that processes remote sensing data to water relevant data;
2. By making overlays with a map of the River Basins, we could process the provided data on actual ET and Precipitation rates needed for compilation of the regional water balances per River Basin as well as the national water balance and the SEEA-type of national water asset account of water;
3. The data that was delivered by eLEAF already included a first distinction in three main types of land use. In addition we managed to make an overlay with a more distinct map with 7 main categories of land use, according to the Land Use map of Statistics Netherlands (in Dutch: BBG). Originally, this map was made up of Polygons and was gridded to the same grid-size of the provided water source data, namely 250 by 250 m. The conclusion can be drawn that the overlay with the BBG grid leads to different results compared to the original land use categories present in the source data of eLEAF. Nevertheless, the data show that the actual ET rate (in mm) differs among land use categories, although differences were expected to be larger;
4. By comparing meteorological data of 2009 and 2014, the differences in the level of the actual ET as well as the seasonal variation could be explained well. Due to lower precipitation rate in summer, the actual ET rate for 2009 was significantly lower than in 2014. In 2014 precipitation in summer was even higher than in winter; in 2009 this was the other way around. Also in the winter months of 2014 the average temperature was higher than normal, resulting in higher actual ET rates and volumes. A more thorough comparison however was hampered due to the fact that for 2009 only seasonal and not monthly data for actual ET were available;
5. As the data on 2014 is both spatial explicit and available on a monthly basis, this allows to further identify water provisioning aspects and for example water stress situations on particular locations and regions in the country as well for particular periods throughout the year.

Remaining issues

6. Due to the fact that the processing of the GIS type of data took more time and consumed more resources than planned, it was not possible to elaborate on the calculation and use of coefficients in order to make rough estimates of actual ET rates and volumes and a functional procedure for other years, based upon inputs of weather data. This is an issue that needs further attention and could be worked out as a follow-up of this project, within the on-going work on the water accounts and water statistics;
7. The current dataset from eLEAF can even be processed more thoroughly by use of heavier hardware processing capacity. For instance the overlay with the land use map could only be done for 8 main categories of land use, being the maximum limit. The wish here is to distinguish more categories, especially with more detail and extra subdivisions in the

agricultural land use. Also a double overlay of land use together with River basins can facilitate to obtain more detail and desired breakdowns in regional data.

6. Conclusions and Recommendations

In this study and reporting we tried to benefit from previous work and develop further in the direction of a comprehensive system of physical water statistics and Physical water flow accounts, including on Water balance / Asset Accounts at the preferred aggregates and according the international formats provided by Eurostat (JQ-IW) and UNSD (IRWS & SEEA-Water). Referring to the grant application a number of general conclusions can be drawn and recommendations made.

6.1 General conclusions

The following conclusions were drawn:

1. In this Eurostat Grant study and on the first aim of the project, we succeeded to compile a full set of Physical Supply and Use tables for water flows (PWFA) for 2014. The result shows overview tables with abstraction of water from the environment, from surface water, groundwater and soil water, distribution of water among economic entities and return flows from the economy to the environment. These flows are determined at detailed industry (NACE Rev2 / ISIC Rev 4) level, this aligned with the information in the National Accounts, allows to calculate water efficiency / water productivity measures;
2. In addition we also tried to compile the physical water asset accounts / water balance (ref. to table 1 of the OECD-ES JQ-Inland Waters) at the level of the national territory. This brings us to the second objective to discover whether the water resource or water asset quantifications in these systems and compilation can be improved. We particularly aim to compile sound figures for actual evapotranspiration (actual ET). Actual ET, in contrast to the substantial higher and more theoretical figure of evapotranspiration under ideal hydrological circumstances of potential ET (or reference crop ET), produces a much more realistic figure for ET in the water asset accounts / water balance sheet. This enhances the ‘balancing’ of the different items in these tables strongly. The data needed for these quantifications were obtained from eLEAF, based upon raw satellite data. This data are processed in a way that allows to derive figures on actual ET in a spatial explicit manner, and present in attractive and informative maps. These maps and gridded data allow making nice overlays with other existing and digitised maps available in the NSI;
3. This procedure we tried before, but only for a single year namely 2009 and by use of data from Waterwatch (predecessor eLEAF). The 2009 data was not representative for a whole time series though. Therefore, we aimed to get an update but with data for another year, 2014. This is informative because 2014 had quite different weather / climatic circumstance compared to 2009. Moreover, the 2014 data has more temporal detail and are spatially explicit so that maps compilation was enabled, overlays with other type of maps done and underlying data processed and combined. This also allows to preparing for and contributing to parallel work that is done on ecosystem accounting (following SEEA-EEA) within the NSI. For example for determining the ecosystem services as part of quantifications in assessing (intermediate) provisioning services;
4. The remote sensing / satellite based data for 2014 constituted monthly rates (mm) of precipitation (P), reference ET (Ref-ET) and actual ET (Act-ET). This thus allows to compile the data for several items on water resources in the water Asset Accounts as in the PSUT on water resource use. This at the level of the national territory as well as for various regional breakdowns at the level of detail one may like. It also allowed he combination of these indicators, i.e. P with Ref-ET or Ref-ET with Act-ET rate. This adds opportunity to derive

additional information and gain further insight and offers handles in the situations of water stress and efficient water resource use;

5. As the data is both spatial explicit and made available on monthly basis for 2014, this allows to further identify water provisioning aspects and for example water stress situations on particular locations and regions in the country as well for particular periods throughout the year. It is expected that eLEAF together with FAO may provide such data for Africa in the near future on a 10-day basis, and made publicly available;
6. The data compiled in the water PSUT and Water Asset tables allow deriving the relevant SDG indicators (particular indices under SDG 6.4);
7. A number of data issues complicated the project in various ways. The National Groundwater Register ('Landelijk Grondwater Register', LGR), which is a promising and potentially a great data source to populate the water tables with containing detailed data on abstractions. However, the data from the LGR is still not in a shape that it allows to perform queries and provide the NSI with the requested data. Several datasets appeared to have incorrect data and conflicting data with previous data dumps. For the project we searched for a solution to overcome the situation with parts of missing data on groundwater abstractions. We will continue to work on this with LGR people organised with the provinces to improve this situation. Other difficulties were with data for agriculture, it appeared we had to correct the data on water that is used for animal drinking. Moreover the data obtained from the satellite images needed an update in the process. In the end it all worked out, although it affected the time schedule and opportunities for additional analysis in of the project.

6.2 Recommendations

For future work on the water PSUT and water balance / asset accounts describing the fresh water resources, the following recommendations can be made:

1. The parameterisation of several parameters of both flows and assets, we will continue to cooperate with the remote sensing community and global hydrological modellers. In the quantifications of actual evapotranspiration easily better and realistic values can be obtained by use of advanced methods based on Remote Sensing / satellite and spatially explicit. This will also support on-going and experimental work on Ecosystem Accounts;
2. Fresh water stocks in the water balance sheet / Asset Accounts at beginning and at end of a reporting year, here 2014, are equalised as we had no sufficient information on the changes therein throughout the year and the actual stocks at 1 January / 31 December. The assessment of its size clearly is relevant, but monitoring the small changes in there is somewhat artificial. It provides an assessment on the availability of (scarce) water resource for agriculture for example. The large incoming flows over the year showing the abundance of (potentially) available fresh water resources is informative;
3. In the project we managed to compile a full water balance for the whole territory, but regarding the water balances per River Basin an important element still needs to be incorporated, namely the internal flows of surface water between the River Basins. This is especially important for the complex hydrological situation in the south-western delta of Rhine, Meuse and Scheldt. Internal flows from and to these River Basins are changing, depending on the variation in the flow from the major rivers Rhine and Meuse. The level and direction (sign) of these flows can vary over the months of the year. This remaining issue will be tackled in the near future;

4. The current dataset from eLEAF can even be processed more thoroughly by using heavier computer processing capacity. For instance the overlay with the land use map could only be done for 8 main categories of land use, being the maximum limit. The wish here is to distinguish more categories, especially with extended subdivision in the agricultural land use. Also a double overlay of land use and River basins could facilitate to gain detail in regional data.

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Annexes

Annex I Physical Use table for water, 2014 (aggregated)

				01-03 Agric., forestry and fisheries	06-09 Mining & Quarrying	10-12 Manuf. food products, beverages and tobacco products	19 Manufof coke & refined petroleum products	20-21 Manuf. of chemicals and chemical products	24-25 Manuf. of basic metals & metal products	Other Manufacturing industry[2]	35 Energy supply	36-39 Watersupply, waste & waste water management	41-43 Construction	45-99 Service Sectors	Consump-tion by household	Rest of the World (ROW)	Environment	Total
From Environment to economy	Fresh Surface water	Total		21.9	0.6	162.1	667.5	1,463.2	22.1	69.4	5,086.5	977.9	0.0	0.0	0.0	0.0		8,471.2
		Of which	Cooling	0.0	0.5	153.3	667.5	1,426.6	21.7	46.3	5,086.5	379.8	0.0	0.0	0.0	0.0		7,782.2
			in product	9.4	0.0	0.0	0.0	2.1	0.0	1.4	0.0	466.4	0.0	0.0	0.0	0.0		479.4
			other	12.5	0.1	8.8	0.0	34.5	0.5	21.6	0.0	131.7	0.0	0.0	0.0	0.0		209.6
	Groundwater	Total		60.8	0.0	55.6	0.1	23.3	17.2	40.6	3.9	759.2	23.5	35.2	0.0	0.0		1,019.4
		Of which	Cooling	0.0	0.0	23.4	0.0	9.9	12.2	21.4	0.0	2.7	0.0	0.3	0.0	0.0		70.0
			in product	0.7	0.0	1.7	0.0	0.0	0.0	0.6	0.0	730.9	0.0	0.0	0.0	0.0		734.0
			other	60.1	0.0	30.4	0.1	13.4	5.0	18.6	3.9	25.6	23.5	34.9	0.0	0.0		215.4
	Marine Surfacewater	Total		0.0	31.2	9.7	0.0	446.3	175.5	0.0	5,266.3	1.1	0.0	0.0	0.0	0.0		5,930.2
		Of which	Cooling	0.0	31.2	9.7	0.0	446.3	175.5	0.0	5,266.3	0.0	0.0	0.0	0.0	0.0		5,929.0
			in product	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
			other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0		1.1
	Soil Water	Total		12,222.2	3.4	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	2,978.4	0.0			15,204.7
		Of which	ET	12,194.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,978.4	0.0			15,172.6
			in product	28.0	3.4	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0			32.1
Within economy	Tap water	Total		44.4	2.7	67.5	11.7	40.6	3.1	27.4	3.5	5.3	2.6	101.9	783.3	2.2		1,096.2
		Of which	Cooling	1.8	0.2	5.6	8.8	30.1	1.6	7.0	0.2	0.1	0.0	0.0	0.0	0.0		55.2
			in product	24.3	0.0	10.9	0.0	0.5	0.0	0.6	0.0	0.2	0.1	2.3	0.0	0.0		38.8
			other	18.3	2.5	51.0	3.0	10.0	1.5	19.9	3.4	5.1	2.6	99.6	783.3	2.2		1,002.2
	Industry water	Total		0.0	0.0	1.7	11.7	26.4	32.3	0.1	10.3	1.0	0.0	0.0	0.0	0.0		83.5
		Of which	Cooling	0.0	0.0	0.2	7.0	10.9	30.6	0.0	0.5	0.4	0.0	0.0	0.0	0.0		49.7
			in product	0.0	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.7
			other	0.0	0.0	1.2	4.7	15.1	1.7	0.0	9.8	0.6	0.0	0.0	0.0	0.0		33.1
	Water in products		Water in product	10.5	0.5	35.6	0.0	0.3	1.2	3.1	2.3	1.8	6.2	6.1	8.4	26.8		102.7
	Waste water		wastewater collection and -treatment									1,894.8				0.0		1,894.8
			industry (re-used water)									4.0				0.0		4.0
From Economy to Environment			Return to fresh surface water													0.0	9,507.0	9,507.0
			Return to marine surface water													0.0	5,750.2	5,750.2
			To soil / land													0.0	67.2	67.2
	Balancing	Waterloss	atmosphere	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	958.7	958.7

This PSUT tables are available in an Excel accompanied and published together with this report.

Annex II Physical Supply table for water, 2014 (aggregated)

				01-03 Agric., forestry and fisheries	06-09 Mining & Quarrying	10-12 Manuf. food products, beverages and tobacco products	19 Manufof coke & refined petroleum products	20-21 Manuf. of chemicals and chemical products	24-25 Manuf. of basic metals & metal products	Other Manufacturing industry[2]	35 Energy supply	36-39 Watersupply, waste & waste water management	41-43 Construction	45-99 Service Sectors	Consump-tion by household	Rest of the World (ROW)	Environ-ment	Total
From Environment to economy	Fresh Surface water	Total															8,471.2	8,471.2
		Of which	Cooling														7,782.2	7,782.2
			in product														479.4	479.4
			other														209.6	209.6
	Groundwater	Total															1,019.4	1,019.4
		Of which	Cooling														70.0	70.0
			in product														734.0	734.0
			other														215.4	215.4
	Marine Surfacewater	Total															5,930.2	5,930.2
		Of which	Cooling														5,929.0	5,929.0
			in product														0.0	0.0
			other														1.1	1.1
	Soil Water	Total															15,172.6	15,172.6
		Of which	ET														32.1	32.1
			in product														0.0	0.0
Within economy	Tap water	Total										1,094.0						1,105.0
		Of which	Cooling									55.2						55.2
			in product									38.8						38.8
			other									1,000.0						1,011.0
	Industry water	Total										83.5				0.0		83.5
		Of which	Cooling									49.7				0.0		49.7
			in product									0.7				0.0		0.7
			other									33.1				0.0		33.1
	Water in products		Water in product	32.6	4.1	21.6	0.0	0.1	0.0	1.8	0.0	0.9	3.1	1.3	0.0	31.1		96.6
	Waste water		wastewater collection and -treatment	6.1	2.5	98.4	10.8	46.6	22.0	49.1	9.9	8.0	6.0	91.2	724.5	0.0	819.7	1,894.8
			industry (re-used water)	.	.	.	0.0	.	.	.	.	4.0	.	.	0.0	0.0	0.0	4.0
From Economy to Environment			Return to fresh surface water	20.9	1.0	206.2	666.5	1,571.8	50.5	76.4	4,815.7	2,070.1	9.3	15.6	2.9			9,507.0
			Return to marine surface water	0.1	31.5	18.3	3.8	407.0	173.1	0.4	4,958.2	157.5	0.0	0.3	0.0			5,750.2
			To soil / land	33.3	0.0	0.0	0.0	2.0	0.0	0.0	1.1	0.4	10.3	18.6	1.5			67.2
	Balancing	Waterloss	atmosphere	72.8	-0.8	-12.4	9.9	-27.6	5.8	13.5	587.9	226.8	3.7	16.2	62.8			958.7

This PSUT tables are available in an Excel accompanied and published together with this report.

Annex III Glossary

Here some elementary terms and concepts are listed, possibly useful for correct interpretation of the PSUT – tables for water.

Tap water (drinking water) - This is water of drinking water quality extracted and produced by (public) water supply companies (PWS). This is purified fresh ground or surface water that is transported through the water mains system.

Abstraction (extraction) by crops - Soil water or soil humidity (irrespective the water in the soil comes from precipitation, or from irrigation or sprinkling) that is abstracted from the soil by crops and plants. For small part this end up in agricultural products.
Abstraction is a special category in the PSUT - tables. Abstraction is done from the sources of the 'inland water' system and the North Sea and concerns salt, fresh and brackish surface and groundwater. Absorption by plants from the water sources in the soil, soil water and/or groundwater can originate from precipitation as well as from irrigation / sprinkling. Water from irrigation or sprinkling does not constitute more than five percent of the total uptake by crops in the country. The use table shows that uptake/absorption by plants (crops) mainly occurs in agriculture. The supply table shows total abstraction as supplied by the entity 'the environment'. Abstractions (absorption) with crops (in crops) are registered in the tables, also to allow for consistency with the material flow accounts (MFA). This is done to enable further monitoring of water flows in the economy, in this case the water flows that enter the economy with the raw materials and products. The large flow of water from the soil via uptake by crops (roots) and then evaporated (transpiration), are also part of the tables. In addition and also recorded in the tables is the surface and groundwater extracted for irrigation or sprinkling purposes in agriculture and horticulture that lands on the soil or substrate etc. and that is absorbed by plants regardless of whether it is evaporated (under extraction). This evaporation is shown as water loss. Those abstractions that return directly to the environment, without having been supplied, are also excluded. For instance sand used for raising the surface, where the water in the sand flows back directly to the environment.

Environment - The 'environment' in the use table means the various sources from which water is abstracted; fresh and salt surface water and groundwater and soil water (for ET and the part of the abstraction by plants that ends up in the crop and harvested product). The big part of soil water, which is absorbed by crops and evaporates to the atmosphere, is also taken into account in the tables and report. In the supply table the item 'environment' means the destinations of used water. This is either fresh surface water, salt surface water, groundwater, the soil/land (soil water) and the atmosphere.

Groundwater - This is water pumped up from the subsoil (the saturated zone) or that comes to the surface, in other words abstraction. The composition of this water can be fresh, salt or brackish.

Industrial water - This is also called 'other water'. This water is not of drinking water quality (but of higher or lower quality). This can be filtered or unfiltered water, semi-manufactured, distilled water, demineralised water, etc. It is supplied by either a specialised industrial water company, another (industrial) company or by a regular water company through a special dedicated water distribution network.

Industry (Regkol) - The National Accounts (NA) describing the monetary flows of the national economy and other Environmental Accounts (I.e. the Materials Flows Accounts), uses a similar classification of 133 industries. Thus in line with the industry classifications used in the monetary accounts or called the monetary SUT system of NA. These industries are called regkols in the economic SUT system.

Abstraction - Abstracting groundwater, surface water (fresh, salt of brackish) or soil water from water bodies or water sources (resources) in the natural environment. This is usually done with technical means such as pumps, or plants/crops (soil water).

Fresh surface water - This is water from inland waterways such as rivers, lakes, canals (except groundwater), transition waters, as far as its chemical consistency is concerned, that is made available for economic activities by extraction.

Return flow - This concerns the water flow from the economy directly back into the environment.

Salt (marine) surface water - This is the surface water that comes from the sea or coastal waters, also known as marine water. In this study we also include the brackish to salt water in transition water like the delta of the Scheldt River and the Wadden Sea.

Water type - For Water type distinction is in fresh and salt surface water, groundwater, soil water, tap water of drinking water quality and industrial water (other water) for all industries distinguished in the Materials Monitor, including wastewater collection and treatment.

Water supply - Water leaves/flows out of an economic unit. Water supply is the sum of the water supplied to other economic units and the water flow to the surrounding environment. Water supply to the environment is also called 'return flow'. Water supply in the economy is water supplied/submitted by one economic unit to another. Water supply in the economy is used after subtracting the losses in distribution.

Water use - This concerns water use by Dutch activities. Water use is the sum of water used in the economy and water use from the surrounding environment. Water use in the economy is the intake of water from one economic unit distributed by another economic unit. In the system this constitutes internal water delivery. Water use from the surrounding environment is water abstracted from the environment by the economic units/the users themselves. Water users in the economy are households, industry (manufacturing), agriculture and other industries.

Annex IV Abbreviations and acronyms

ET	Evapotranspiration (evaporation and transpiration)
e-AER	Electronic annual environmental report
GDP	Gross Domestic Product
JQ-IW	OECD/Eurostat - Questionnaire on Inland Waters
IRWS	International Recommendations for Water Statistics
ISIC	The International Standard Industrial Classification of All Economic Activities (ISIC)
ISIC, Rev.4	The fourth revision of ISIC
LGR	National Groundwater Register ('Landelijk Grondwater Register'
LTA	Long Term Average
LTAA	Long Term Annual Average, normally the minimum period of calculation for the LTAA is 30 consecutive most recent years. This is for example done in context of the JQ-IW. The recent recommended period of calculation for the LTAA is 1981-2010, with often an update for every ten years
NA	National Accounts
NACE (Rev.2)	Statistical classification of economic activities in the European Community, with the 2nd – Revision
NSI	National Statistical Institute
PSUT	Physical Supply and use tables
Physical SUT	Physical Supply and use tables
PWS	Public Water Supply (companies)
SEEA CF	System of Environmental-Economic Accounting – Central Framework
SEEA-Water	System of Economic and Environmental Accounting for Water (SEEA-W)
SNA	System of National Accounts
SUT	Supply and use tables (i.e. monetary or economic SUT in NA)
UWWTP	Urban Waste Water Treatment Plant