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URBAN_WFTP

Introduction of Water Footprint (WFTP) Approach in Urban Area to Monitor, Evaluate and Improve the Water Use

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CONTENS

Foreword

The present document was prepared for illustrate the approach follow in the urban water project and it is based on the activities of the work package WP3. It want to be supportive to the project newsletter. ('Water use and management baseline assessment according to Water Footprint approach and sharing of results among partners') of the URBAN_WFTP project (http://www.urban-wftp.eu).

Thanks are due to all partners of the URBAN_WFTP project for fruitful discussion and provision of city level data.

1. INTRODUCTION

The Water Footprint concept has become increasingly popular for analysing environmental issues associated with the use and management of water resources. The concept was introduced by Hoekstra in 2002 (Hoekstra, 2003), and subsequently elaborated by Chapagain and Hoekstra (2004) as an indicator of human appropriation of freshwater resources that incorporates both direct and indirect water use of a consumer or producer. This method has a wide applicability; it is possible to derive the Water Footprint of an individual, a community, a business or a nation (Jefferies et al., 2012). The Water Footprint is an indicator of freshwater use that looks not only at direct water use of a consumer or producer, but also at the indirect water use (Hoekstra et al., 2011). This indicator assess and represent three aspects of water use called blue water, green water, grey water. The blue water refers to consumption of blue water resources (surface and groundwater). “Consumption” refers to loss of water from the available ground-surface water body in a catchment area. Losses occur when water evaporates, returns to another catchment area or the sea or is incorporated into a product. The green water refers to consumption of rainwater insofar as it does not become run-off. It is therefore this part of rainwater which evaporates from the surface and/or is transpired by the crops. Finally, the grey water refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards.

1.1 Overview of URBAN_WFTP model

The Water Footprint concept is primarily intended to illustrate the hidden links between human consumption and water use and between global trade and water resources management (Galli et al., 2012). While this is a powerful tool for communication, the concept bears a number of shortcomings, most important the lack of data.

Blue, Green and Grey water indicators described in this report are based on existing knowledge on Water Footprint. They are assigned for an elementary module to better represent the water use and management aspects. After the definition and assessment of the Blue, Green and Grey water indicators suitable characterization factors are determined for each elementary module. The elementary module can be represented by the whole city, an area of the city or a single building as it will be explained below.

2. GENERAL INFORMATION

Analysis of urban system reveals the following activities which influence the water use within the city boundary (Figure 1):

- collection of water from a catchment,
- storage of the water ,
- cleansing and purification,
- distribution through water supply network,
- carrying wastewater into the sewers,
- processing at a sewage treatment plant,
- returning treated water to the catchment.

The model developed within the framework of URBAN_WFTP project does not take into account any water consumption related with industrial and agricultural activities.

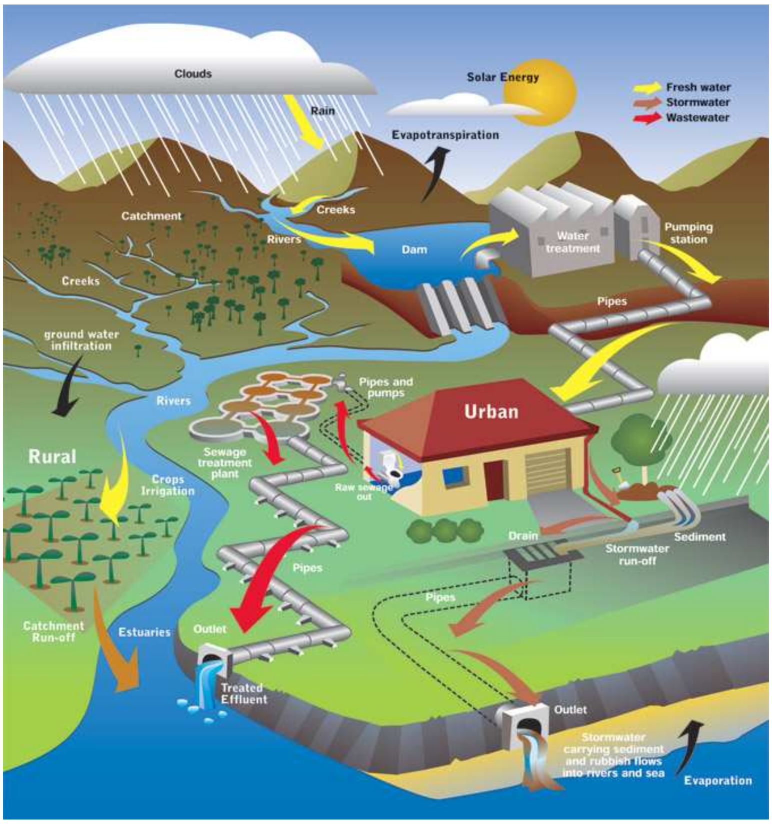

Figure 1: Water cycle in urban area (source: http://www.jointheevolution.ca/blog/2009/06/22/the-water-that-flows-part-1/)

2.1 Primary function of URBAN_WFTP model

First of all the URBAN_WFTP model will be used to assess and measure the water use and management performances of a municipality. The application of characterization factors will determine the Blue, Green and Grey water indicators. Using the model Water Footprint Baseline of the city will be computed based on general data available for the whole city.

Further study will enable to extend Water Footprint Approach to more detailed elements of the urban area.

2.2 *Structure of URBAN_WFTP model*

The term Water Footprint is used for both direct (real) and indirect (virtual) water use of a consumer and or producer (e.g. Vanham et al, 2013 and Galli et al., 2012) in a certain region. Therefore it is assumed that the model will calculate in parallel the fluxes of virtual and real water that occur within the city boundaries.

If we include the virtual water content that is inherent connected with the production process of goods, we find that we are utilizing an even greater area of (virtual) hinterland in order to derive a water balance. The water footprint indicator gives an idea how big such imbalance is.

In the schematic of the water flux model (Figure 2) one need to be concerned with both real water fluxes and virtual ones. The virtual water fluxes that are connected to trade are reported separately. Reason being that pure import-export of goods creates only a through flow of virtual water. As trading goods are neither created nor used the virtual water fluxes connected with those goods does not need to be considered specifically – but of course could be.

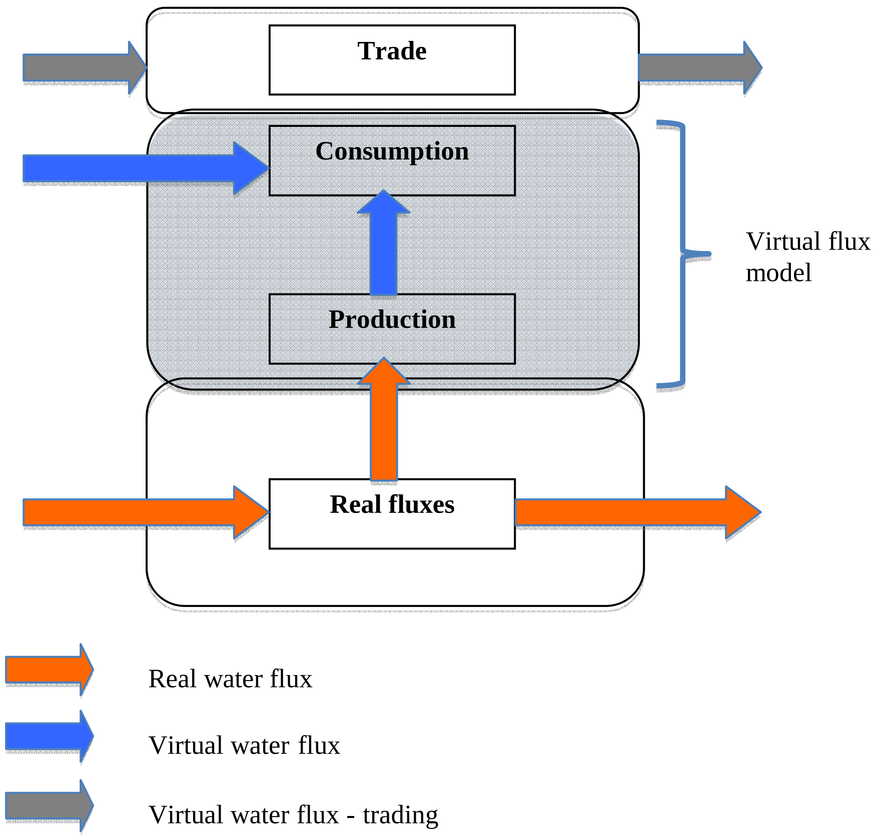

Figure 2: Water flux model on city level

2.2.1 Virtual water fluxes

The virtual water content can be determined for the production process of individual goods. If the used quantity of the goods (inside the model boundaries) is known then the virtual water flux for either persons or a region can be determined. The problem is the lack of data.

What has been achieved over the last years is a large database of virtual water demand that is connected with the production of specific goods – mostly agricultural products. Note that the demand varies based on the origin of the product as it is e.g. different if technical irrigation is needed for the growth process or not.

While there is data available for most agricultural production, less is known on the use of the products. Reliable data is only gathered on the national level and thus there is a database available on virtual water fluxes for most European nations. However, such data is rarely collected for smaller units as e.g. for urban catchments.

Virtual water fluxes are conveniently to be separated in fluxes connected to the consumption of goods = equals import of virtual water and to the production = equals export of virtual water. It is clear that the virtual water connected with production must be matched by real water fluxes. Last, some of the produced goods are consumed inside the city.

2.2.2 Real water fluxes

The consideration of real water fluxes inside model boundaries has been done for ages based on a mass balance approach. Likewise there is ample experience and data available on such input-output models. Most important these real flux models are used to express the balance of water resources and water usage in a certain catchment.

An equation by Mitchell et al. (2003) describes the water balance of urban catchments as:

$$\Delta S = (P + I) - (E_a + R_s + R_w)$$

where ΔS is change in catchment storage including water held in the soil profile, groundwater aquifers and natural and constructed surface water storages; P is precipitation; I is imported water; E_a is actual evapotranspiration; R_s is stormwater runoff; and R_w is wastewater discharge.

In the case of urban catchments it is clear that a water balance can no longer be established on the city catchment itself but requires a certain amount of hinterland. The main fluxes that characterized an urban area are presented in the following figure:

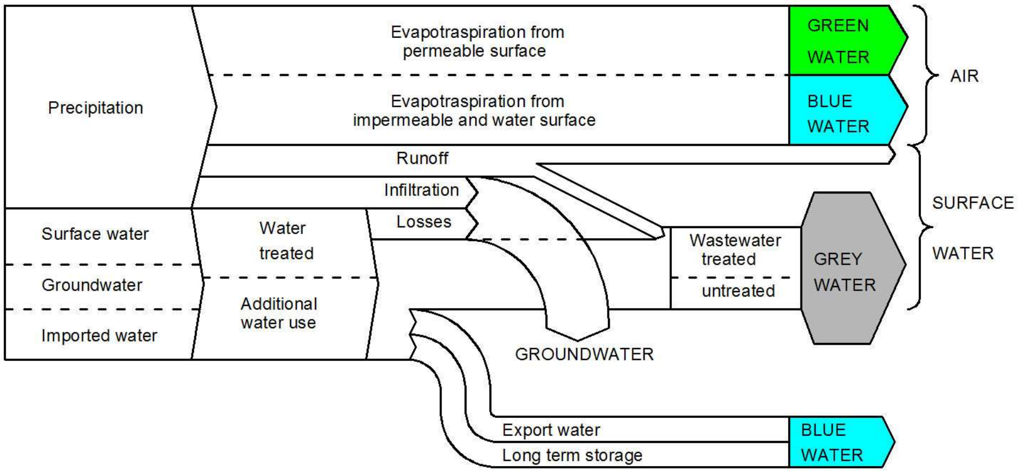

Figure 3: Real water fluxes in the urban area

3. MODEL DEVELOPMENT

The water, as a local resource, requires that its correct management is achieved even in urban areas. The water, in an urban area, can be used for domestic and industrial uses: while industrial uses are related to the dynamics of the process, civilian use are strongly influenced by the lack of awareness of citizens, which often involves severe wastage. In this context, it is evident that the proper management of the water through the rationalization of the civilian uses is a good way to counter future problems of this type, which permits excellent potential of reduction of the water wastage. To deal with the problem of urban water management the URBAN_WFTP project was set up which aims at improving the conservation of water resources through the deployment of new water-saving technologies and policies starting from citizens awareness. The element of strong innovation consists in the application of the Water Footprint (WFTP) approach to the urban areas as water management instrument and as planning tool. In addition, the project considers different urban contexts in order to obtain a common approach that will be used throughout the Central Europe in order to study and optimize water civilian consumptions. The application of the water footprint methodology to an urban area is not simple, represents an element of novelty and requires to overcome some obstacles due to the complexity and sizes of urban realities. Therefore, it was decided to use a multilevel modeling approach.

3.1 Overview of development process

The water balances defined by the WFTP methodology have been structured in three different levels of application. For each level a specific model has been drawn up. The three different levels are distinguished by the degree of details, the information they provide and the load of data that are require (Figure 4).

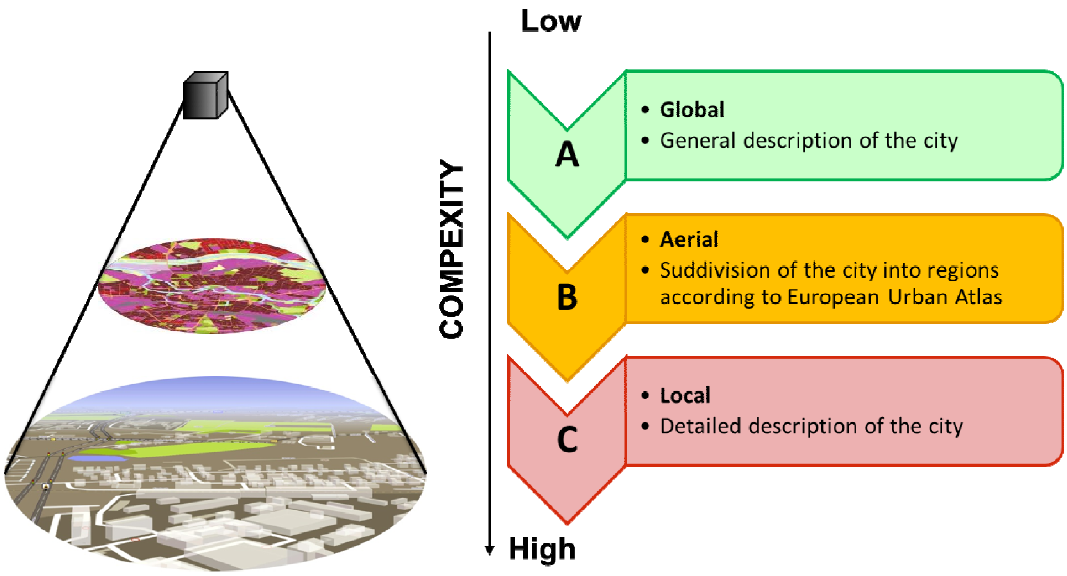

Figure 4: Three level model of Urban WFTP

The first level is the global level. The city is defined as a black box, and all water fluxes are studied with an input-output approach. The second level is represented by the areal model and the focus is posed on the different land uses that can be possible to distinguish in the city and how they interfere with water uses. Through the use of geographical information system (GIS), it will be possible to create a map of the city that shows the hot spots where the WFTP is the highest. The last level is the local model which analyses all the structures that generate the water consumptions. Starting from the data of a representative district and using a multi-linear regression the model will allow the calculation of the WFTP of the city using bottom-up approach.

The innovative approach used in the project allows to study the water uses in the city in order to identify points of intervention and choose the specific technologies to be introduced to reduce consumptions. The URBAN_WFTP project is in full implementation phase, but already represents a good example of application of the water footprint as an instrument for the urban water management.

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