Sustainable Water Use in 21st Century

UDC: 005.52:628.11"20?"

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Exposing the hidden links between consumption and the depletion of water can provide arguments for change and create a basis for formulating new strategies for water resource management. The knowledge that the impact of people on the composition of drinking water can be directly linked to overall consumption and that problems such as scarcity and water pollution can be better understood and addressed by looking at the supply chain as a whole resulted in the creation of the "water footprint" concept. The water footprint is an indicator of direct and indirect water consumption by a producer or a consumer. The mission of water footprint is to promote water footprint transition to sustainable, equitable and efficient use of freshwater resources worldwide.

1. Introduction

Water is a renewable, however, a scarce natural resource. The demand of various sectors of economy for water frequently exceeds the local availability, which is likely to be further aggravated by the effects of climate changes [1,2].

Exposing the hidden link between the consumption of water and the depletion of water can provide arguments for change and create a basis for formulating new water resource management strategies[3].

2. State and outlook

The 2009 European Environment Agency (EEA) report on water resources reveals that the consumption of water in a large number of regions of the European continent is not sustainable [4].

Throughout the European continent, 81% of the total quantity of freshwater is pumped from surface waters such as lakes and rivers, to be mostly used in industry, energy production and agriculture. Contrary to this, public supplies primarily lean on ground waters due to their generally superior quality (Figure 1). While almost all the water used in energy production returns into the watercourse, this does not apply for a large portion of water pumped to be used in agriculture [4,5].

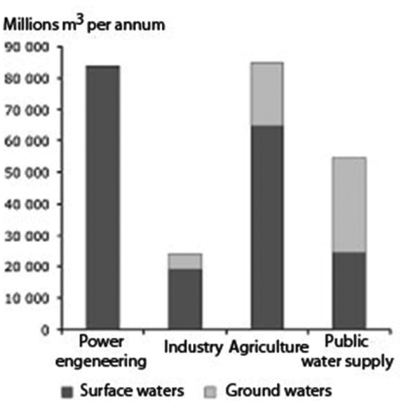

Figure 1. *Exploitation of freshwater resources in Europe in 2009 by sectors (million m³/year), source: EEA*

In Europe as a whole, 44% of pumped water is used in the energy production, 24% is used in agriculture, 21% water is used in public water supply and 11% is used in industry.

The above listed data, however, do not reveal the significant differences in water consumprion among the regions of the continent. Thus in Southern Europe, 60% of the total quantity of pumped water goes to agriculture; in certain regions the quantity amounts to as high as 80% [4,5].

Water exploitation index (WEI), the indicator of the annual water catchment expressed as a percentage of long-term disposable freshwater resources, shows that river watersheds are over-exploited, especially in the Mediterranean region in Europe (Figure 2). The warning treshold, on the basis of which the regions that are not endangered by this problem are differentiated from those suffering shortages of water, amounts to 20%, whereas the shortage of water is serious in the regions where the WEI exceeds 40% [5,6].

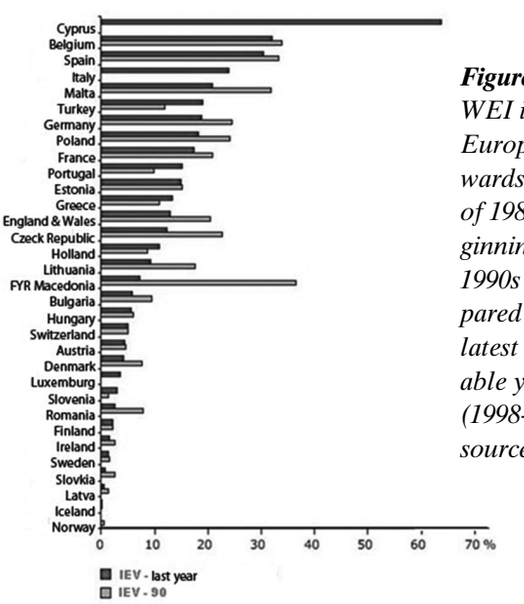

Figure 2. *WEI in Europe towards the end of 1980s/beginning of 1990s compared to the latest available years (1998-2007), source: EEA*

The solution to the shortage by pumping still larger quantities of water from the surface and ground watercourses is short-termed as overuse of water has a highly negative impact upon the quality and quantity of the remaining water, as well as upon ecosystems that depend on it. It is necessary that requirements be reduced in order that the quantities of water people pump should be reduced to a minimum and the efficiency of water use be improved [4,5,7].

3. Water footprint concept

The knowledge that the human effect upon the composition of drinking water can be directly related to the overall consumption and that the problems such as shortage and pollution of water can be better understood and resolved by observing the production and supply chain as a whole, resulted in 2002 in the creation of the "water footprint" concept as a water consumption indicator [8].

3.1 WATER FOOTPRINT STRUCTURE

Water footprint has three components [3]:

1. blue water footprint
2. green water footprint and
3. grey water footprint.

1. **The blue water footprint** refers to the drinking water consumption from the global water resources (surface water and ground water). The consumption of drinkable water includes evaporation, water integration into products where it does return to the same watershed or does not return there over the same period of the year.

2. **The green water footprint** signifies the quantity of consumed water from the global green water resources (rainwater stored in the soil as moisture).

3. **The grey water footprint** describes the quantity of water that is polluted due to the production of goods and services for individuals or a social community.

3.2 Water footprint classification

On the basis of the consumer categories as a criterion, the following types of water footprint can be distinguished [3]:

1. individual water footprint
2. corporate water footprint and
3. national water footprint.

1. **The individual water footprint** refers to the overall quantity of drinking water an individual consumes directly or indirectly. The direct water consumption is the water consumed by the individual at home. The indirect water consumption is the total quantity of drinking water used in the production of goods and services that this individual consumes [3]. In the 1997-2001 period, the average water footprint in the world was 1,240m3 water per capita annually [9].

2. **The corporate water footprint** is defined as the total quantity of drinking water directly or indirectly used in business doing and business support. The direct corporate water footprint is the quantity of water the producer uses in manufacturing or ancillary activities, whereas the indirect water footprint refers to the consumption of water in the producer's supply chain [3].

The increase in the water consumption and the excessive use of water systems has already resulted into a dramatic deterioration of aqueous ecosystems worldwide. This imbalance resulted in freshwater no longer being available in certain regions. The consequence of the overconsumption of water will be manifold; at the very exit, the offers fall due to considerably higher prices for drinking water. This means that companies will have to separate the management of the risk of high direct water consumption at their own sites from that of indirect water consumption in their supply chains [10].

3. **The national water footprint** indicates the quantity of water used in goods and services, consumed by the members of a certain nation. There are the internal and the external national water footprints [3,9].

The internal national water footprint is defined as the use of domestic water resources in the production of goods and services consumed by the citizens of a certain nation. It is the sum of the annual quantity of water from the domestic water resources used in agriculture, in the industrial sector and in the households, reduced for the quantity of exported virtual water related to the exports of national products [3,9].

The external national water footprint is the annual quantity of foreign water resources used in other countries in the production of goods and services imported and consumed by the citizens of a certain country. It is equal to the difference between the quantity of virtual water imported into the country reduced for the quantity of virtual water exported to other countries (the reexport of imported products) [3,9].

The four major factors determining the country's water footprint are the following:

1. scope of consumption (related to the gross national income),
2. consumption pattern (e.g., high compared to low consumption of meat),
3. climate (conditions of growing) and
4. agricultural practice (water use efficiency).

In rich countries, people generally consume more goods and services, which is immediately reflected into a bigger water footprint. It is not, however, only the scope of consumption that affects the people's demend for water. Also relevant is the contents of the consumer basket because the production of certain goods requires large quantities of water (beef meat, rice). In many poor countries, the combination of unfavourable climate conditions (massive evaporation) and bad practices in agriculture (resulting into a low water productivity) contribute to a big water footprint. The basic factors affecting bad agricultural practice, and consequently a big water footprint, are the inadequate price of water, subsidies, the implementation of an inefficient water technology and the lack of insight into simple water saving measures employed by farmars. The impact of different determinants varies from one country to another. The water footprint per capita in the USA is big partly because the consumption of meat is high (three times as high as the average world consumption of meat). The water footprint per capita in Iran is relatively big due to a low yield of crops and partly due to evaporation [9].

The problems concerning water are closely related to the structure of the global economy. A large number of countries have significantly reduced their water footprint by importing water-intensive goods from other countries. This in turn increases the burden on the water resources in the countries – exporters of such products, where there is frequently a lack of mechanisms for preservation and prudent management of water [11,12]. Not only the governments, but also the consumers, business entities and the communities of the civil society can play an important role in achieving a better management of water resources [12,13,14].

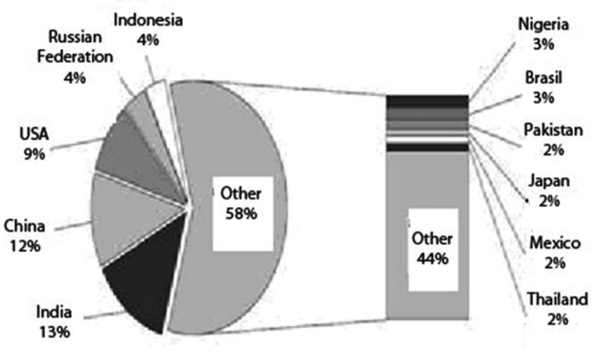

Figure 3. *The share of major consumers in the global water footprint, source: Hoekstra and Chapagain, 2007*

Estimares are that the global water footprint amounts to 7,450 Gm^3 annually. Eight countries – India, China, the USA, Russia, Indonesia, Nigeria, Brasil and Pakistan – together have a 50% share in the global water footprint. The biggest consumers of global water resources are India, China and the USA (Figure 3) [9].

Absolute nimbers indicate that India is a country with the biggest water footprint in the world – 987 Gm^3 annually. However, as the population of India makes 17% of the world population, the share of this country's population in the global water footprint is only 13%. The population of the USA is characterised with the biggest per capita water footprint in the world – 2,480 m^3, whereas China has a relatively low annual water footprint of 700m^3 per capita. Countries differ both in the size of the water footprint and in its composition (Figure 4) [9].

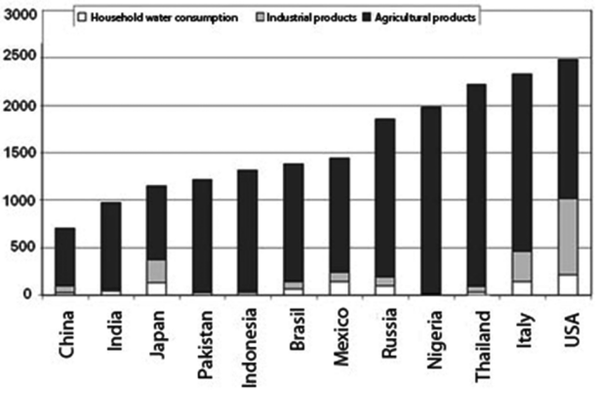

Figure 4. *National water footprint per capita and the share of different consumption categories of certain countries, source: Hoekstra and Chapagain, 2007*

The consumption of industrial products in rich countries contributes to a relatively high degree to the total water footprint in comparison with the developing countries. Thus the consumption of industrial products contributes significantly to the total water footprint of the USA (32%), but not in India (2%). The contribution of external water footprint to the total water footprint is rather high in Japan (65%) in comparison with the USA (18.4%), China (6.5%) and India (1.6%).

3.3 Product waterprint

The water footprint of a product is defined as the total quantity of freshwater used directly or indirectly in the manufacturing of a product [3].

The analysis of technological procedures allows for calculating the quantity of water used in the production of certain types of goods. Good examples to illustrate this are the following data [15]:

- as much as 16,000 l of water is required to produce 1 kg of beef meat,
- 900-1,350 l of water is required to produce 1 kg of weat,
- 3,000 l of water of water is required to produce 1 kg of rice,

– 900 l of water of water is required to produce 1 kg of corn,
– 140 l of water of water is required to produce 1 cup of coffee,
– tThe production of 1 l of milk requires 1,000 l of water,
– 10 l of orange juice needs 1 l of fuel for production and transport and 220 l of water for irrigation and washing the fruit.

The quantification of water consumption per product provides an insight into an uneconomical consumption of water and stress the need to improve the technological processes.

4. Waterprint mission

An international network of governments, corporations, non-government organization and the United Nations bodies was established in 2008 – the *Water Footprint Network* – to coordinate the efforts in the development and dissemination of knowledge of the water footprint concept and methods [3].

The water footprint mission means the promotion of transition towards a sustainable, fair and efficient use of freshwater resources worldwide [15]:
– by improving the " water footprint" concept that is spatial and time explicit indicator of direct and indirect water consumption by the consumers and producers;
– by promoting the water footprint concept in the communities of people, state bodies and companies and their understanding the manner in which the consumption of goods and services, as well as production chains affect water consumption and drinkning water; and

– fostering those types of water management that reduce the negative ecological and social effects of the water footprint by the communities of people, states and companies.

5. Conclusion

Water crisis could be avoided or its consequences for the overall development could be mitigated if the following principles on water sustainability be observed:

– reduction of the specific consumption of water in all the consumption spheres by gradual transition to technologies with compulsory recirculation and reuse of water,
– planning urban and industrial development in view of the available water resources, in accordance with the capacities of water management and the problems of water protection,
– protection of existing and potential drinkable water sources using the measures of spatial planning and economic policy,
– purification of industrial and communal waters prior to their sinking into watercourses as the most important measure of environmental protection and improvement,
– antierosive protection of watersheds and river regulation by regulation of banks as a precondition for the urbanization of settlements.

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