WATER FOOTPRINT IN HUNGARY

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Abstract: More and more news report on water-related extreme environmental phenomena. Some of these are natural, which are often beyond the human race. But others are definitely due to anthropogenic effects. I think the water footprint index is able to highlight national and international water-use processes and gives us the opportunity of organizing a sustainable, consumer-, environmental- and governance-friendly management.
81% of the fresh water withdrawal is from surface water bodies in the EU. In Europe as a whole, 44% of abstraction is used for energy production, 24% for agriculture, 21% for public water supply and 11% for industry. Public water supply is confined to ground waters. To the water resources related human activity caused qualitative and quantitative amortisation will grow worse in the foreseeable future due to the climate change. Beside seasonal differences the sectoral differences are increasingly becoming critical between different areas, such as Southern and Western Europe. The former, wrong agricultural support system has worsened the situation since it gave financial aid for the used improper techniques of water-intensive crop cultivation. By today, this seems to be solved. Public water abstraction is affected by many factors, of which mostly are based on social situation and habits, but technological leakage receives a big role as well. Interesting, that for example the residents' water consumption in Eastern Europe decreased because price were raised and regular measurements were introduced. But in Southern Europe it increased due to tourism in the past period. Industrial water withdrawal decreased across Europe because of the decline of industry and the development of technologies. According to the European Environment Agency (EEA), the Union needs a sustainable, demand-driven leadership which focuses on the preservation and use efficiency. This have already appeared in politics and legal administration as well.
Current research calls the attention to the significance and difficulties of this kind of domestic estimation presented trough the water footprint calculation of bread and pork in Hungary. The received data indicate the domestic water consumption trends in a modern approach. There is no doubt for me about the urgent necessity of water footprint calculation because as a result innovative, sustainability supported environmental, social, economical, and political relationships can be created – not just on local, regional or national level, but on inter-regional, European and even global stage.

Key words: water economics, water consumption, externality management, environmental economics, climate change adaptation

I. Introduction

"We are living beyond our means when it comes to water. The short-term solution to water scarcity has been to extract ever greater amounts of water from our surface and groundwater assets. Overexploitation is not sustainable. It has a heavy impact on the quality and quantity of the remaining water as well as the ecosystems which depend on it. We have to cut demand, minimise the amount of water that we are extracting and increase the efficiency of its use."

Professor Jacqueline McGlade,
Executive Director of EEA.

Our fresh water recourse is one of the greatest treasures of mankind. Namely, water is the sensitive link between the biosphere and the lithosphere, the life itself. This characteristic makes the fresh water strategically important in all ecological, all economical, environments economical, all social, and sociological, all though in a political, environment political sense.

Economics rates water among free goods, which serves to satisfy human needs. At the same time also appears at the resources as a natural factor. Meets all relevant criteria, as it can be found in nature, may get exhausted easily, its replacement is very expensive, it's very inflexible (can't be substitute), usually immovable, its utilisation may depend on weather and seasons, and it has a country specific quality and quantity availability.

Water is classified among common goods, its place is among boundaries [fixed], its transportation and storage is complicated and costly (rather happens in the form of a product even at a national or regional level – for example grains, fruits, meat ...). In addition its substantive value is large (often not expressed in money), as it is related to life, beauty, wealth and health. People like the proximity of water. The economic consequence is that we should use it when and where it is available considering that it gravitates, leaks downward. There is always the threat of market failures in water supply so it has no homogeneous market because it is too expensive – pricing and water rate determination (can) cause extreme social conflicts and tensions. There is no other economic good that has such a complicated combination of characteristics like water (*Savenije* and *Van Der Zaag* 2006).

Considering the Union's water use guidelines very limited data are available in FAO AquaStat and Eurostat databases. The latest data are from 2007 and not available for all countries. According to the existing figures water use of Malta is the typically smallest, and Spain, Great Britain, France, Greece and Germany are the largest. Macedonia emerges from the row where popular and industrial water consumption from 2004 to 2007 has considerably decreased. I have to emphasize that the underlying data are incomplete. European Water Partnership (EWP) has come into existence for the common solution of water problems, which assists in developing strategies and executing measures.

Domestic water use on EU level is low and according to forecasts by 2015 compared to 2004 data despite of the population decline the residential water consumption will show little change while the industrial will show weaker and the agricultural will show stronger growth. Domestic River Basin Management Plan – in our case this covers whole Hungary – in relation to EU Water Framework Directive has to be prepared collaborating with 13 other concerned countries. The International Commission for the Protection of the Danube River (ICPDR) supplied the coordination of this project.

For the complex measurement of our water consumption A. Y. Hoekstra and A. K. Chapagain Dutch professors created as a result of an extensive research work the water footprint. Water footprint is the absolute quantity of the fresh water used during the production of a product or a service which expands on measuring contaminated water as well. This measure allows complex, horizontal and vertical sectoral data integrated multifactoral estimations. With its application still not known, sometimes not even suspected economic, social and political contexts may come to light, which is a new approach to our water-related personal and community attitude. So the water footprint means an all-time complex perception of water. The regular usages of water footprint calculations allow the re-evaluation of current water resource management in social and economic systems and points on the absolute measure of our diverse water demand. Water footprint can be calculated for a product, service, company, sector, nation, geographic unit or the whole humanity.

II. Virtual water and water footprint

Water footprint is the total quantity of water used to produce products and services by a person, company or nation. It consists of two main components: direct and indirect water use. Indirect use of water is measured as virtual water (the amount of water needed for produce a certain product). Water footprint includes blue water (rivers, lakes, water-barrier water), green water (rainfall at primary crop cultivation) and gray water (contaminated water after agricultural, industrial and domestic use). Although water footprint tells us how much water is used, the increase or decrease of the effect of full abstraction depends on location and time. The growth of water footprint in an area where water is abundant, probably does not have adverse effect on the society or the environment, but in a place where water scarcity is already experienced may cause serious problems, such as rivers drying out, habitats destruction, species extinction – besides it has impact on agricultural prices, stocks and local economies (*WWF* 2010).

A product water footprint is similar to the so called 'virtual water content', although water footprint covers not only the quantity but the type of water used (blue, green, gray) and where and when it was used. Thus, contrast to the 'virtual' water the water footprint is a multi-dimensional indicator. A 'virtual' water term is used in the context of international or regional water flows. If a nation or a region exports (imports goods that means water is exported) imported on 'virtual' way. In this context we can talk about virtual water export and import, generally virtual water flow or virtual water trade (*Hoekstra* et al. 2009).

Types of water footprint

Product water footprint can be defined as direct and indirect fresh water requirement during its production. This is an estimation that considers water consumption and pollution of all the elements of the production chain. The calculation is the same for all kind of products coming from the agricultural, industrial or service sector. Product water footprint is divided into blue, green and gray parts.

Water footprint of a consumer is defined as the total amount of fresh water used and contaminated during the production of all the products and services consumed by the consumer. Water footprint of a group of consumers is the same as the total amount of water footprints of the individual consumers of the group.

Water footprint of a business can be defined as the directly and indirectly used fresh water during the operation and supply of the company. There are two main building blocks. Operational (direct) water footprint of a business is the used or contaminated fresh water during its functional operation. Supply chain (indirect) water footprint of the company is the used or contaminated fresh water during its input production, which is needed for the production. 'Business water footprint' or 'corporate water footprint' or 'institutional water footprint' can be used as well.

Water footprint of a given area can be defined as the total fresh water consumption and pollution of the area within its borders. It is extremely important to clearly define the boundaries of the considered area. It can be catchment area, river basin, province, state or nation, or other water or administrative territorial unit (*Hoekstra* et al. 2009).

In the light of the results

Because of the international trade of water-intensive products virtual water flows are moving around the world. Most of these flow in the wrong direction from water-poor areas to water-rich regions. The majority of these flows are food, bio fuel and cotton. Solution of this wrong-way flow could be if the dry areas would discontinue agricultural production, since the responsibility of this sector in water use is the largest worldwide. According to experts the solution is the change of import and export patterns, where tool would be modern water pricing. Nowadays some countries (like China or Saudi Arabia) are already taking steps to buy large and fertile places in Africa, Asia or Latin America. Instead of food, land purchasing. This is the guarantee of the access to water in the future. Land purchaser countries are not alone, directly competing with food production giants like Nestle or Coca-Cola (*Spiegel Online International* 2009).

Water footprint calculation is a useful tool to build awareness around the used water that products consumed in the production value chain. But at this point of the developing method consumer labelling is at best leading to undesirable results or at worst misleading. This is due to underlying complexity behind the numbers of the water footprint of companies and the level of detail considering local environmental, economic and social impacts. The future of companies on water depends largely on their understanding, measurements and involvement. 21st century complex challenges on water are only growing in coming years and companies must be prepared to get involved beyond their own fences and traditional comfort zones to ensure long-term viability of this critical resource (*WFF* and *SABMiller* 2009).

International water-dependence is significant and seems to increase with the continual world trade liberalization. Today, 16% of the world's water use is not for the production of goods for domestic consumption but for export. Considering this significant and increasing tendency according to *Chapagain* and *Hoekstra* (2007.) the national and regional water policy studies in preparation should include international or interregional virtual water flows analysis.

As an indicator of water use water footprint differs in three aspects form the classic water withdrawal (as it is shown at Figure 1):

– Not limited to blue water use, but also includes the green and gray water use.

	Water footprint of a product or consumer		
	Direct Water Use	Indirect Water Use	
	Green Water Footprint	Green Water Footprint	Water Use
Water Withdrawal	Blue Water Footprint	Blue Water Footprint	
	Grey Water Footprint	Grey Water Footprint	Water Pollution

Source: own editing according to Hoekstra et al. 2009.

Figure 1: Schematic representation of water footprint components

– Not limited to direct water use, but also include indirect water use.

– Not include the use of blue water if it returns where it was.

Consequently, water footprint offers a wider field of view of the relationship with the consumer or the producer and the use of fresh water systems.

Background

Chapagain and *Hoekstra* (2007) pointed out that the reveal of hidden water use of products can help to understand global nature of fresh water and to quantify the effects of the consumption and trade water resources usage.

Water footprint is a fresh water use indicator, which shows direct and indirect water use of a consumer or a producer. It can be considered as an overall fresh water use index in addition to traditional and simplified abstraction rates. Water footprint of a product is the fresh water volume used during the production measured on the entire supply chain. It is a multi-dimensional index, which shows the water consumption measure to the source and pollution degree by the type of pollution – all the elements of the total water footprint both geographically and in time are determined (*Hoekstra* et al. 2009).

Blue water footprint refers to the consumption of blue water (surface and groundwater) through a product's supply chain. 'Consumption' refers to the water loss from the surface and subsurface water bodies of the catchment area, that happens when the water evaporates and returns to a different catchment area or the sea, and when incorporated into a product. Green water footprint refers to the consumption of green water (stored rainwater in the soil, soil moisture). Gray water footprint refers to pollution and can be defined as the amount of fresh water needed to saturate the processing of existing environmental pollutants in water quality standards.

The four sections of total water footprint evaluation: laying objectives and responsibilities, calculating water footprints, assessing water footprints sustainability, formulating of the results. This means that the water footprint evaluation studies begin with clarifying the objectives and powers. Water footprint evaluation can have a lot of different reasons. For example, a nation's government wants to know the foreign dependence on water sources, or perhaps the sustainability, or maybe is interested in the suppliers of water-intensive products regional water use. The water authority may also wonder whether the total water footprint of the human activities within the catchment area harms environmental conditions and trends or water quality standards. Or it may be wondered what the extent of the incorporation of the scarce water resources into the low-value export crops in the river basin. A company may know its dependence on scarce water resources through his own supply chain, or the exposure of its allowance to the lower degree water system impacts through its supply chain and operation.

III. Materials and methods

Background of the national research

In 2008 consumption of bread was 44.9 kg/capita – that was more than baker's ware and other cereal products in total. In the same year poultry (17.0 kg/person) was more popular, but I chose pork (15.8 kg/person) because in the light of water footprint calculation the existing data were available (*KSH* 2010).

On the official website of the water footprint calculation wheat's website was not available during the writing of the paper (*www.waterfootprint.org* 2010). Among National Central Statistical Office (KSH) public figures general data were available about water usage; there were no concrete information of the water consumption of wheat production.

In view of the information source (*KSH Gyorstájékoztató* 2010) data relating to wheat production differentiates durum wheat from other wheat. The average of harvested durum wheat was less than 1% of the total wheat gathering (2004–2008) so I did not count with distinguished breed.

During the research I have used CropWat 8.0 software. This decision support computer program is developed by the FAO Land and Water Development Department. Water and irrigation needs of plants data is used for the calculation which were taken from soil, climate and crop data by the tool. It determines a watering schedule for different plants, to evaluate the farmers' irrigation practices (*FAO* 2010/a). The other software I have used was ClimWat: developed by the FAO. It is a CropWat supporting computer program. All over the world, measures more than 5,000 synoptic stations to collect weather data. These stations may be the selection of the salvage program CropWat. (*FAO* 2010/b)

Water footprint of Hungarian bread

Blue and green water footprint of Hungarian wheat

To calculate the water requirement of wheat (crop water requirement – CWR) the used CropWat 8.0 software requested data was provided by several sources of information. Climatic data of wheat growing regions were supplied by the closest synoptic meteorological stations (Table 1), which data were imported from the program ClimWat. During the calculations I used the simplifying assumption used by Water Footprint Manual that the stations represent the same size of crop areas, so in this regard the weight of data are the same.

Considering the sowing of wheat there was no precise data, so for simplicity I dated the total quantity of all regions on the same day. From this the system calculated off harvest date, so it was everywhere at the same time. In this respect I relied on the existing FAO data and other factors in Water Footprint of Nations Appendix (*Hoekstra* and *Chapagain* 2004/a) for example estimates of humidity, root depth, crop coefficient and geological data. After all the required data are entered the software calculates the value of the reference evapotranspiration (ETo), the degree of solar radiation (Rs), the plant – in this case wheat – water requirement (CWR) and from these makes irrigation plan (Crop irrigation schedule). (Due to the special case of the water demand of rice the software can calculate only complement additional data, so rice (rice) and non-rice (not rice) plants are distinguished.)

Table 1: Crop cultivation regions in Hungary and their associated meteorological stations

Crop	Region	Meteorological station
Wheat	Central Hungary	Budapest-Met.
	Central Transdanubia	Hurbanovo (SK)
	Western Transdanubia	Szombathely
	South Transdanubia	Pécs
	Northern Hungary	Miskolc
	Northern Great Plain	Debrecen
	South Plain	Szeged

Source: own editing

The date I used uniformly for the wheat sown is October 15. from which the software worked with its already existing winter wheat FAO data. Considering the Water Footprint Manual assumption (during the cultivation the crop water requirement is fully satisfied) I determined from the used data that the wheat green and blue evaporation equals total water demand (ETgreen + ETblue = ET = CWR) (*Hoekstra* et al. 2009). The condition of these is the existence of 'ideal circumstances', which means that the plant growth and yield is not limited. During the use of this software it can be deflected.

The resulted estimated value of crop evapotranspiration (ET) must be converted, thus after multiplied by 10 we get wheat green, blue, and total water use (CWU) measured in m3/ha. After this can process water footprint be calculated, where wheat water use is divided by the yield. According to these the estimated process water footprint of a ton of wheat is just 1000 m^3. It is clear from the results that green water footprint is slightly more than blue one. This means that a little bit more than half of the process water needs in growth stage of wheat are obtained from rain and a part of it returns back into the atmosphere during evaporation. And a little bit less than half is provided from surface and ground water. (On national level the water requirement of 1 kg domestically cultivated wheat is 221 mm in the production period – calculated by FAO (*Hoekstra* and *Chapagain*, 2004/b)). It is important to note that this figure does not include blue and green water contents of the harvested plants. Average moisture content of wheat is 12-14%. This means that the water footprint of the crop itself is 0.12 to 0.14 m3 / t, which is negligible in relation to the plant process water footprint.

Grey water footprint of Hungarian wheat

In the case of grey water footprint calculation there was relatively little data available for me, so I used estimations and conclusions at this relation as well. The effects of pesticides, other nutrients and herbicides beside fertilizers used in agriculture on the environment have hardly or not at all been scanned. In the absence of local, free-flowing water bodies' water quality standards (nitrates content) U.S. EPA (U.S. Environmental Protection Agency) standards were used which were also used by the Water Footprint Manual. According to this assumption the amount of nitrogen is10% which flows back into the water body of the applied fertilizer rate (*Hoekstra* et al. 2009). The data of gray water footprint calculation in connection with wheat production were available by KSH and FAO databases.

Gray water footprint of a ton of Hungarian wheat is an average 267.5 m^3. Wheat grown in Southern Transdanubia has the smallest gray water footprint. The one grown in Central Hungary has the largest one despite of the fact that here is the least amount of estimated water body pollution.

Water footprint of Hungarian wheat

Based on the above I conclude that total water footprint of the wheat grown in Hungary is 1,268 m^3/t. (According to summary tables given by www.waterfootprint.org the average water footprint of wheat which was grown in different places varies from 1,000 to 2,000 m^3/t.)

Water footprint of Southern Plain's wheat is 10%, Northern Great Plain's is 12%, and Central Hungary's 27% higher and Southern Transdanubia's 12% and Western Transdanubia's 16% lower than the national average.

From 1 kg of wheat average 0,76 kg flour is made, the rest is mostly wheat bran (≈ 0,228 kg) and wheat germ (≈ 0,012 kg) according to FAO data related to Hungary. (Less than 1% is lost, but it's so little rate that I have not counted separate thus. In addition, wheat germ has a very small share of the products, so it combined counted with wheat bran.) As additional data was not available for me I estimated the value fraction of the resulting flour based on Italian example at 0.88, which means that the 88% of the total value of mill products is flour (*Hoekstra* and *Aldaya* 2009).

Based on the above the water footprint of flour, which can be estimated by the amount of green (WF_{green}), blue (WF_{blue}) and gray (WF_{grey}) water footprint of wheat regard to Hungary is (1268 × 0,88/0,76 =) 1,468 m^3/t.

There is no significant difference between the water footprints of wheat flour and bread. In Hungary, on average **1,014 liters** of water is needed to produce 1 kg bread. Central Hungary has the largest water needs (1290 l/kg) in this respect. This should be reduced (for example with technological change, development or production redistribution). Western Transdanubia (847 l/kg) and South Transdanubia (892 l/kg) have the smallest ones. This means that the domestic 'bread production" should rather focus on these regions. (In the lack of the regional share of "bread production" data the national average is based on the previous calculation, not a weighted average of the regional water footprints of bread.

Of course, bread production has many specifics so regional optimization appears pointless, but wheat and bread water footprint data clearly show where and what to produce and consume if we basically want to be water-efficient. It can be important in the light of the calculations to prefer mainly on the production sites of export wheat production where water footprint has the lowest values.)

The calculations and KSH figures show that the estimated annual water footprint of bread consumption per capita in Hungary is 45528,6 l/kg. At this point, I find it important to emphasize again that a very large part of the data used is based on estimates and conclusions.

Water footprint of Hungarian pork

Background

Official website of the water footprint of the products of animal origin page was still under construction during the research (www.waterfootprint.org, 2010/a.). From FAO (2003) data can be stated that in our country 100 sows get 1891 pig every year. The picking rate annually is also 133%. (A number of animals are taken from the total national herd for slaughter, or for live export in the same year. Here expressed in total percentage of same species including newborn animals.) Average slaughter weight of swine is 117 kg, average amount of meat weight is 97 kg (more than 80%, which is a very high rate). An average 3,6 kg of edible swine offal which is about 3% of the slaughter weight. The slaughter fat is 5 kg an average, it is roughly 4,3% of the slaughter weight. Skin has no data. In addition, the Agricultural Economics Research Institute (Hungary) records data including the swine breeding and slaughter on the slaughterhouses, too (*www.aki.gov.hu* 2010).

Water requirement of a pig farm can be detected on the simplest way on the relation of yield of pork and the water meter. This method does not count only with the water demand of the swine in biological sense, but reflects the technology water withdrawal also in which for example cleaning or process water losses are also shown. In addition, the topic can be complicated by differences of feeding habits of each swine species, differences of keeping technologies, of transport and ensiling habits of forage, by the diversity of nutritions' components (in which selection the price-value ratio has a major role as well) and quality standards (which should be considered in different stages of swine growth), or by the differences of watering.

Direct consumption of swine's drinking water is changing at different stages of its life in proportion to the live weight and the water demands of sows even differ from these. There are technologies to measure the storage of environmentally harmful and/or pollutant liquid end-product from metabolism but their application may vary like keeping technologies. Measuring household swine water demand is difficult; probably there is no separate water meter for this.

My oriental calculations for the estimation of the pork water footprint are shown below. According to the KSH calculated data approximately seven percent of the national swine stock is sow, so I did not deal highly with them, especially their water needs is highly dependent on their physiological trait.

On the count of swine water footprint the following assumptions have been calculated:

- Swines are kept in optimal conditions (vitality is good, no need for medical treatment, nutrients supply is nonstop, et cetera).
- Genotype and keeping technology are the same (such as comfort – crowd, lack of water or oxygen ...).
- Feed intake and feeding technology are optimal (for example, the regular feeding time, specific rations, et cetera).
- The quality of the food is the same as human's.
- Pork is a secondary product in terms of calculation, since processing is required – just like butter or sausage (*Chapagain* and *Hoekstra* 2003).

According to *Chapagain* and *Hoekstra* (2003) and the conversation with *Dr. John Gundel* (former college of Agricultural Economics Research Institute - Hungary) the following data were based on for the calculation.

- Live weight a full-grown swine: 120 kg
- Daily drinking water needs of adult swines: 7,5 l
- Daily drinking water needs of 5-month-old piglets: 6 l
- Daily technological water needs of adult swines: 40 l
- Daily technological water needs of 5-month-old piglets: 10 l
- The slaughter age is 10 months.
- The water requirement of the feed consumed by swines is suspected 50%.

The determination of the amount of feed consumed to reach adulthood is assumed linear growth in feed consumption. This quantity is multiplied by the appropriate crop types' specific water needs, so we get the data on daily virtual water consumption of animals. Following *Dr. Gundel* (2005) I did not dealt with "... such – in some conception possibly listed here – feeding technology issues as feed storage, processing, handling and distribution, chemical composition ...."

Methodology

The formula used to calculate according to *Chapagain* and *Hoekstra* (2003):

$$VWC_a = VWC_{drink} + VWC_{serv} + VWC_{food} =$$

$$= \frac{\text{water from drinking}}{W_a} + \frac{\text{water from servicing}}{W_a} + \frac{\text{water from feeding}}{W_a}$$

Where:
VWC_a = virtual water content of the live animal (m^3/ton)
VWC_{drink} = virtual water content of drinking (m^3/ton)
VWC_{serv} = virtual water content of keeping (m^3/ton)
VWC_{food} = virtual water content of feeding (m^3/ton)
water from drinking = consumed water with drinking (m^3)
water from servicing = used water for servicing (m^3)
water from feeding = consumed water with feeding (m^3)
W_a = live weight of animal (tons). In our case W_a = 0,12 t.

Table 2: Water from drinking

	Piglet	Swine
Age (month)	2	10
Daily consumption (l/animal)	2	7,5
Average daily consumption (l/animal)	4,75	

Source: own editing

From Table 2 can be calculated the average water demand of drinking, which is in this case (the average daily consumption [l/animal] x time [days] =) 1448,75 litres for a swine.

Table 3: Water from servicing

	Piglet	Swine
Age (month)	2	10
Daily consumption (l/animal)	5	40
Average daily consumption (l/animal)	22,5	

Source: own editing

From Table 3 can be calculated the average water demand of servicing, which is in this case (the average daily consumption [l/animal] × time [days] =) 6862,5 litres for a swine.

Table 4: Water from feeding

Crop	Food quantity (tons/year)			SWD (m^3/t)	Crop water requirement (m^3/year)
	Swine	Piglet	Average food quantity		
Barley	0,39	0,003	0,197	247	48,7
Peas	0,018	–	0,009	1879	16,9
Wheat	0,069	0,001	0,035	898	31,4
Corn	0,221	0,013	0,117	731	85,5
Total	0,698	0,017	0,358		182,5

Source: own editing

Where:
SWD = specific water demand
(plant water requirement [m^3/month] / plant yield [t/ha])

SWD result has been counted according to CropWat calculations from KSH and FAO data. The estimates of the quantities of feed based on *Chapagain* and *Hoekstra* (2003) calculations.

From Table 4 can be seen that the annual water consumption of swine is 182,5 m^3. The water consumption of animal feed can be extracted from this data, which is in our case (age of animal [year] × annual water consumption from feed [m^3/year] =) 152,1 m^3.

Table 5: Water use for prepare feed

	Average	
Food quantity	0,358	ton/year
Used water of preparation (about 50%)	0,179	m^3/year
Total quantity (in the animal's life – 10 month)	0,149	m^3/animal

Source: own editing

From the results of Table 4 and Table 5 can be calculated the virtual water content of swine feed (152,1+0,149=) 152,25 m^3/animal.

According to these the virtual water content of pork is found below:

$$(1448{,}75 / 0{,}12) + (6862{,}5 / 0{,}12) + (152{,}25 / 0{,}12) = \\ = 1\,338\,010 \text{ (l/t)}$$

This means that about 1338 m^3 of water is required to the "production" of 1 ton of swine. This calculation is illustrating actually the direct water demand of the process. *Chapagain* and *Hoekstra* (2003) estimate that worldwide average of this value is 3,5 m^3/kg. The above finding also inferred that direct drinking water consumption is low, less than 1% of this value and the technology water consumption is hardly more than 4%. Water content of consumed plants is responsible almost 95% of the virtual water content of 1 kg "swine".

Counting on the calculation above water footprint of 1 kg pork (VWC_p) with help of the amount of virtual water content of live animal (VWC_a) and process water requirement (PWR) can be figured out. [$VWC_p = VWC_a + PWR \times (vf/pf)$] Based on *Chapagain* and *Hoekstra* (2003) processing water demand was calculated with 10 m^3/ton by the live weight of the animal.

Table 6: Product fraction and value fraction of swine products

	Product fraction (pf)	Market price (thousand HUF/t)	The value on 1 ton of live animal (thousand HUF)	Value fraction (vf)
Primary products: swine carcass				
Swine carcass	0,82	600	492	0,96
Edible offal	0,03	250	7,5	0,01
Fat	0,04	185	7,4	0,01
Skin	0,05	80	4	0,01
Total			**510,9**	
Secondary products: pork				
Pork	0,83	1250	1037,5	0,95
Eating fat	0,17	250	42,5	0,04
Total			1080	

Source: own editing according to Agricultural Economics Research Institute (Hungary), FHO and own estimation

From Table 6 can be estimated through swine carcass' water demand [(1338+10) x 0,96/0,82 = 1578 m^3/t] the water footprint of pork as well:

$$(1578+10) \times 0{,}95/0{,}83 = \mathbf{1818\ m^3/t}$$

Summarizing the above, we can say that virtual water content of 1 kg pork extracted from an (industrial range) 120 kg scaled swine as an example I took is 1,818 litres. That's almost double of the previously calculated value of 1 kg of bread.

IV. Results

The water footprint of bread has been successfully calculated at national level, this is 1014 l/kg. The investigation covered separately the seven statistical regions. As a result, I found that bread has the smallest water footprint at Western Transdanubia (847 l/kg), while the largest at Central Hungary (1290 l/kg). In addition, the context has become clear, that water footprint of flour is about the same as it is needed to produce finished bread.

Calculations proved and it is also shown above, that the largest water footprint of wheat is at Central Hungary of the seven statistical regions. South Transdanubia and Western Transdanubia have the best data.

The result of the domestic pork water footprint calculation is 1818 l/kg. In my experience the data required for these types of calculations have difficult availability.

Furthermore, it can be concluded from the calculations that the directly consumed drinking water is low, less than 1% and the technology is hardly more than 4% of the consumption of a swine. The consumed water content of plants is responsible for almost 95% of the virtual water content of 1 kg "swine".

V. Conclusions and recommendations

On reviewing the literature my conclusions, recommendations are the following:

1. Hungary would have to fulfil voluntary data service to the EU as soon as possible. If each member state do the same we can get a picture of our own competitiveness, because – although we know that only same properties can be compared – there is also a competition among different areas, regions.
2. In addition, we can get a more realistic picture of our position in terms of hydrology – both the Union and in Central and Eastern European region. As a result, more accurate forecasts can be made both economically and in terms of the effects of climate change, providing safer living conditions for residents.
3. The data got in this way may present current

disadvantaged areas in a novel approach, which could reduce the enormous economic and social differences at Hungary between the central region (Budapest and the agglomeration, Győr-Budapest axis) and 'rural' areas or the periphery.

4. As a result of more accurate and more widely available hydrological surveys should be recognized that in the (near) future Hungary can become a central, strategic area in hydrological sense. In my view, the spread of water footprint index could revalue current market prices of land and property. We have to make the best use of these positive potentials at national, regional and smaller regional levels.
5. The publicity of data service can not only serve community interests, gives also rise to exploiting speculations which can be influenced and should be kept at bay with adequate political infrastructure.
6. Water footprint calculations reveal a new dimension to agriculture, but we must recognize that the real bogeyman is the consumer himself. If one does not need clothes, coffee and other products coming from water-poor countries the global problem of water flow processes can be solved involving the local markets, which are closely related to sustainable consumption as well. At this point, pricing has a very important role with the support of local agricultural production to the local market. The key of this question is also in decision-makers hands.
7. In addition, spreading of voluntary standards systems across sectors (for example manufacturing, engineering, tourism, transportation) and appropriate information (developing sign and label system) related to water footprint would emphasis the liability of consumers and bring closer water footprint reduction case to the user.
8. However one must see that the responsibility of agriculture is not a few drops of water in the case of irrigation with fresh water. Building a non-potable irrigation-based structure could be considered, which even after the initial investment can be more cost-effective and sustainable than the current solution.

On the results my conclusions, recommendations are the following:

1. In my opinion, these few results now can clarify water resources in a new way as a national environmental one. Water footprint indicator encourages new thinking of sustainable consumption and careful use of environmental resources.
2. Most data come from foreign databases, which were concluded from international data (for example FAO data). These and the used generous estimations of CropWat program consistently make water footprint indicator inaccurate.
3. The adjustment of numerical values and replacement of the estimated data would significantly clarify existing results. It would be essential to clarify roundings, thus we could get a fuller picture as a result. Over or undervaluation could cause environmental problems, social conflicts and economic effects.
4. As I see this is based on highly responsible data service and database update both at national and international, for example, at EU level. If this would be resolved other nations' water footprint related results would be available for us.
5. Other products' water footprint calculations would make the current results more complete, and in correlation with each other would light the domestic production and consumption trends from a new perspective.
6. Based on the results, the water footprint of wheat should be reduced by the Central Hungarian region. New (irrigation) technologies could be introduced. Perhaps plants should be emphasised which growth has much less strain on water bodies, which are much more favourable to the local environmental conditions. In parallel, at the Southern Transdanubia and Western Transdanubia regions wheat cultivation should be encouraged to.
7. Activities related to bread production should be arranged at the Southern Transdanubia and Western Transdanubia regions where the main raw material is locally available to manufacturers. These may induce additional positive environmental, economical and social outcomes.
8. The need of efficient, "water-friendly" agricultural innovations (at local, regional and national level) is also supported by virtual water content of swine. The typically consumed crop of swine is responsible for 95% of direct and indirect water use. This rate, even if it is estimated is too large to ignore.
9. In my opinion (with the hope of total availability of necessary information), beside national water footprint calculation other calculations which are similar to mines can give a more complex and consistent picture of the domestic water consumption. This is important not just at sectoral level, but also gives important information about examined geographical, spatial, infrastructural, economical, technological, environmental, and sustainability issues.

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