Neubauer, Éva – Bakosné Böröcz, Mária[961]*:* **Water Allowance Coefficient as a tool for Hungarian water resource valuation**

Introduction

This publication exists as part of a greater research work. The project was no smaller than monetary valuation of Hungarian fresh water natural resource.

Optimizing tasks and working out effective strategies in connection to water resources goes back to historical ages because civilisation or cultural centres of humanity are settled down and developed near some kind of water body for generations. Economic approach of water management today is greater than before. The elementary growth of the number and needs of humanity, the growing rate of priority of sustainability in market mechanisms, the global climate change etc, are all request responsible answers and decisions from us considering water both in the present and future. Related to water usage externalities are significant in consumption habits of households, industrial water withdrawal, agricultural irrigation and livestock production also in relation to water treatment.

This is a global phenomenon. In those places where marginal costs of water exploitation and usage are beyond political boarders the existing water need satisfaction can be provided more economical from abroad. This can lead to sensitive diplomatic co-operations and market relations by showing transnational economic and social processes as well as dependency. This could be also true for relations between areas within national borders. In terms of sectors for example central support, taxation and regulation system and market incentives, the agricultural irrigation have big impact on water consumption and contamination. Thus in terms of water either horizontal or vertical cross-ties cannot be ignored. This means that optimizations and efficiency improvements related to water management can show further additional beneficial effects for example in reducing energy consumption, cutting back on carbon dioxide emission by the spread of the so-called low-carbon mechanisms or promoting adaption to climate change.

So it is necessary also from the point of water to ecological and social benefits be significantly appeared beside economic profitability. Optimization of water management and water use is necessary at all times, where centralised methods are inefficient the demand driven water resource management which can be understandable by market also can be interpreted. It is acceptable, that economic values and prices appear between availability and usage.

Natural resource valuation methods

When someone decides to scan and evaluate a natural resource, in our case water, she can choose from several existing methods depending on the aim of her investigation. The most important of these are the followings.

Total Economic Value (TEV)

TEV includes all reasons why people may attribute a value for a natural resource. Its parts belong to Marjainé[962]:

<u>Use values</u>: these are the value ingredients which are derived from the actual use of the environment. This use can be direct or indirect, present or future.

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[962] MARJAINÉ Sz. Zs. (2001): *A természeti erőforrások pénzbeli értékelése*, Közgazdasági Szemle XLVIII. évf., 2001. február, Budapest, Közgazdasági Szemle Alapítvány, pp 114–129.

- *Direct and indirect values* are related to present and future use of the resource.
- *Option value* expresses the preference if the resource is not used in the present; it is supported to be prevented for the opportunity of potential use in the future.

Non-use values: these are based on the assumption that people attribute monetary value to natural resources even regardless to their usage.

- Consists: *existence values*, *preservation values* or *non-use values*.
- Quasi option value is based on the assumption if a natural resource is not preserved, we lost values are not currently aware of, but with the growth of science and our knowledge those become evident in the future. Quasi option value is transition between use and non-use value components.
- *Heritage value* is attributed to preserve environmental resources for future generations even if we ourselves do not want to use them neither today nor tomorrow.
- *Pure existence values* include those which would lose if the resources cease to exist.
- In other category values are listed which are associated with the resources still exist, but degradation occur in their quality or volume.

There experts who attribute a so-colled *primary value* for the complete ecosystem. Thus discussed use and non-use values are listed in *secondary values* (*Table 1.*).

Table 1.: Summary table of economic valuation hierarchy

Value components					
Primary values	Secondary values				
	Total economic value (TEV)				
	Non-use values		Use values		
	Heritage value preserve for future generations	**Existence value** every living being has right for exist independently from humanity	**Direct use** hunting, fishing, logging, recreation ...	**Indirect use** protection against erosion, reduce flood risk, carbon sequestration ...	**Option value** ensure possibility of future use

Source: own editing according to Marjainé[963]

[963] MARJAINÉ Sz. Zs.: op. cit. 2.

Table 2. summaries the methods of TEV estimation above and classifies those by different dimensions.

Table 2.: Methodological foundations of TEV

Based on demand curve				**Not on the basis of demand curve** (meant for effect)
Stated preference		Revealed preference		
Indirect	Direct	Indirect	Direct	
Conditional choice	Conditional valuation	Travel cost method	Market prices	Lost income
Conditional ranking		Hedonic price method	Artificial market	Replacement cost
		Income differences		Substitute market goods
		Cost approach		Shadow project method
				Defence cost
				Change in porductivity

Source: own editing according to Marjainé[964]

Demand curve based elements of *Table 2.* are able to estimate values of natural resources in manageable ways for economic theories as not demand curve based methods, so these has particular importance in monetary valuation of natural goods. [965]

Monetary valuation methods

Revealed preference methods

According to Kerekes[966] and Marjainé[967] we can define some revealed preference methods. These methods are based on current behaviours. One can estimate the demand for or the value of the natural resource by the real actions of consumers which are already taken place.

Travel cost method

Commonly one's assumption is based on that time is money. From this approach, one have to calculate in case for example a lake, a river, an aqua park or a spa how much is to arrive, to enter and to be there, getting home and in addition work is not processed. By collecting these data from the visitors one can prepare the demand curve, which can serve the base of examination like how quality changes of the destination change its demand.

Hedonic price method

[964] MARJAINÉ Sz. Zs. (2000): *A természeti erőforrások monetáris értékelésének lehetőségei Magyarországon, különös tekintettel a feltételes értékelés módszerére*, PhD. értekezés, BKÁE, Budapest.
[965] MARJAINÉ Sz. Zs.: op. cit. 4.
[966] KEREKES S. (1995): *A környezetgazdaságtan alapjai*, Budapest, Aula Kiadó, pp. 126.
[967] MARJAINÉ Sz. Zs. (szerk.) (2005): *A természetvédelemben alkalmazható közgazdasági értékelési módszerek*, A Környezetvédelmi és Vízügyi Minisztérium Természetvédelmi Hivatalának tanulmánykötete, BCE-KTT, Budapest, ISBN 963 218 307 x

When one examines the factors that affect price of a certain property (such as infrastructure, quality, neighbourhood...) and the properties sold in the area than she can calculate how much is the role of the environmental factor in the real estate price trends by a multivariate linear regression model that is determinates the value of natural environment (for example natural endowments, environmental pollution, distance to water, etc.).

This method has several statistical problems, such like the data are difficult to collect and in addition large numbers of variables are required to describe the difficult problem; with this it is cannot be ensured that variables are independent from each other, but these statistical difficulties are usually eliminated.

Income differences

For certain additional income employee agrees to work under health risk due to hazards of the workplace. If all the factors are disabled except from the environmental one, one can get the effect of the environmental factor on incomes. This method assumes free movement of workers. And wages contain ingredients that relates to environmental quality and dangerous nature of jobs.

Stated preference methods

In general, these methods are based on suspected reactions on hypothetical situations, not on real market behaviour.

Conditional valuation

This method is based on interviews on how much people are willing to pay for a certain benefit (for example for cleaner fresh water) or how much they willing to accept, how much compensation they need to be paid for the deterioration of the environmental quality. The results of this method are affected by both the interviewer and respondent. Reliability of results must be examined and should only be accepted if the same results are obtained using other methods or cross-analysis.

Conditional choice

This method is contains analysis of choice situations of certain characteristics of a given environmental good. Different features and their different levels (including 'price') are used for describing the situations. Respondents are then asked to choose the 'package' or situation which is most appreciated.

Conditional ranking

Respondents are given cards on which there are different quality levels of the environmental good along with other factors that are influence the choice. Respondents are asked to rank the situations on cards according to their preference. The value of the environmental good or its qualitative changes can be calculated by the rankings.

Before one decides which of the methods will be used in the main research she has to think, by following Marjainé[968] that 1) for what kind of decision making process does she want to use the results, 2) how much money and time is available for the research and 3) which components of the Total Economic Value are dominant in the decision making process.

Water Footprint and Water Allowance Coefficient

Water footprint is a relatively new environmental economic index, which shows new side of processes related to water consumption, use, and virtual water flows both at the national and

[968] MARJAINÉ Sz. Zs.: op. cit. 2.

international level. The development of the methodology is connected to the Dutch professor Hoekstra. The structure, the composition of water footprint is different from casual water withdrawal indicators, since it has three main factors. Green water footprint refers to the consumption of the total rainwater evapotranspiration (from fields and plantations) and the water incorporated into the harvested crop or wood. Blue water footprint shows the consumption of surface and groundwater. Grey water footprint refers to pollution with the quantity of water required to dilute pollutants. During the water footprint calculation these are combined and completed with the basic processing water needs of each step of the production process. Water footprint is the absolute amount of freshwater which is used during the production of a product or a service, and also includes the measurement of polluted water. This indicator makes integrated complex, horizontal and vertical sectoral data multifactorial assessment procedures possible. Whit its application previously unknown, sometimes even unsuspected economic, social and political correlations could come to light, which are approaching our personal and social attitudes related to water in a new way.[969] Researches of this direction may reveal the absolute water need of a product production throughout the total product life-cycle. The index shows the actual, direct and indirect water usage measured on the whole value chain – only valid for the given area and period. It can be calculated for a product, a consumer, a company, a nation or group of these and a geographic area.

Water Allowance Coefficient (WAC) can be described as availability potential of freshwater resource. It has been worked out by further thinking the estimation system of water footprint. In point of Hungary, it is based and foregone by national water footprint estimations of wheat production by Neubauer[970]. Based on these a Water Allowance Coefficient (WAC) was concluded that can be determined mainly at regional level. Water Allowance Coefficient is formed according to the equation below:

$$WAC_i = \frac{100}{WF_{wheat,i}\ \%}$$

where:

WAC_i = Water Allowance Coefficient, based on wheat water footprint changes at region *i*.

$WF_{wheat,i}$ = Changes of wheat water footprint at region *i*, %.

The regional value of WAC is between zero and one ($0 < WAC_i < 1$), if value of water footprint of wheat produced in the region is higher, unfavorable than the national value ($WF_{wheat,i} > WF_{wheat,nat}$). If regional wheat water footprint is less, favorable than the national estimation ($WF_{wheat,i} < WF_{wheat,nat}$), it shows value above one ($WAC_i > 1$). The lower the Water Allowance Coefficient in a region, which is the closer to zero is, the more unfavorable the assessment of water resources availability at there. In other words, larger values of WAC increase the monetary value of available water resources in a given region (*Table 3.*).

[969] NEUBAUER É. (2010): *Vízlábnyom Magyarországon*, Tudományos Diákköri Konferencia dolgozat, Szent István Egyetem GTK RGVI. Eredmények publikálva in: FOGARASSY Cs. – NEUBAUER É. (2011): Vízgazdaságtan, avagy a vízlábnyom mérése és gazdasági összefüggései, in: TAMÁS P. – BULLA M. (szerk.) (2011): *Sebezhetőség és adaptáció a reziliencia esélyei*, MTA Szociológiai Kutatóintézet, Budapest, pp. 215–236.

[970] NEUBAUER É.: op. cit. 7.

Table 3.: Water Allowance Coefficient, based on water footprint change of wheat, by type and region, Hungary = 1.

Region	Water footprint change based Water Allowance Coefficient (WAC)			
	WAC*green*	**WAC*blue***	**WAC*grey***	**WAC*total***
	$\frac{\mathbf{100}}{\mathbf{WF}\mathit{green}\%}$	$\frac{\mathbf{100}}{\mathbf{WF}\mathit{blue}\%}$	$\frac{\mathbf{100}}{\mathbf{WF}\mathit{grey}\%}$	$\frac{\mathbf{100}}{\mathbf{WF}\mathit{total}\%}$
Southern Great Plain	1,01	0,76	0,99	0,91
Northern Great Plain	0,88	0,94	0,86	0,89
Southern Transdanubia	1,04	1,23	1,23	1,14
Western Transdanubia	1,12	1,39	1,11	1,19
Central Transdanubia	1,12	0,96	1,04	1,05
Northern Hungary	1,03	1,45	0,93	1,11
Central Hungary	0,76	0,81	0,81	0,79
Hungary average	**1,00**	**1,00**	**1,00**	**1,00**

Note: WAC*green*, WAC*blue*, WAC*grey*: green, blue and grey Water Allowance Coefficient
Source: own calculation

Results by WAC

Water assessment as natural resource starts, at this point, to connect to market price of water, because certain monetary value must be assigned to the developed coefficient. Therefore, a basic consumer price of water consumption values of national users has been determined. According to the database of CSO[971] the average consumer price of water consumption was 331 HUF/m^3. Equation changes like:

$$\bar{\bar{X}}_{p,irr,i} = \bar{\bar{X}}_{irr,i} \cdot \bar{\bar{X}}_{p,cons}$$

where:

$\bar{\bar{X}}_{p,irr,i}$ = Average price of irrigation water at region *i* per hectare (HUF/ha).

$\bar{\bar{X}}_{irr,i}$ = Average volume of irrigation at region *i* (m^3/ha).

$\bar{\bar{X}}_{p,cons}$ = Average consumer price of water (331 HUF/m^3).

By linking Water Allowance Coefficient results (*Table 3.*) and its water value to be adjusted, regional values corrected by Water Allowance Coefficient, complemented by green, blue and gray coefficient values, can be calculated as results of following (*Table 4.*):

$$AWV_{total,i} = WAC_{total,i} \cdot \bar{\bar{X}}_{p,irr}$$

where:

$AWV_{total,i}$ = Adjusted total (or green, blue, grey) water value of Water Allowance Coefficient (HUF/ha) at region *i*.

$WAC_{total,i}$ = Total (or green, blue, grey) Water Allowance Coefficient at region *i*.

$\bar{\bar{X}}_{p,irr,i}$ = Average market price of irrigation water per hectare at region *i* (HUF/ha)

[971] *3.6.3. Egyes termékek és szolgáltatások éves fogyasztói átlagára (1996–)*, Táblák (STADAT) www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_qsf003b.html

Table 4. Values of adjusted, corrected Water Allowance Coefficient by regions and types (AWV) (HUF/ha)

Region	Adjusted values of WAC (HUF/ha) (AWV)			
	AWV*green*	**AWV*blue***	**AWV*grey***	**AWV*total***
Central Hungary	305 226	325 307	325 307	**317 275**
Central Transdanubia	254 561	218 195	236 378	**238 651**
Western Transdanubia	298 265	370 168	295 602	**316 906**
Southern Transdanubia	214 462	253 642	253 642	**235 083**
Northern Hungary	252 591	355 590	228 068	**272 210**
Northern Great Plain	348 047	371 778	340 137	**352 002**
Southern Great Plain	378 848	285 073	371 346	**341 338**

Note:

AWV*green*, AWV*blue*, AWV*grey*, AWV*total*: green, blue, grey and total water value according to Adjusted Water Values of Water Allowance Coefficient values.

The gained results may show little distortion due to rounding errors.

Source: own calculation

Further values in relation to Adjusted Water Value types appeared form *Table 4.*, which are determined by average consumer prices on a hectare. From these turned out, that value of rain water at Southern Transdanubia is the lowest while Southern Great Plain the highest. It also turned out, that value of irrigation water measured on average consumer, price compared to the other regions and their values, is very favourable at Central Transdanubia, 218 195 HUF/ha. The next favourable value of this type is about 35 000 HUF/ha higher than it, and the most expensive Adjusted Water Value of irrigation water are at Western Transdanubia and Northern Great Plain (370 168 and 371 778 HUF/ha). From the table it is also clearly seen that the value of water need for dilute pollutant water, which is actually an indirect water need, is the lowest in Northern Hungary and the highest in Southern Great Plain.

Table 5. Aggregate value of water used for agricultural production, which is based on average price of water consumption, Hungary

Type of **Adjusted Water Value**	**Water Allowance Coefficient** based on changes of Water Footprint (WAC) (100/WF%)	**Value of water used for agricultural production** on a hectare, based on average price of water consumption (HUF/ha) (AWV)	**Aggregated adjusted value** of Water Allowance Coefficinent on Hungary (HUF) (AWVagg).
AWV*green*	0,47	170 920	912 369 518 740
AWV*blue*	0,32	116 371	621 187 757 440
AWV*grey*	0,21	76 368	407 654 465 820
AWV*total*	**1**	**363 659**	**1 941 211 742 000**

Source: own calculation

From the results of *Table 5.* the aggregated total water values of Hungary, on the basis of agricultural water use, by on water footprint calculations based adjusted values of Water Allowance Coefficient can be seen. According to these value of rain water (green water) is close to 912.5 billion forints. The values of irrigation water (blue water) is more than 621.18 billion forints and the volume of dilute water need (grey water) is over 407.65 billion forints. According to this estimation, the national aggregate water value is more than 1 941.211 billion forints.

Discussion

As it seen from the review of references of general methodology related to natural resources it has been proved that the widespread assessment processes are not able to evaluate water as a natural resource. Water Allowance Coefficient is able to demonstrate the total value of water and its types. For example as a correction co-factor of land valuation, at the right place, it may change land prices regarding to the green, blue and grey components. Using AWV may also cause interesting, unexpected results at industry and the tertiary sector. However, urbanisation effect calculations must be considered, which can be reflected, for example, by population density data involvement as a limitation factor. These opportunities are challenging, it is expected to meet them as results of further researches.

Summary

I took the opportunity of the 5th Báthory-Brassai Conference to introduce Water Allowance Coefficient (WAC) and its results as part of a main research of Szent István University about valuation of Hungarian natural resources. The idea of WAC is based on previous water footprint calculations related to Hungarian wheat production from the year 2010. According to this the entire absolute freshwater need of producing 1 kg wheat is 1 268 l. This estimation is the Hungarian average, but regional data also known and used for further calculations. We have divided hundred by the resulted values thus have determined WACs. The next step was giving a value, which was the average consumer price of water according to CSO (331 HUF/m^3). From these data we have calculated Adjusted Water Values (AWV). Finally it is turned out, that for example the value of water used for agricultural production is about 363 659 on a hectare on Hungary as an average, but regional data are differing from it. WAC based aggregated AWV in Hungary is over 1 941.211 billion forints. Value of rainwater (green water) is close to 912.5 billion forints. Value of irrigation water (blue water) is over 621.18 billion forints, the value of water need for dilute polluted water (grey water) is more than 407.65 billion forints.

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