How to estimate the value of water?
Methodology of calculating the gros margins and the water footprint in agriculture

Katarzyna Bańkowska
European Regional Centre for Ecohydrology
PAS

Waterdrive
Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
WITH FINANCIAL SUPPORT OF THE RUSSIAN FEDERATION

Different perspectives of water value

Value of the water source - in this aspect it is about the valuation of the resource which is water and access to it, but also about the context of the environment, the state of water quality and the impact of ecosystem services on water resources.

Value of water infrastructure - from this perspective, we can evaluate all devices for storing and transporting water - not only in terms of investment, but also in terms of maintenance and operation.

Value of water services - universal access to water to provide drinking water, health and hygiene in places of residence and work - in developed countries this is generally a cost incurred by the state in the interest of its citizens and their access to water as a good ensuring a decent living.

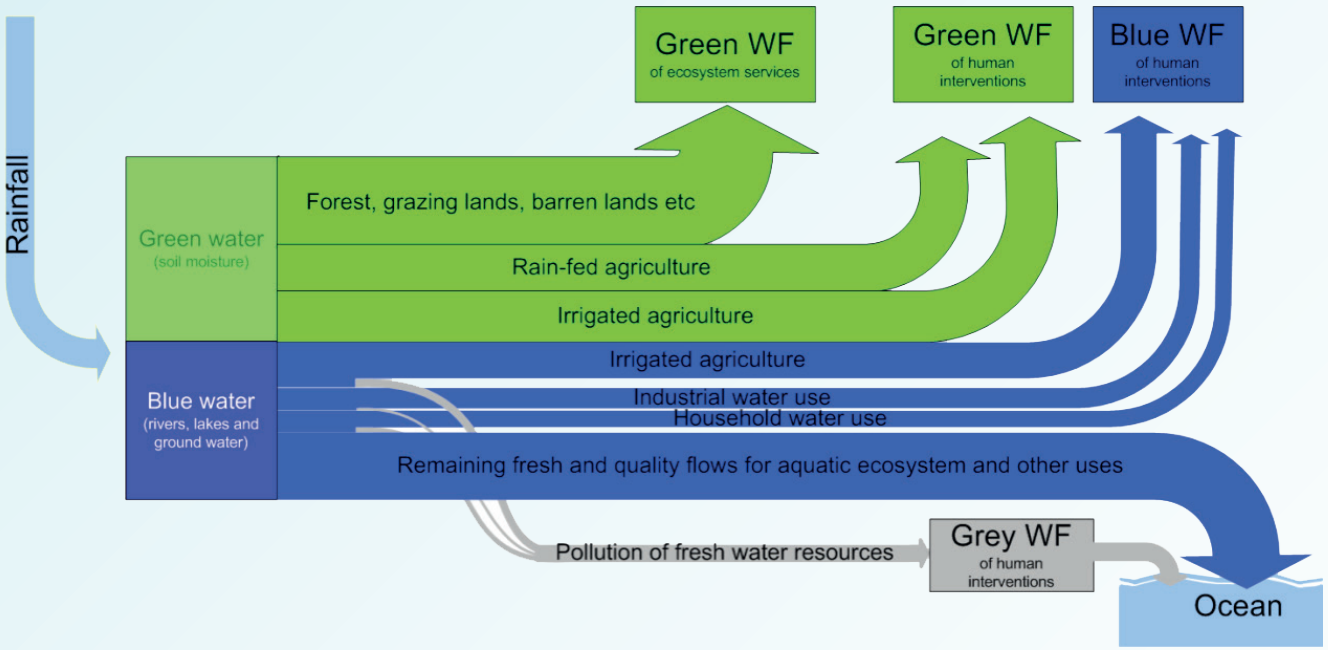
Economic value in the production process - depending on the sector of the economy, the perception of water resources as a production cost / input varies. Agriculture and food production are the sectors with the highest share in the global use of drinking water.

Cultural and social value - Depending on the cultural circle, the perception of the value of this resource differs. The psychological perception of water is different in regions with a constant water deficyt and others in countries where its respect may result not so much from accessibility for the citizen but from the dependence of the economy on water use The perception of the value of water may result from historical conditions, religion, beliefs and mentality, but also from economic interests and issues of security and sovereignty of a given state.

Further considerations focus only on the economic value of water in the production process that occurs in agriculture

SOURCE | The United Nations world water development report 2021: valuing water

Water footprint



A water footprint (WF)* is a multidimensional indicator that looks at both direct and indirect water use of a consumer or producer and that can show water consumption volumes by source and polluted volumes by type of pollution.

Water footprint is expressed in the volume of water used per ton of product produced during one year.

WF is the sum of 3 components:

Water footprint (WF) = Green WF + Blue WF + Grey WF

SOURCE | Mekonnen, M.M., Hoekstra, A.Y. 2010. The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands. **Chapagain, A.K. and Tickner, D. 2012. Water footprint: Help or hindrance? Water Alternatives 5(3): 563-581

Green water footprint in plant production

Green water footprint

Water consumed from rainwater insofar it doesn't become runoff

https://www.greeneconomycoalition.org/news-and-resources/promoting-water-sustainability-of-financial-institutions

Green WF is the volume of green water (rainwater) consumed and is a proxy for the volume of soil moisture used by rain-fed cropping. It is equal to the volume of water lost through evapotranspiration during crop growth.

How to reduce the green water footprint of crop production*:

- Increase total production in rainfed agriculture
- Reduce yield gaps (especially in the eastern EU zone)
- Improve in situ soil and water management techniques

SOURCE | Vanham D., Bidoglio G. 2013. A review on the indicator water footprint for the EU28. Ecological Indicators 26: 61-75

Blue water footprint in plant production

Blue water footprint

Water consumed from surface water (lakes and streams) and groundwater

Blue WF refers to consumption of blue water resources (water collected from rivers, lakes, ponds and groundwater). Typically, blue WF consists of irrigation water. The uptake of these waters reduces the water resources in the catchment area.

How to reduce the blue water footprint of plant production:

- Increase of irrigation efficiencies (eg. drip instead of sprinkler irrigation)
- Replace original crop choice to others better fitting climate conditions
- Approprite timing and quanification of water delivery

https://www.greeneconomycoalition.org/news-and-resources/promoting-water-sustainability-of-financial-institutions

Grey water footprint in plant production

Gray water footprint

Water needed to dilute pollutants down to safe concentrations

https://www.greeneconomycoalition.org/news-and-resources/promoting-water-sustainability-of-financial-institutions

Grey water footprint is a hypothetical volume of water necessary to dilute the pollutants introduced into the environment as a result of production to such an extent that the water quality does not exceed the established water-quality. Not all grey water is derived from blue water; soil leaching means that rain-fed agriculture can have a grey WF too.

How to reduce the grey water footprint of plant production:

- Reduce use of artificial fertilizers and pesticides
- More effective application - precision agriculture
- Economic instruments for agricultural bleu water demand management include appropriate pricing

Grey WF is zero for organic farming!

Example water footprint of crop production

Crop	Green WF [m3/t]*	Blue WF [m3/t]*	Grey WF [m3/t]*	Global average WF [m3/t]*	WF in dolnoslaskie voivodship, Poland [m3/ha] **
sugar beet	82	26	25	132	10 739
sunflower	3 017	148	201	3 366	10 098
rapeseed	1 703	231	336	2 271	4 519
soybean	2 037	70	37	2 145	2 145
mustard seed	2 463	1	345	2 809	2 809
bean	3 945	125	983	5 053	5 053
chickpea	2 972	224	981	4 177	4 177
Clover, lupine, alfalfa	1 063	0	0	1 063	2 674
cherry	961	531	112	1 604	7 803
plum	1 570	188	422	2 180	7 178
pear	645	94	183	922	5 624
apple	561	133	127	822	4 684
currant	457	19	23	499	3 409
strawberry	201	109	37	347	3 101
fodder pumpkin	228	24	84	336	20 160
fodder beet	82	26	25	132	10 739

SOURCE | Mekonnen M.M. & Hoekstra A.Y. 2011. The green, blue and grey water footprint of crops and derived crop products. Hydrol. Earth Syst. Sci., 15: 1577–1600 **Burszta-Adamiak E.& Fiałkiewicz W. 2018. Ślad wodny jako wskaźnik zużycia zasobów wodnych w produkcji roślinnej na terenie województwa dolnośląskiego Inżynieria Ekologiczna 19: 71-79

Example water footprint of crop production

Crop	Green WF [m3/t]*	Blue WF [m3/t]*	Grey WF [m3/t]*	Global average WF [m3/t]*	WF in dolnoslaskie voivodship, Poland [m3/ha] **
pumpkin, zucchini, squash	228	24	84	336	20 160
potato	191	33	63	287	7 693
onion	176	44	51	272	4 164
cabbage	181	26	73	280	3 462
cucumber	206	42	105	353	3 217
tomato	108	63	43	214	2 916
parsley, carrot, leek	106	28	61	195	1 731
spring and winter wheat	1 277	342	207	1 827	8 696
maize	947	81	194	1 222	7 243
winter barley	1 213	79	131	1 423	6 401
spring barley	1 213	79	131	1 423	6 401
spring rye	1 479	181	128	1 788	4 818
winter rye	1 419	25	99	1 544	4 818
oat	1 479	181	128	1 788	4 428

SOURCE | Mekonnen M.M. & Hoekstra A.Y. 2011. The green, blue and grey water footprint of crops and derived crop products. Hydrol. Earth Syst. Sci., 15: 1577–1600 **Burszta-Adamiak E.& Fiałkiewicz W. 2018. Ślad wodny jako wskaźnik zużycia zasobów wodnych w produkcji roślinnej na terenie województwa dolnośląskiego Inżynieria Ekologiczna 19: 71-79

Agricultural economic calculations: Gross margin

- In agricultural calculations, one of the categories used to compare the economic effects of crops is the gross margin
- When deciding what to sow on the area owned, in order to obtain the highest possible income in the economic calculation (if other factors such as crop rotation, soil quality, availability of labor, knowledge of technology, etc. allow it), the farmer should choose a crop from an economic point of view with the highest gross margin.
- By extending the gross margin account with the estimated cost of water calculated on the basis of the above-mentioned water footprint tables it is possible to try to theoretically estimate the influence of the water footprint on the profitability of the production of a given plant

https://blog.familyfarmsgroup.com/managin
-agricultural-economics-in-todays-market

Example of calculating the gross margin

Calculation for grain maize, acreage 1 ha

	Specification	Measure unit	Price [PLN]	Quantity	Amount [PLN]
Revenue	product	dt	61	85	5 185.00
	subvention	PLN/ha			807.64
Costs	seeds	j.s	460.3	1,8	828,54
	fertilizers				1 194.18
	chemical protection				506.16
	harvest				400.00
	Fuels and lubricants				433.35
Gross margin					**2 630.41**

An attempt to estimate the value of water in the profitability calculation for cultivation

	Specification Water Cost	Measure unit	Price [PLN]	Quantity Water footprint [m3 per ha]	Amount [PLN] The theoretical cost of water
Costs	Option 1: price of tap water	PLN/m3	4.18*	10 387	43 417.66
	Option 2: rate for water services for groundwater agriculture	PLN/m3	0.068**	10 387	706.32
	Option 3: the rate for surface water services	PLN/m3	0.040**	10 387	415.48

NOTE: The authors are aware that it may be questionable to adopt the same price rate for the total water footprint (WF) without differentiating the proportions between the green, blue and gray footprint - nevertheless, the example presented here is only to illustrate the principle of the proposed calculations

SOURCE | price of 1 m3 of tap water for Łódź City: http://www.cena-pradu.pl/woda.html
** national regulation: https://sip.lex.pl/akty-prawne/dzu-dziennik-ustaw/jednostkowe-stawki-oplat-za-uslugi-wodne-18669415

Gross margin less the cost of water

Costs	Specification	Measure unit	Price [PLN]	Quantity	Amount [PLN]
Gross margin					**2 630.41**
Gross margin with Option 1: price of tap water					**-27 645.30**
Gross margin with Option 2: rate for water services for groundwater agriculture					**2 137.89**
Gross margin with Option 3: the rate for surface water services					**2 340.69**

Interpreting the obtained result, it can be stated that the inclusion in the profitability calculation of the value of total water inputs needed to obtain a certain level of yield from 1 hectare significantly changes the economic result of a given crop. The adoption of the water valuation at the level of tap water prices indicates that the crop is unprofitable (negative result) This method opens up the possibility of conducting many more calculations, in which we can change the proportion of different water sources used. This would constitute the basis not only for the monetary valuation of the water absorption by the crop, but also for the calculation of the profitability of investments regarding the sources of irrigationfor crops.

How to estimate the value of water?
Methodology of calculating the gros margins and the water footprint in agriculture

Katarzyna Bańkowska
European Regional Centre for Ecohydrology
PAS