



## Quantification of Israel's virtual water fluxes

### Key findings

- 1,806 MCM of virtual blue water and 6,498 MCM of virtual green water were used in the production of 100 crops consumed in Israel in 2005.
- From total blue water consumption, 1,044 MCM originated from Israel's domestic production.
- Israel exported 132 MCM of virtual blue water. This represented 11.3% of the total blue water used for Israel's agricultural production.
- For domestic consumption, wheat had the highest virtual water volume, followed by maize. Regarding exports, potatoes and dates were highest.

### Motivation

This study focuses on Israel's crop water use. It takes into account crop imports as well as Israel's domestic crop production in quantifying green and blue water use in a spatially explicit manner. Different crops are associated with varying rates of water use. Spatial variation is introduced by factors such as climate, soil type, yields, irrigation techniques, and water sources.

There are multiple public databases containing water volumes consumed per ton of crop on country and watershed levels. This study primarily uses the watershed-scale Pfister and Bayer (2014) data (PB). We compare it to Mekonnen and Hoekstra (2011) Water Footprint Network (WFN) data to illustrate the differences between the two databases. Israel is a particularly interesting case study due to its relatively high blue water use per capita, while also importing virtual water to maintain water and food security. Analysis is also carried out at finer spatial scales (grid cell and watershed levels) to identify hotspots of water use within countries as well as individual crops that are heavily represented in the overall virtual water budget.

### Methodology

We analyzed the virtual water use of 1) imports and domestic crop production for consumption in Israel and 2) Israel's crop production for export. In the first step, global data on water use (Million Cubic Meters (MCM) of green and blue water per ton of primary crop equivalent) was applied to production data (in tons) to derive blue and green water use by crop. The primary crop production dataset is from 2005 and consists of bilateral trade and

production data relating to 142 crops, as defined by the Food and Agriculture Organization of the United Nations (FAO), and 239 processed products. The dataset producers (Fridman & Kissinger, 2018) used an origin-tracing algorithm to assign import flows to the original countries of production. We combined the trade data with the PB database on water use at the watershed level to calculate water volumes in MCM. The main analysis is limited to some of the 'thirstiest' countries and crops. Data processing was mainly done with ArcGIS and Microsoft Excel.

### Virtual water content

"The water footprint of a product (alternatively known as 'virtual water content') expressed in water volume per unit of product (usually m<sup>3</sup>/ton) is the sum of the water footprints of the process steps taken to produce the product" (Mekonnen & Hoekstra, 2011). In this study, we take into account global data on green (precipitation) and blue water (surface and groundwater) in Million Cubic Meters per ton of primary crop equivalent.

## Results

1,806 MCM of virtual blue water and 6,498 MCM of virtual green water were used in the production of all crops consumed in Israel in 2005. From total blue water consumption, 1,044 MCM originated from Israel's domestic production. At the country level, Israel's production for domestic consumption accounts for approximately 58% of blue water volume across all crops while it only covers 36% in terms of crop production tonnes. Wheat was the dominant crop with 22% of the total volume of Israel's blue water consumption. Maize was second at 7%, followed by apples, olives, soybeans, and sunflower seeds. In 2005, Israel exported 132 MCM of virtual blue water. This represented 11.3% of the total blue water used in Israel's agricultural production. Potatoes, dates, grapes, and olives were particularly relevant. The two data-

sets resulted in largely different water volumes: For wheat, the PB data resulted in 405 MCM, the WFN data in only 63 MCM of blue water. Overall, the WFN data yielded lower blue water volumes (1,083 MCM compared to 1,806 MCM), while the opposite was true with respect to green water (9,161 MCM compared to 6,498 MCM).

## Application

These analyses produce data with which Israel can refine a strategy of regional optimization, decreasing its dependence on blue water, minimizing groundwater depletion, and avoiding imports from blue water hotspots. The approach demonstrated here is applicable to any other country in the world. However, there is high uncertainty with respect to water volumes data due to low temporal and spatial resolutions. Including green water

demonstrates the degree to which watersheds from which crops are imported to Israel rely on blue water as a share of total water use. This information provides useful insights for regional optimization, including choosing alternative suppliers from other watersheds or

## References

- Fridman, D., & Kissinger, M. (2018). An integrated biophysical and ecosystem approach as a base for ecosystem services analysis across regions. *Ecosystem Services*, 31, 242-254. <https://doi.org/10.1016/j.ecoser.2018.01.005>
- Mekonnen, M.M., & Hoekstra, A.Y. (2011). The green, blue and grey water footprint of crops and derived crop products. *Hydrology and Earth System Sciences*, 15, 1577-1600. <https://doi.org/10.5194/hess-15-1577-2011>
- Pfister, S., & Bayer, P. (2014). Monthly water stress: Spatially and temporally explicit consumptive water footprint of global crop production. *Journal of Cleaner Production*, 73, 52-62. <https://doi.org/10.1016/j.jclepro.2013.11.031>

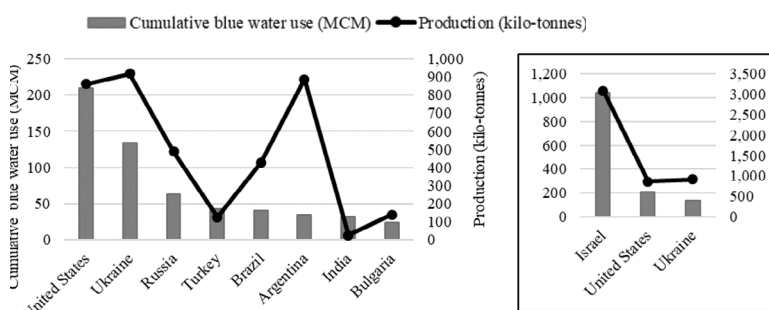


Figure 1: a) Blue water use in million cubic meters and crop production in kilo-tonnes for countries exporting to Israel and b) Comparison of Israel, United States and Ukraine

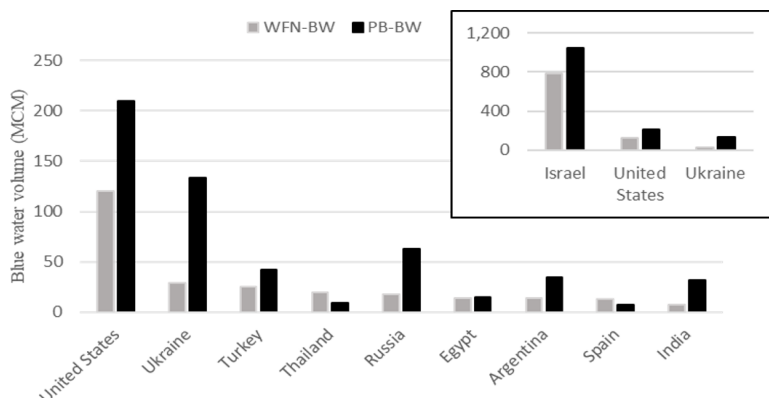


Figure 2: Comparison of blue water volumes in million cubic meters as calculated with the Water Footprint Network (WFN) and Pfister & Bayer (BP) datasets

### Authors

Steven Myburgh  
Ervin Kosatica  
Thomas Koellner

### Affiliation

University of Bayreuth  
University of Bayreuth  
University of Bayreuth

### Department

Professorship of Ecological Services  
Professorship of Ecological Services  
Professorship of Ecological Services

### Email

salba151@gmail.com  
ervin.kosatica@uni-bayreuth.de  
thomas.koellner@uni-bayreuth.de

