A different perspective on agricultural products within the scope of water footprint intensity

Hakan Cüney, Selman Türkeş, Bülent Arı

Abstract. There are many studies on the water footprint (WF) of agricultural products. Lovarelli et al. (2016) conducted a comprehensive literature review on the WF of crop production. However, there is no study that evaluates the water consumption of agricultural products using Water Footprint Intensity (WFI), which is the subject of our study and offers a different approach to the assessment of WF. Therefore, in this study, it is aimed to evaluate the amount of water used in agricultural production from an economic perspective with the facilities, the amount of water required to dilute the blue or grey water, and the extent of water pollution it causes, is presented as an important tool in water management. Nowadays, the direct and indirect use of water resources is a term used to express the amount of water consumed in the process from the supply chain of goods and services so that they remain above water quality standards. The sum of these three gives the total water footprint (WFtotal). In general terms, while Hoekstra comprehensively created the terminology and methodology that forms the basis of WF research, it also divided WF into 3 categories taking into account the water source used: green (WFgreen), blue (WFblue), and gray (WFgrey) water footprint [9-10]. In later studies, the WF was elaborated with different sub-units that reveal the effect of water consumption. WFgreen refers to water that is trapped in the soil by precipitation, stored in the root zone of the plant and evaporated by plants through metabolic activities. WFgreen is particularly related to agriculture, horticulture and forestry products. WFblue is water that is obtained from surface or groundwater sources, incorporated into a product or taken from one water body and returned to another or returned at a different time. Irrigated agriculture, industry and domestic water use can each have WFblue. WFgrey is a measure of the volume of water required to dilute the concentration of pollutants contained in the volume of polluted water associated with the production of goods and services so that they remain above water quality standards. The sum of these three gives the total water footprint (WFtotal). [11-12]

1 Introduction

As the world population is growing rapidly, the demand for food production is increasing at the same rate. This situation causes the agricultural sector to use more resources and especially to increase its dependence on water resources. Water, which is an indispensable requirement for plant growth and cultivation of crops, is a fundamental element of agricultural production. Although 75% of the Earth is covered with water, the amount of water available for agricultural activities (fresh water) constitutes 2.5% of all water and its distribution on Earth is not homogeneous [1]. Therefore, in many regions facing limited water resources, agricultural water consumption is a major concern in terms of sustainability. Therefore, measuring, evaluating and managing the water used in agricultural activities is important for a sustainable future.

While some of the methods developed for the environmentally friendly, economical and sustainable management of water are accounting tools used for water use and operational risks, other approaches are tools that reveal the effects of consumption or aim to encourage resource management [2-3]. One of these tools is the "water footprint (WF)", which offers an effective approach to sustainable water management and was introduced in 2002 as an indicator of water use [4-5]. Although the concept of WF is defined in various ways in the sources, in the most general sense, it is a term used to express the amount of water consumed directly and indirectly in process (including supply chain of goods and services) and the extent of water pollution caused from the process [6-8].

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concept of WFI and to create a different idea for the readers.

2 Material and method

2.1 Data collection

In Equation 1; $WF_{\text{total}} = \frac{WF_{\text{total}}}{m_i}$

2.2 Water footprint intensity (WFI)

Total monetary profit from product $i$ (b)

3 Results and discussion

3.1 General information about agricultural products subject to the study

$WF_{\text{total}} = \frac{WF_{\text{total}}}{m_i}$
3.2. WFI assessment

As can be seen from Table 2, wheat has the largest cultivated area among the crops subject to the study. The cultivation area of each crop and the yield information obtained from the study in Turkey in 2022, are given in Table 2.

Table 2.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Production (ton)</th>
<th>Sown Area (decare)</th>
<th>Land Use Efficiency (ton/decare)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower</td>
<td>19253962</td>
<td>2975096</td>
<td>1.00</td>
</tr>
<tr>
<td>Maize</td>
<td>2550000</td>
<td>515960</td>
<td>0.26</td>
</tr>
<tr>
<td>Barley</td>
<td>8500000</td>
<td>1571820</td>
<td>0.93</td>
</tr>
<tr>
<td>Wheat</td>
<td>8500000</td>
<td>1571820</td>
<td>0.27</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

The average WFtotal, WFblue, WFgreen, and WFgrey values resulting from the irrigation assessment, are given in Table 3. The WFI values are given in Table 4.

Table 4.

<table>
<thead>
<tr>
<th>Crops</th>
<th>WFtotal (m³/ton)</th>
<th>Price (₺/ton)</th>
<th>WFI (m³/ŧ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower</td>
<td>11000</td>
<td>1431</td>
<td>0.11</td>
</tr>
<tr>
<td>Maize</td>
<td>5559</td>
<td>2782</td>
<td>0.25</td>
</tr>
<tr>
<td>Barley</td>
<td>9118849</td>
<td>1571</td>
<td>0.17</td>
</tr>
<tr>
<td>Wheat</td>
<td>2369</td>
<td>125</td>
<td>0.27</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>192</td>
<td>141</td>
<td>0.13</td>
</tr>
</tbody>
</table>

3.3. Conclusion and recommendations

As can be seen from Table 4, wheat has the highest WFtotal value. However, because of its WFI, which is an economic indicator, sugar beet is a product with approximately 65% less water footprint per unit monetary value. For the same monetary value, sugar beet has approximately 65% less water footprint than wheat. For the same monetary value, sugar beet is a product with approximately 65% less water footprint than wheat. Therefore, when evaluating the product subject to the study, they are listed as sunflower, wheat, barley, maize, and sugar beet ranked from highest to lowest according to WFtotal. This shows that for the same production amount, sugar beet has the highest WFtotal value. However, its WFI, which is an economic indicator for the producer, is 0.11, which is the lowest among the crops. Therefore, sugar beet is the most economical and environmentally friendly product. This result also shows that when evaluating agricultural production, whether the amount of water, which is a basic element of agricultural production, is sufficient for crop development and yield. Because the amount of water required by each crop during the development and maturation period is different, there are some constraints in the objective function. Therefore, when doing this, there are some constraints in the objective function. One of the constraints is to maximise the monetary profit from production. However, while doing this, there are also constraints other than the economic objective. Therefore, the economic and environmental objectives in the objective function are also possible for farmers to make a choice for the crop to be planted among these crops. The production amounts of some crops coincide with the same period. Therefore, it is important to consider the concentration of crops planted among these crops. The production amounts of some crops coincide with the same period. Therefore, it is important to consider the concentration of crops planted among these crops.
Thus, because this calculation method supports the selection of agricultural products planned to be planted, it will be possible to calculate how much water will be needed for unit monetary return and make decisions accordi

### References