The Water Footprint in the Andriani SpA grain legume production chain - considerations regarding the 2018 crop year

By Horta Srl

Introduction

This document is aimed at: 1) examining the Water Footprint of various protein sources on the basis of official bibliographical sources, 2) providing a detailed description of the method used and the results for the Water Footprint calculated in the Horta Legumi.net® DSS used in the Andriani production chain and 3) assessing the efficiency of the production chain in terms of Water Footprint.

1-The Water Footprint and the different protein sources

According to the definition of the Ministry of the Environment, the Water Footprint is an indicator of fresh water consumption that includes both direct and indirect use of water and is defined as the total volume of fresh water used to produce goods and services, measured in terms of volume of water consumed (either evaporated or incorporated into a product) and polluted per unit of time. In the definition of the water footprint, importance is also given to the geographic location of the sources of the resource.

The overall calculation of the Water Footprint is given by the sum of three components:
- **Blue Water**: refers to the drawing of surface and underground waters for agricultural, domestic and industrial use. This is the quantity of water that does not return to the source following the production process, or returns to the source but at a later time;
- **Green Water**: refers to the quantity of rainwater that does not contribute to surface runoff and mainly concerns the water evapotranspired for agricultural use.
- **Grey Water**: refers to the volume of polluted water, quantified as the volume of water necessary to dilute contaminants to the point in which the water returns to acceptable quality standards.

The three virtual components of water each have a different effect on the hydro-geological cycle. For example, the consumption of green water has a less invasive impact on environmental balance than the consumption of blue water. The Water Footprint therefore offers a better and wider-ranging view of the impact of the consumer or producer on the use of fresh water. It is a volumetric measurement of the consumption and pollution of water. It therefore does not measure the gravity of impact on a local level, but rather provides an indication of the sustainability of water resources used for the purpose of human activity.

For this study, in which we will assess the Water Footprint of different protein sources, we will use m^3 of water per product as is as a main unit of measurement (table 1).

Table 1 - Water Footprint expressed in m^3 of water per ton of product as is.

Protein source	Water Footprint (H_2O m^3/t)
Legumes	4,055
Chicken	4,325
Pork	5,988
Lamb and goat	8,763
Beef	15,415

Source: Mekonnen and Hoekstra (2010)

As can be seen in table 1, the value for legumes is 4,055 m^3/t. The figures are slightly higher for chicken (4,325) and are significantly higher for the other sources of meat, resulting as more than 3 times the figure for legumes in the case of beef (15,415 m^3/t of water).

However, the various protein sources differ from each other for their protein content as is (Table 2). In general meat has a lower protein content than legumes. On average, legumes contain 21.5% protein, while meat has no more than 14% according to all the various sources analysed in this study.

Table 2 - Percentage protein content of the various protein sources.

Reference protein source	Protein in untreated sources (%)
Legumes	21.5
Chicken	12.7
Pork	10.5
Lamb and goat	13.9
Beef	13.8

Source: Mekonnen and Hoekstra (2010)

Consequentially, in order to obtain the same quantities of proteins obtained from legumes, it would be necessary to produce higher amounts of products from animal sources.
For example, producing 1 ton of protein from legumes requires 4.65 tons of grain, while 7.87, 9.52, 7.19 and 7.25 are required for chicken, pork, lamb or goat and beef, respectively.

Table 3 - Tons of protein sources required to produce 1 ton of protein.

Protein source	Untreated raw material (t)
Legumes	4.65
Chicken	7.87
Pork	9.52
Lamb and goat	7.19
Beef	7.25

Source: calculations carried out by Horta

If we multiply the singular impact of the Water Footprint (Table 1) by the tons of untreated raw materials necessary to obtain 1 ton of protein (table 3), the figures that emerge demonstrate how this indicator is higher than grain legumes for chicken, pork, lamb/goat and beef, respectively 81%, 202%, 234% and 492% (Table 4).
This data is very significant and fully justifies interest for vegetable-origin protein rather than animal-origin protein.

Table 4 - Effects of protein sources on the Water Footprint in order to obtain 1 ton of protein.

Protein source	Water Footprint, (H_2O m^3/t)	Water Footprint, percentage variation compared to legumes
Legumes	18,856	-
Chicken	34,038	+81%
Pork	57,006	+202%
Lamb and goat	63,006	+234%
Beef	111,759	+492%

Source: calculations carried out by Horta

2 Calculation of the Water Footprint for the Horta Legumi.net® DSS

The Water Footprint indicator used in Legumi.net® is based on the methodology proposed by the Water Footprint Network, and has been implemented by Horta in collaboration with Life Cycle Engineering S.r.l, a company dedicated to the study of product life cycles (Life Cycle Assessment).
The Water Footprint measures the consumption of fresh water on a company level by the farmer, and the water potentially polluted by plant health products and fertilisers used in the field. The indicator also takes into account the quantity of water used by the plants to produce the harvest. Consumption can be measures both for single cultivation activity (in other words an anti-parasite treatment or irrigation) and for the entire activity related to the production and transportation of the products (from the working of the soil to the transportation of the harvest to the warehouse). Furthermore, the indicator can be expressed as the water consumed in order to produce a ton of legumes (H_2O m^3/ton of product) or the water consumed for a specific area (a hectare of field land, H_2O m^3/ha).

The indicator takes into account three elements:
- *Blue Water Footprint*
This type of water includes:
• the water used during crop irrigation (if carried out);
• the water used by industrial producers of plant health products and fertilisers in order to obtain the technical resources used in the field;
• the fresh water used in the farm for treatments (if carried out) as well as the water used for cleaning. Mekonnen, M.M. and Hoekstra, A.Y. (2010) is the main methodological source.

- *Green Water Footprint* is the water contained in the soil and potentially available for absorption by plants. This water is absorbed by the plants, incorporated into the tissue of the crop and then evaporated from emergence to senescence. The consumption is proportional to the luxuriance of the plant and the level of production obtained. SAB Miller and WWF 2009 is the main methodological source.

- *Grey Water Footprint* is the third type of water considered in the indicator. It quantifies the fresh water necessary in order to dilute the pollutants potentially introduced into the agricultural system during cultivation until specific water quality standards are reached. The footprint regarding grey water also takes into account punctiform and widespread pollution, as well as the loss of nutrients into subsurface water due to leaching.

The main databases used are: Ecoinvent 3.4 (2017), Agrifootprint 4.0 (2018) and Industry data 2.0 2018

The water footprint in Legumi.net® takes into account the consumption of water for:

1) fertilisers. Users enter the fertilisers applied (name and dose per hectare) into the relative field in the Register of Cultivation Operations. Thanks to the names recorded by the user, the system recognises the composition of the fertilisers, and the unit impact on water (which depends on the composition) is multiplied by the dose of fertiliser applied in the field. The impact on water therefore varies not only according to the dose, but also the composition (percentage of urea, ammonium nitrate, ammonium sulphate, organic nitrogen, diammonium phosphate, triple superphosphate, potassium chloride, etc.);

2) plant health products. Users record the plant protection products applied in the field in the Register of Cultivation Operations (name and dose per hectare). Thanks to the names recorded by the user, the system recognises the type of product, and the unit impact on water is multiplied by the dose of plant health product applied in the field;

3) seeds. The users record the name of the variety in the Register of Cultivation Operations and the dose per hectare used. In accordance with the species (chickpea, lentil or pea), the system calculates the water impact necessary to obtain the seeds used in the field. A water impact value is multiplied by the chosen dose. The water impact of the seed also takes into account the water used by the person who cultivated the seed;

4) material items, such as plastic, paper, wood, steel, etc. that are used for irrigation, sewage irrigation, pruning, the preparation of the planting layout and harvesting. The users record the materials used and their quantities per hectare in the Register of Cultivation Operations;

5) fuel. The users record the activities carried out on the crop, from the preparation of the field to harvesting, including transportation of the harvested crop to the storage facility. For each activity (ploughing, seeding, fertilising, treating, watering, foliage management, harvesting, transportation etc.) the system estimates the fuel consumption on the basis of the name of the activity recorded, the slope of the land, the texture of the soil, and the depth the soil has been worked to (in the case of working of the soil). The water footprint is 1.5 litres of H_2O/litre of fuel according to Ecoinvent 3.4.

An update of the parameters and the methodology used is under way and will be adopted for the data regarding 2020. New water footprint factors for fertilisers, plant health products, fuel, seeds, etc. will be adopted to adapt to the most recent scientific knowledge. This update will see the adoption of the international Ecoinvent 3.4, Ecoinvent 2.0, Agrifootprint 4.0, Agribsalyse and Industry data 2.0. databases.

The calculation of the Legumi.net® database cannot be directly compared to bibliographic references as the methodology used has been adapted to the situation in Italy. The main modifications regard the assessment of nitrogen leaching and the calculation of the Green Water Footprint.

The calculation for the leached nitrogen does not follow the indications of the IPCC, in which nitrogen leaching is estimated at 30% of the applied nitrogen, neither does it follow the recommendations made by Ecoinvent. This latter approach estimates a percentage of leaching and surface runoff of nitrogen that changes according to the month (Table 5).

Table 5 - estimate of nitrogen leached and lost through runoff.

Month	% of leaching and runoff
October	90
November	90
December	90
January	50
February	30
March	10
April	0
May	0
June	0

Source: Ecoinvent

The method used by Horta, which is similar to that of Ecoinvent, estimates the loss of nitrogen from leaching via an equation that describes the variation in the ozone leached on a daily basis.

Other modifications regard the regionalisation of the Green Water Footprint.
In the calculation of the Water Footprint, 80 - 90% of the water used regards the green component, in order words the water used by crops for the process of evapotranspiration. In Legumi.net® the green water footprint is based on the crop and the latitude, instead of using unit values that are the same for the entire country. Therefore, national Green Water Footprint values have been substituted with regional data influenced by latitude. The consequence of this for Legumi.net® is that Green Water tends to be higher in the southern regions of Italy (due to the latitude, which causes increased evapotranspiration in plants).

Table 6 shows the typical values of the Andriani process and the Water Footprint, calculated according to the Legumi.net® system.

Table 6 - Typical values of the Andriani production chain and the Water Footprint calculated according to Legumi.net®. Harvesting campaign 2018.

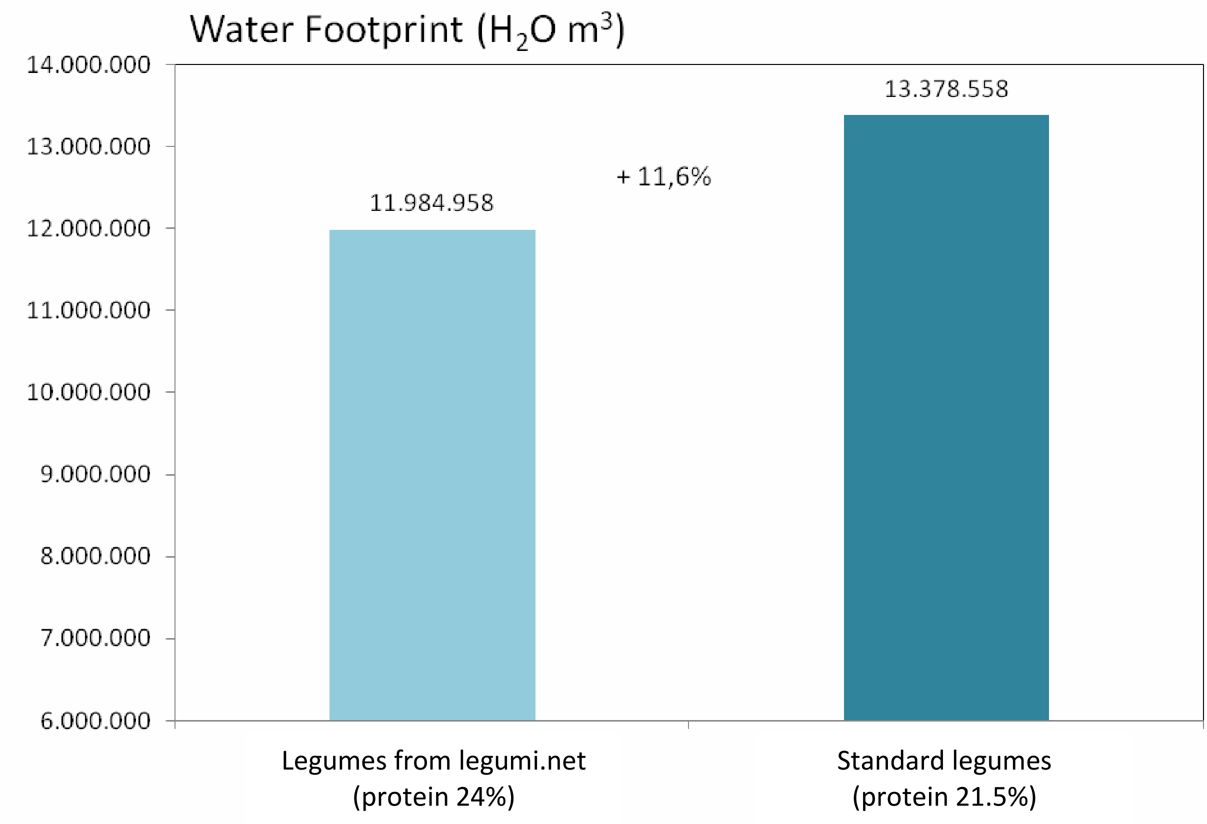
Total area in hectares of Legumi.net (ha)	3,508.9
Grain produced with legumi.net (t)	2,955.6
Protein (%)	24
Total protein produced	709
Water Footprint per ton produced (H_2O m^3/t).	3,264.9

3 - Efficiency of the Legumi.net® production chain

As the components for calculation of the Water Footprint are different, it would be fundamentally incorrect to compare the Water Footprint per ton produced (H_2O m^3/t) of Legumi.net® with the bibliographical data (respectively 3,264 and 4,055 respectively).

However, by using the bibliographical value of 4,055.0 H_2O m^3/t at 21.5% protein, it is possible to make an initial assessment of the efficiency of the Andriani production chain for the production of vegetable protein. The cultivation of lentils, peas and chickpeas with Legumi.net® has guaranteed a level of production with an average protein value of 24%. Legumi.net® has therefore guaranteed more efficient production. In 2018 the tons of protein obtained with Legumi.net® were 709 from an overall production of 2,955.6 tons of grain (Table 6). In order to obtain the same 709 tons of protein with 25.5% protein (bibliographical value), 3,299 tons of legume grain would be required.
As with Legumi.net® fewer tons of grain are required to obtain the same quantity of protein, the impact in terms of Water Footprint per ton of the Andriani production chain was lower.
In fact, the m^3 of H_2O theoretically used to produce the 709 tons at 21.5% (bibliographical data) prove to be 11.6% more than those used by Legumi.net® (Figure 1).

Figure 1 - overall Water Footprint to obtain 709 tons of protein. Comparison between the impact of the Andreini production chain (24% protein) and the impact of standard production (21.5% protein).



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