The water footprint of Austria for different diets

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ABSTRACT

This paper analyses the Austrian water footprint of consumption (WF_{cons}) for different diets: the current diet, a healthy diet (based upon the dietary recommendations issued by the German nutrition society, or DGE), a vegetarian diet and a combined diet between both latter diets. As in many western countries, the current Austrian diet consists of too many products from the groups sugar, crop oils, meat, animal fats, milk, milk products and eggs and not enough products from the groups cereals, rice, potatoes, vegetables and fruit. Especially the consumption of animal products accounts for high WF amounts. These diets result in a substantial reduction (range 922–1,362 l per capita per day (lcd)) of the WF_{cons} for agricultural products, which is currently 3,655 lcd. However, the Austrian water footprint of agricultural production (WF_{prod} = 2,066 lcd) still remains lower than even the WF_{cons} for a vegetarian diet (2,293 lcd). As a result the country is a net virtual water importer regarding agricultural products for all analysed scenarios.

Key words | Austria, consumption, diet, healthy, virtual water, water footprint

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INTRODUCTION

In order to provide sustainably a healthy diet (by eradicating hunger and overweight/obesity) to the 9.3 billion people projected for the middle of this century, changes in current global agricultural production processes (e.g. closing the yield gap on existing agricultural lands by means of sustainable intensification) as well as consumption behaviour (especially in the western world) need to be made (Foley *et al.* 2011). Today, hunger and famine coexist with overconsumption and associated health problems. The current average Austrian diet is characterised by a higher daily consumption of kcal and proportion of animal proteins (Vanham 2012a) than recommended. Austrian adults also consume less fruit and vegetables than recommended (Schätzer *et al.* 2010).

Land and water are the most important elements for the production of agricultural goods. The water footprint (WF) and virtual water (VW) concepts provide the opportunity to link the use of water resources to the consumption of goods. Although Austria is generally perceived by its inhabitants as a water rich country only exporting water (Vanham *et al.* 2009a, b; Laghari *et al.* 2012; Vanham 2012b), a substantial part of its WF is abroad and it is a net VW importer (it imports more VW than it exports) (Vanham 2012c).

Within this paper the Austrian WF of the following different diets will be analysed: the current diet (reference period 1996–2005), a healthy diet (based upon the dietary recommendations issued by the German nutrition society), a vegetarian diet and a diet between both latter diets. Vegetarian diets do not contain meat, poultry or fish; vegan diets further exclude dairy products and eggs (Key *et al.* 2006). Pesco-vegetarian diets include fish and shellfish.

METHODOLOGY

The methodology of this paper is a combination of a literature review and statistical data analysis. An overview of the data sources used is given in Table 1. Data on food supply quantity (Tonnes and kg/cap/yr) of different products are obtained from the food balance sheets (FBS) of FAOSTAT (FAOSTAT 2012) and Statistics Austria (Statistics Austria 2012). The FBS present food supply (food reaching the consumer) information/data on the basis of 'primary equivalents' (FAO 2001). For example, bread is converted into wheat equivalent in the database. Total energy, fat and protein contents are computed from the original processed commodities, aggregated and presented alongside

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Table 1 | Data sources used within the paper

Data	Period	Data source
Production and consumption values for agricultural products	1996–2005	FAOSTAT (2012) and Statistics Austria (2012)
WF_{prod} and WF_{cons} values, VW flows (import and export)	1996–2005	Mekonnen & Hoekstra (2011)
Data and specifications on actual consumption of different products	1996–2005	Statistics Austria (2012) and Zessner *et al.* (2011)

Table 2 | Specification of the different diets

Diet	Specification
Current or reference diet (REF)	The average Austrian diet for the reference period 1996–2005
Healthy diet (DGE)	Based upon the dietary recommendations issued by the *Deutsche Gesellschaft für Ernährung or DGE* – German nutrition society
Vegetarian diet (VEG)	The same diet as the healthy diet, but all meat products are substituted by pulses and oilcrops. Dairy products are still of animal origin (due to the economic and ecological importance of dairy production on the grasslands and meadows of Austria)
Combination diet (COM)	Diet between a healthy and vegetarian diet, in the sense that half of the meat products is replaced by pulses and oilcrops

primary equivalents for the edible food parts (Srinivasan *et al.* 2006). WF amounts of different products are obtained from Mekonnen & Hoekstra (2011). They include green, blue and grey water. The reference period is 1996–2005. Within the paper different units for water use will be listed: km^3 and lcd (l per capita per day). The following abbreviations are used: WF_{cons} for the WF of consumption; WF_{prod} for the WF of production; VW_i for VW import; VW_e for VW export.

Important in the assessment is the conversion of food product supply values (as given by the FAO FBS) or consumption values to actual consumption or intake values (as given in the food-based dietary guidelines). Data on intake of different products were derived by means of Statistics Austria data and specifications described in Zessner *et al.* (2011). The latter implies the use of two correction factors to convert consumption to intake values. The first factor accounts for food components not eaten (e.g. bones in meat or fruit kernels) and the second for food waste but also, e.g., feed to domestic animals, assumed 15% for all product groups (Zessner *et al.* 2011). The specification of different diets (see Table 2) is based upon food-based dietary guidelines (Elmadfa & Freisling 2007), more specifically those of the German nutrition society (DGE). The latter is used within the German-speaking countries, e.g. resulting in the Swiss food pyramid (Walter *et al.* 2007). Within this paper the amounts of fish recommended by the DGE are substituted by meat. The reason for this is that WF analyses do not account for fish and that a shift from the terrestrial to the freshwater and marine system for human consumption would have dramatic effects on already stressed fish ecosystems. Therefore also in the combination diet no fish is included. For the vegetarian diet, all meat is substituted by the group pulses, nuts and oilcrops, by an increase in the consumption of pulses and soybeans (in practice, e.g. soy burger, tofu). This is a simplification; in practice meat can of course also be substituted by other protein-rich products like cereals. The intake amounts chosen based upon Elmadfa & Freisling (2007) and Zessner *et al.* (2011) are shown in Table 3. For pulses or nuts there is no specific recommendation by the DGE.

The target of the Swiss food pyramid is 1,800–2,500 kcal/d. Within this paper a population average energy intake of 2,200 kcal/d is set as target, as also recommended by WHO (2007) for a healthy diet. The recommended values are 2,500 kcal for young men and 2,000 kcal for women, and less for children and elderly people. A sex and age based analysis (with data from UN (2012)) results in the average value 1,985 kcal for people with medium physical activities. For high physical activities energy requirements are higher. Therefore a national average target value of 2,200 kcal is appropriate. This results in a recommendation of 18–27 kg/yr protein intake (50–75 g/d) (WHO 2007; Westhoek *et al.* 2011).

RESULTS AND DISCUSSION

Reference situation of the WF

The national WF accounting scheme (Figure 1) shows that, for both the total WF and the WF of agricultural products, Austria is a net VW importer and a substantial part of the WF_{cons} is situated abroad. The WF_{cons} is higher

Table 3 | Intake amounts for product groups as recommended by the DGE

Product group	Quantity chosen (g/d)	Data source/justification
Cereals, rice, potatoes	180 cereal eq. bread/cereal flakes + 200 potatoes/cereal products (e.g. pasta)	Elmadfa & Freisling (2007); Zessner *et al.* (2011)
Sugar	Max. 60 (most countries with a recommendation on sugar intake suggest that less than 10% of daily energy intake comes from sugar)	WHO (2003), based upon intake of 2,200 kcal/d
Fruit	250 (2–3 portions) daily	WHO (2003); Zessner *et al.* (2011)
Vegetables	400 daily	Walter *et al.* (2007); Zessner *et al.* (2011)
Crop oils	10 (2 teaspoons) of high-quality plant-based oils such as rapeseed oil or olive oil and 10 (2 teaspoons) of plant-based oils for cooking	Walter *et al.* (2007); Zessner *et al.* (2011)
Animal fats	10 (2 teaspoons) of butter or margarine	Walter *et al.* (2007)
Meat	450 meat and 80 fish (substituted by meat) per week	Zessner *et al.* (2011)
Milk and milk products	200 milk/yoghurt and 50 cheese (400 milk eq.)	Zessner *et al.* (2011)
Eggs	Up to 3 eggs per week (1 egg 60 g)	Zessner *et al.* (2011)

Figure 1 | The Austrian national WF accounting scheme for (left) the total WF and (right) the WF of agricultural products, average annual values for the period 1996–2005. Data source: Mekonnen & Hoekstra (2011).

than the WF_{prod}. Explanations for the latter are the facts that (1) for some products Austria is not self-sufficient (although for many products it is) and (2) the production of agricultural goods is very water efficient as compared to other countries from which goods are imported (VW contents of goods are relatively low in Austria) (Vanham 2012a). Theoretically the sum of WF_{prod} and VW_i should equal the sum of WF_{cons} and VW_e. However, due to different data sources (all WF accounting scheme components are assessed by means of the bottom-up approach, a methodology in which each component is estimated based on direct underlying data on either production, trade or consumption), there is a value range for the components of the WF accounting scheme. The advantage of using the bottom-up approach is that it is more stable (Hoekstra & Mekonnen 2012). It also enables the WF to be assessed in a detailed way per commodity or product category.

The WF of agricultural products represents by far the largest fraction in the total WF_{prod} and WF_{cons} (Figure 2). With an average domestic water withdrawal of about 120–150 lcd in Austria (Vanham *et al.* 2011), the WF of domestic

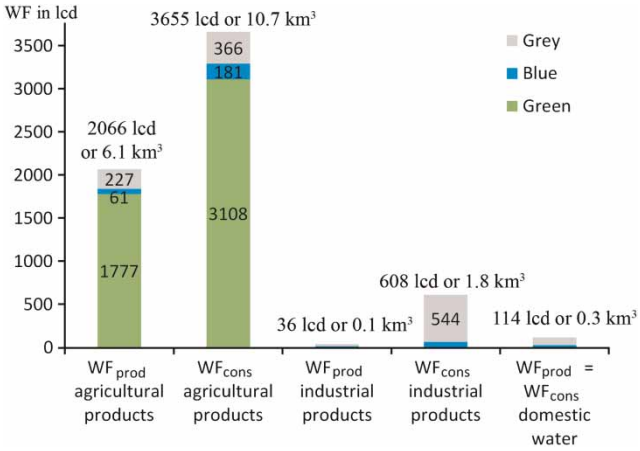

Figure 2 | The Austrian WF_{prod} and WF_{cons} components for agricultural and industrial products as well as domestic water use. Data source: Mekonnen & Hoekstra (2011).

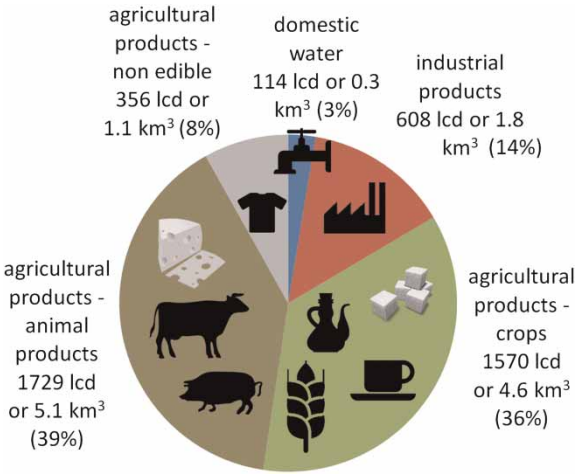

Figure 3 | The Austrian WF_{cons} for different product groups. Data: Mekonnen & Hoekstra (2011).

water only represents a minor fraction of the total WF. Green water represents by far the dominant part of the WF of agricultural products.

The WF_{cons} of different product groups (Figure 3) shows that edible products account for the largest fraction of the total WF_{cons}. The WF due to the edible consumption of animal products (1,729 lcd) is larger than the one due to the consumption of crop products (1,570 lcd).

Different diets

An overview of the intake amounts for the reference period and the DGE scenario (Figure 4) shows that the intake of several product groups should be reduced (sugar, crop oils, meat, animal fats, milk and milk products and eggs) and the intake of other product groups increased (cereals, rice and potatoes, vegetables and fruit).

Table 4 shows the absolute amount (kg/yr), energy (kcal/d) and protein (g/d) intakes for the different scenarios. For the vegetarian and combination diet, all respectively half of the meat intake is substituted by a slightly larger amount of pulses and oilcrops (no nuts are added). The amount equals an intake of 28.4 kg/yr (existing 8.9 + 19.5) for the VEG scenario. For the COM scenario an amount of 17.3 kg/yr (existing 8.9 + 8.4) is chosen. These amounts are chosen because they result in the same total energy and protein intake for the VEG and COM scenarios as the DGE scenario (Total 1 and 2 in Table 4). For the product groups assessed by the DGE (Total 1 in Table 4), the percentage of total energy intake from animal products ranges from 35% (REF) to 18% (VEG). The percentage of total protein intake from animal products ranges from 64% (REF) to 31% (VEG).

The WF_{cons} of the different diets

The WF_{cons} for agricultural products decreases substantially (–922 lcd DGE, –1,362 lcd VEG, –1,143 lcd COM) for the different diets with respect to the existing situation (REF, 3,655 lcd) (Figure 5). Especially the VEG diet WF is much lower (2,293 lcd), although all diets still result in a WF_{cons} larger than the WF_{prod} (2,066 lcd, Figure 1) of agricultural goods. This means that Austria still imports more VW than it exports, even for the VEG diet. Nevertheless, there is even more potential in a reduction of the WF_{cons}, i.e. in a reduced consumption of stimulants (especially coffee and cocoa) and non-edible agricultural products (e.g. cotton, leather or rubber). Combined with lower WF diets this could result in Austria becoming VW neutral or even a net VW exporter. Also the preferred import of products with a lower WF (more water efficiently produced abroad – especially with lower blue and grey WF, e.g. coffee from Vietnam instead of Colombia) could contribute to this (Vanham 2012a).

In the wake of climate change and global demographic changes, it is necessary to act on a reduction of the blue, green and grey WF of Austria (Vanham & Bidoglio 2013). A detailed justification for this can be found in Hoekstra *et al.* (2011) and Vanham & Bidoglio (2013). Whether a country is a net VW importer or exporter depends very much on its resources (agricultural land and water) and demographics. A country like Egypt (low per capita agricultural land and water resources availability) is therefore a net

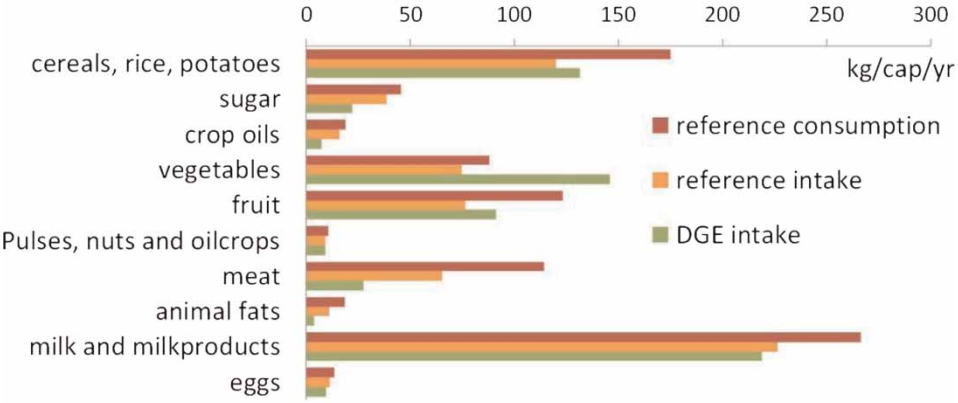

Figure 4 | Consumption and intake of product groups for the reference period and as recommended by the DGE. For some product groups, consumption values (from FAO FBS) are given in product equivalent (eq.) values (e.g. bread as wheat eq. and meat in carcass weight). Meat intake values are retail quantities. Milk and milk products are expressed as milk eq. (e.g. 8 l milk eq. for 1 kg of cheese). Pulses, nuts and oilcrops are not specifically recommended by the DGE.

Table 4 | Reference and scenario intake values per product groups in absolute amount (kg/yr), energy (kcal/d) and protein (g/d). All values per capita

	Amount (kg/yr)		Energy (kcal/d)		Protein (g/d)	
Product group	**REF**	**Scenario**	**REF**	**Scenario**	**REF**	**Scenario**
Cereals, rice, potatoes	120.1	131.4	861	942	24.8	27.1
Sugar	38.6	21.9	383	217	0.0	0.0
Crop oils	15.8	7.3	391	180	0.1	0.0
Vegetables	74.7	146.0	50	98	2.4	4.7
Fruit	76.4	91.3	129	154	1.3	1.6
Pulses, nuts, oilcrops	8.9	8.9[a] (DGE) 28.4 (VEG) 17.3 (COM)	37	37[a] (DGE) 209 (VEG) 121 (COM)	2.7	2.7 (DGE) 15 (VEG) 9.7 (COM)
Meat	65.3	27.6 (DGE) 0 (VEG) 13.8 (COM)	418	176 (DGE) 0 (VEG) 88 (COM)	31.8	13.4 (DGE) 0 (VEG) 6.7 (COM)
Animal fats	10.8	3.7	277	94	0.3	0.1
Milk and milk products	226.5	219.0	278	269	19.7	19.0
Eggs	11.2	9.4	43	36	3.5	2.9
Total 1	648.4	666.3 (DGE) 658.3 (VEG) 660.9 (COM)	2,869	2,205 (DGE) 2,200 (VEG) 2,200 (COM)	86.6	71.6 (DGE, VEG) 71.9 (COM)
Stimulants	8.3	8.3[b]	17	17	1.4	1.4
Alcoholic beverages	126.9	75.9[c]	218	130	1.3	0.8
Total 2	783.6	750.5 (DGE) 742.5 (VEG) 745.1 (COM)	3,104	2,352 (DGE) 2,348 (VEG, COM)	89.3	73.8 (DGE, VEG) 74.1 (COM)

[a]For pulses, nuts and oilcrops the DGE gives no recommendation; for the scenarios the same existing amount plus the meat substitution amount is assumed.
[b]For stimulants (coffee, tea, cocoa) no DGE recommendations are available; the same amount is assumed.
[c]For alcoholic beverages the thresholds 20 g/d for men and 10 g/d for women (minimum age 16, population data from UN (2012)) are used.

VW importer, a country like Canada (high per capita agricultural land and water resources availability) a net VW exporter (Hoekstra & Mekonnen 2012). They both, however, have the potential to reduce their WF_{prod} and WF_{cons}, as does Austria. Nevertheless, the sustainability of the WF_{prod} and WF_{cons} of Austria needs to be assessed with the right

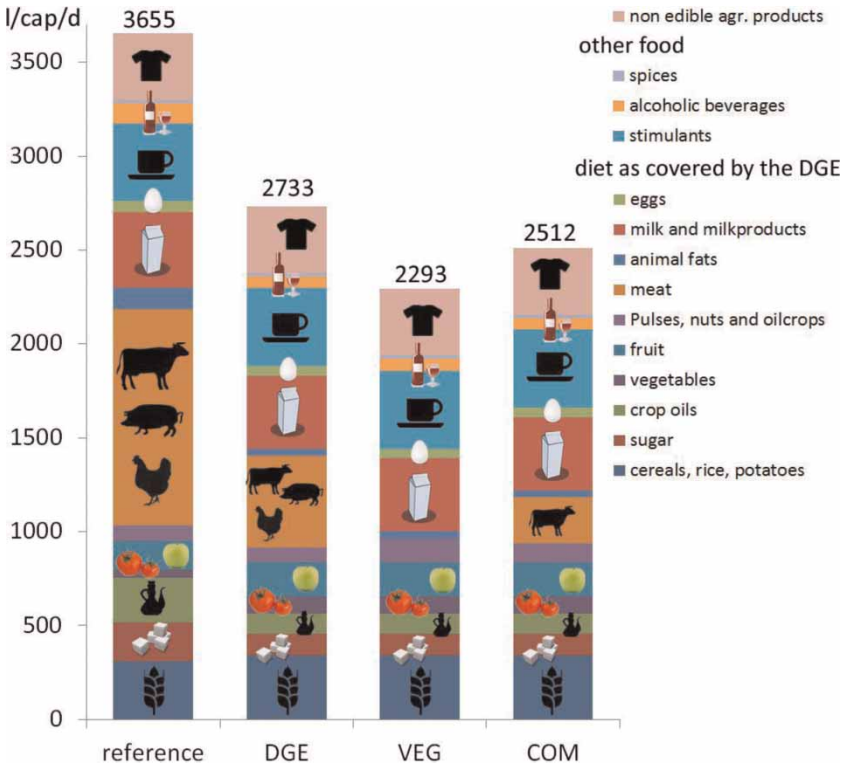

Figure 5 | The Austrian WF_{cons} regarding agricultural products for different scenarios.

indicators (Vanham & Bidoglio 2013), in order to make decisions regarding VW flows of Austria.

CONCLUSIONS

This paper has shown that different average Austrian diets as compared to the current one would result in a substantial reduction of the Austrian WF_{cons} for agricultural products. The latter is by far the most dominant part of the total WF. The current diet consists of too much sugar, crop oils, meat, animal fats, milk and milk products and eggs and not enough cereals, rice and potatoes, vegetables and fruit. Of the diets analysed (healthy, vegetarian and combined), a vegetarian diet would result in the lowest WF_{cons}. However, for all analysed diets Austria would remain a net VW importer.

Although the WF concept has some weaknesses (Thaler *et al.* 2012; Vanham & Bidoglio 2013), it provides the unique opportunity to link the use of water resources to the consumption of goods. The concept has been brought into water management science in order to show the importance of consumption patterns and global dimensions in good water governance. Nevertheless, it is a partial indicator. To evaluate the sustainability of the Austrian agricultural production system and consumption behaviour, an integrated approach including other factors is necessary: land resources, greenhouse gas emissions, (fossil) energy use and environmental impact.

DISCLAIMER

The conclusions and statements presented are those of the author and may not in any circumstances be regarded as stating an official position of the European Commission.

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