Water footprint of a large-sized food company: The case of Barilla pasta production

Original
Water footprint of a large-sized food company: The case of Barilla pasta production / Ruini L; Marino M; Pignatelli S; Laio F; Ridolfi L. - In: WATER RESOURCES AND INDUSTRY. - ISSN 2212-3717. - STAMPA. - 1-2(2013), pp. 7-24.

Availability:
This version is available at: 11583/2557945 since:

Publisher:
Elsevier

Published
DOI:10.1016/j.wri.2013.04.002

Water Resources and Industry 1–2 (2013) 7–24

Contents lists available at ScienceDirect

Water Resources and Industry

journal homepage: www.elsevier.com/locate/wri

Water footprint of a large-sized food company: The case of Barilla pasta production

L. Ruini [a], M. Marino [b], S. Pignatelli [b],*, F. Laio [c], L. Ridolfi [c]

[a] Health, Safety and Environment Team—Barilla G. R. Fratelli Spa. 166, via Mantova, I-43122 Parma (PR), Italy
[b] Life Cycle Engineering c/o Environment Park—60, via Livorno, I-10144 Torino (TO), Italy
[c] Department of Environmental, Land, and Infrastructure Engineering, Polytechnic of Turin (Politecnico di Torino)—24, Corso Duca degli Abruzzi, I-10129 Torino (TO), Italy

ARTICLE INFO

Keywords:
Water footprint
Durum wheat
Pasta
Virtual water trade
Industrial case

ABSTRACT

The water footprint is an indicator of freshwater use taking into account both direct and indirect water use of a consumer or a producer. The concept of water footprint can be applied to business companies to provide indications about the sustainability of their production process. We considered the case of pasta production from a large-sized company, Barilla. The water footprint of 1 kg of Barilla pasta has been shown to range between 1.336 and 2.847 l of water, depending on the production site, local environmental conditions and agricultural techniques used to cultivate durum wheat. Relevant virtual water fluxes, involved in pasta and durum wheat trade among different countries, were also quantified and analysed, demonstrating the need to consider water-related production processes on a global scale when examining the water footprint of an international food company.

1. Introduction

Around 70% of the world's surface is covered with water [23], most of which is salty. Only 2.5% of the total is freshwater which is mostly embedded in glaciers, ice caps or at great depths underground. The difficulties associated with the use of this resource are evident: nearly 45,000 km^3 of water is theoretically usable [23]; however, only 9–14,000 km^3 is actually available for human use if we consider quality and accessibility [23]. Furthermore, freshwater resources are distributed unevenly.

* Corresponding author. Tel.: +39 0 11 22 57 311; fax: +39 0 11 22 57 319.
E-mail addresses: pignatelli@studiolce.it, sonyp84@gmail.com (S. Pignatelli).

2212-3717
http://dx.doi.org/10.1016/j.wri.2013.04.002

In spite of global freshwater withdrawal having increased nearly sevenfold since the end of the 19th century [5], around 1.2 billion people, one fifth of the world's population, live in areas of water scarcity where water supplies drop below 1000 m^3/person each year. Yet another 1.6 billion people face economic water shortages as they lack the necessary infrastructures to draw water from rivers and aquifers. Due to population growth, diet changes, and economic development, by 2025 this figure will likely increase. It has been estimated that 1.9 billion people will live in regions of absolute water scarcity, while two-thirds of the world population will face conditions of water stress [18].

Scarcity and overexploitation of the freshwater natural resource in many parts of the world is on the rise, leading to a series of social, environmental and economic problems. Awareness regarding this issue is growing, resulting in an increased interest in the water footprint in parallel with the carbon footprint over the last decade. Despite this fact, the water footprint remains an indicator of scant use if compared to the adoption of the carbon footprint in greenhouse gas accounting and reporting standards (e.g., ISO 14067) as well as in product labelling schemes [12,13]. Hoekstra and Hung [8] introduced the concept of water footprint in analogy to the 'ecological footprint' as "the cumulative virtual water content of all goods and services consumed by one individual or by the individuals of one country", where 'virtual water' was previously described by Allan [2] as the total volume of water needed to produce a good or service. Water footprint is a geographically explicit indicator that takes into consideration the place and time of water use as well as the type of water consumed, by differentiating consumed water into ground and surface water (blue water), infiltrated rainwater (green water), and polluted water (known as grey water) [17,9]. Consequentially, different climatic conditions and agricultural practices lead to different values of the water footprint (blue, green and grey) [4].

Traditionally, companies and investors have considered clean water as being constantly available whilst consumers of water-based commodities have generally been charged only a partial amount of the full cost of water, including opportunity costs, negative externalizations and a scarcity rent [16]. However, companies are recently facing significant challenges due to insufficient freshwater availability for business operations as well as stricter water regulations. As the business sector is heavily dependent on water resources for the production of goods and services, companies unable to cope with the freshwater issue may incur serious problems in the future [19,14]: these are expected to take the form of both physical and financial risks, the former caused by pollution and insufficient freshwater availability, while the latter is due to increased water costs and/or reduced revenues as a result of damage to the corporate image.

The water footprint of a business is represented by both an operational (direct) and a supply-chain (indirect) water footprint. The former is the volume of freshwater consumed (or polluted) during business operations, i.e. the direct freshwater use for production, manufacturing or support activities. The latter is the volume of freshwater required to produce the array of goods and services representing the input of production [7]. Both direct and indirect water footprints consider not only the quantity of water that can be directly related to inputs applied in or for the company's production, but also an overhead water footprint. The latter is represented by all intakes used in a business that cannot be exclusively attributed to the production of a specific product; consequently, the overhead water footprint refers to the use of freshwater considering all the support activities and materials employed by the business [4].

In this perspective, the water footprint can help companies better understand water issues and their relative impact [10]. The concept of water footprint can prove extremely useful in businesses insofar as it informs better decision-making regarding plant management, supplier collaboration, and interaction of governments and communities with business activities. As reported by Hall [6], environmental innovations in product life cycles are attained by leader companies, themselves under specific environmental stress, with technical competencies and sufficient channel power over their suppliers.

Businesses can reduce their water footprint not only by reducing the water consumption and pollution in their own operations, but also through engaging with their suppliers or transforming their business model in order to better control their supply chain [1]. The establishment of specific and measurable targets with respect to water footprint reduction, product transparency (e.g. through a water label), and demonstration to external and internal stakeholders of actual improvements (e.g. by preparing annual business water footprint accounts) can lead to evident competitive advantages for business [20].

In order to demonstrate the key role that companies can play in the water footprint of a community, this paper will focus on food companies, particularly revolving around Barilla, one of the most important pasta producers in the world. Its water footprint and analysis of the corresponding evolution thereof during recent years will allow us to show (i) the relevant volumes of virtual water involved in the activity of a large-sized company, (ii) the need to analyse all manufacturing processes, aside from raw material, (iii) the non-negligible contribution of company-related trade to the geography of virtual water trade, and (iv) the suitability of water saving strategies to reduce the water footprint.

2. Characteristics of the Barilla case

Barilla was founded in Parma in 1877 and started out as a small bakery that sold bread and pasta. Today, it is one of the top Italian food groups and is a lead player in the pasta market around the world. The Barilla Group employs a workforce of over 13,100 and has an annual turnover of 4 billion euro in 36 production plants (9 in Italy and 27 abroad), including 9 mills that provide the majority of raw materials required for the Group's production of pasta and oven-baked goods. Products are exported to more than 100 countries. The Group's brands fall into two principle business areas: meal solution and bakery products. In the meal solution section, Barilla leads the pasta market both in Italy and worldwide, where products are sold under the Barilla brand name and through lead brands at a local level (Misko in Greece and Filiz in Turkey). In 2011, Barilla produced about 943,000 t of pasta worldwide, 63% in Italy, 9% in Turkey, 23% in the USA, and 5% in Greece.

Since 2008, Barilla has begun to evaluate the environmental burdens of its products by adopting the life cycle assessment (LCA) methodology. The aim is to take into account the entire production chain and to reduce the impact of its products. The LCA studies have been conducted in a systematic manner which enabled Barilla to calculate and validate the main indicators of the environmental impact of its products. In particular, this work is concentrated on the analysis of the water footprint of Barilla durum wheat pasta and on the virtual water exchanges associated with the trade of durum wheat and pasta.

Barilla purchases durum wheat from different areas of the world. Most comes from Italy, while a fair amount also originates from other European countries such as France, Greece, Bulgaria, Spain and other areas of the world, primarily Canada, USA, Australia, and Mexico. Every country in which Barilla produces pasta has a different durum wheat origin mix (see Fig. 1).

Durum wheat semolina pasta is made of durum wheat (*Triticum durum*) and water. Wheat grains must be milled into semolina before undergoing transformation into pasta. The semolina production process can be described through the following steps (see Fig. 2).

Pre-cleaning and tidying up: the raw wheat is subjected to preliminary and thorough cleaning operations. These processes are aimed at removing foreign materials, such as other cereals, stones, metal contaminants, feed, bran layers, seeds and powders.

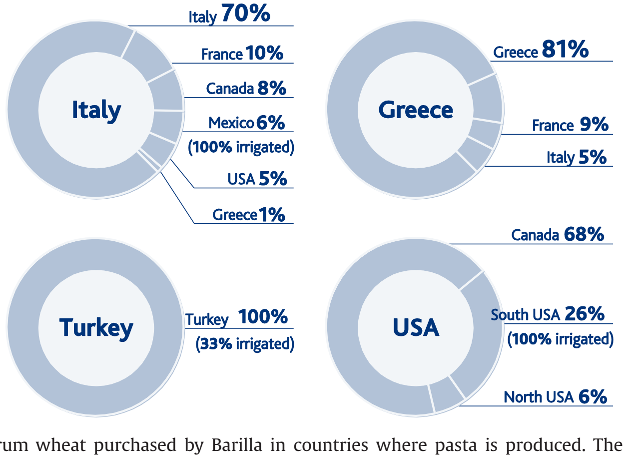


Fig. 1. Origin of the durum wheat purchased by Barilla in countries where pasta is produced. The percentage of irrigated agriculture (where it occurs) is also specified.

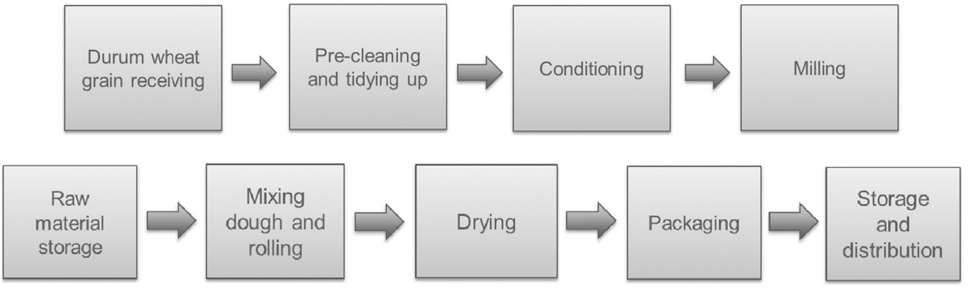


Fig. 2. Main steps in pasta production.

Conditioning: grain humidity is raised from about 10% to 17% by adding water. Conditioning promotes the separation of bran from the endosperm (bran, germ and endosperm are the three main components of the grain) due to hardening of the bran, and it allows a more effective endosperm rupture in the following process phases.

Milling: the conditioned grain proceeds to a series of progressive grinding steps performed using rolling mills that crush the endosperm and stretch the external cortical particles. Following the breaking phase, flours are classified according to the size of the granules through a series of vibrating sieves (plan sifter). A purifier separates grain with pure endosperm (heavier) from grains with adherent particles of bran (lighter). At the end of the re-milling process, most endosperm has been transformed into semolina. The material may require up to 10 milling steps.

Durum wheat semolina is then transformed in pasta by extruding and drying a mixture of semolina and water. The maximum amount of moisture in the final product is 12.5%. The main technological steps of durum wheat semolina pasta production are the following:

Raw material storage: durum wheat semolina is stored in silos and sent to the production area through pneumatic transport and pressurisation by pump.

Mixing dough and rolling: the semolina and water are transported to the mixers located above the production lines via a pipe network. A worm screw conveys the mixture into bells where it is pressed in dies. Then wet pasta is sent to the drying process.

Drying: pasta is put inside hot air dryer ovens with controlled humidity, in which pasta stations from 6 to 12 h depending on the shapes and lines.

Packaging: after the drying process, pasta is weighed, placed into individual or primary packaging (plastic film, recycled and virgin cardboard boxes) and placed into secondary packaging (cartons/exhibitors) and lastly into tertiary packaging (pallets wrapped with stretch film).

Storage and distribution: every wrapped pallet is moved to the finished product storehouse and then sent to distribution.

3. Methods for water footprint calculation

Environmental footprints of Barilla products are evaluated through LCA methodology, according to ISO 14040:2006 (environmental management—life cycle assessment—principles and framework). LCA, emissions and resource use from all phases in a product's life cycle are quantified and used to calculate the environmental impact divided among a number of impact categories such as global warming potential, water footprint (WF), ecological footprint, acidification, eutrophication, primary energy use, biodiversity, etc. LCA results can be presented as mid-point indicators in the form of one or all impact categories listed above to show how a product affects the environment, e.g. the manner in which it contributes to climate change or water consumption and depletion. LCA studies include agricultural phases, industrial processes, packaging, storage, distribution, consumption, and waste management [3].

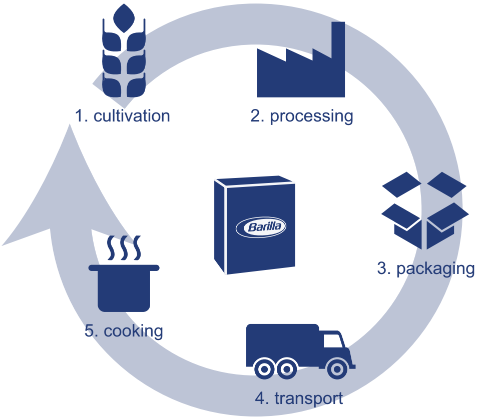


Fig. 3. Steps considered in the water footprint assessment related to pasta production.

The water footprint considers the use of water resources in terms of volume of water consumed and/or polluted by the entire chain, from production of raw material to the consumption of virtual water embedded in goods/services. The water use associated with the production of capital goods, transports, power generation and other energy production systems must also be included in the analysis. Companies have traditionally focused on water usage in their operations rather than their supply-chain, often discovering late in the game that their supply-chain water footprint is much larger than their operational water footprint [20].

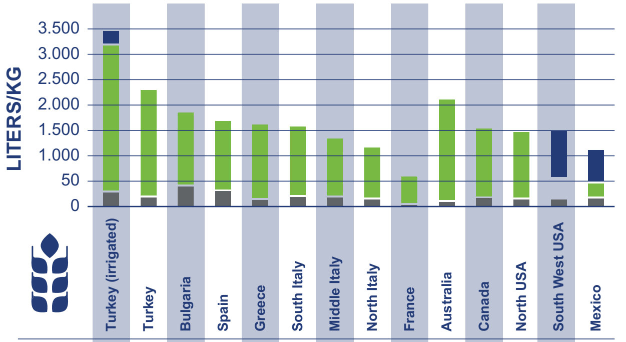
A water footprint is split into three specific components which correspond to different sources of water being used: (i) the green water footprint, being the volume of rainwater evapotranspired from the ground and transpired by cultivated vegetation; (ii) the blue water footprint, defined as the volume of freshwater consumated in surface or ground water sources that is not repleneshed into the basin (this footprint includes both irrigation and process water consumption); (iii) the grey water footprint, corresponding to the volume of water needed to assimilate pollutant loads in order to have a post-process water which meets water quality standards.

The water footprint differs from the traditional “water use” measurements, which is in terms of “water withdrawal”, as the water footprint does not merely consider the amount of water consumed with distinction of different sources of water (blue and green water), but also accounts for water that undergoes potential pollution (grey water footprint). The water footprint, thus, offers a broader and enhanced vision of water consumption from either a consumer or producer viewpoint, also in terms of opportunity costs (e.g., green or blue water). Our evaluation of Barilla's durum wheat pasta water footprint considers both the operational and the supply chain water footprint, following the Water Footprint accounting methodology, edited by the Water Footprint Network [9]. We have considered two components for both the operational and supply-chain water footprints: the water footprint that is directly related to inputs consumed by Barilla production, and the overhead water footprint. We use spatial, temporal and other product-specific primary data, which is indispensable in providing clear characterisation at product brand level.

The water footprint analysis presented herein is referred to the production of durum wheat semolina dried pasta produced by Barilla in Italy, USA, Greece and Turkey. The water footprint has been calculated considering 2009, 2010 and 2011. System boundaries include all activities from durum wheat cultivation to transportation of products to the main distribution centres (see Fig. 3). The cooking phase was accounted for under average conditions since it is strictly dependent on the behaviour and habits of consumers.

3.1. Durum wheat cultivation

The water footprint of durum wheat cultivation for Barilla pasta production was evaluated using data available in the Water Footprint Network database “WaterStat” [11] considering the set of countries



	Turkey (irrigated)	Turkey	Bulgaria	Spain	Greece	South Italy	Middle Italy	North Italy	France	Australia	Canada	North USA	South West USA	Mexico
Grey	265	196	373	279	135	212	193	172	5	102	201	184	156	185
Green	2.909	2.074	1.471	1.394	1.486	1.372	1.157	997	581	1.998	1.336	1.256	399	333
Blue	172	–	–	–	–	–	–	–	–	–	–	–	848	558

Fig. 4. Water Footprint of durum wheat in different areas of the world. Data from Mekonnen and Hoekstra [11].

from which durum wheat is grown (Fig. 1). Notice that the largest amounts of water used for pasta production occur during cultivation and depend strongly on the water management methods adopted by farmers (e.g., [22]). Blue Water contribution was accounted for only in regions where durum wheat is actually irrigated, namely Mexico, South West USA (Colorado), and Turkey (Sanliurfa region). The water footprint was calculated multiplying the WF of durum wheat (see Fig. 4) by the total amount of purchased durum wheat from each country of origin, considering the four production plants (in Italy, Greece, Turkey and USA) and the total amount (Barilla worldwide).

3.2. Milling processes

In Italy durum wheat is transformed into semolina in four mills (Pedrignano, Altamura, Castelplanio, Ferrara), and durum wheat pasta is produced in the facilities of Pedrignano, Marcianise, and Foggia (see Fig. 5). Barilla has only one mill in the USA (Ames) and two factories (Avon and Ames). Turkey and Greece have one factory in Bolu (that also has a mill) and Thiva, respectively. Specific water consumptions during milling processes have been calculated for each mill. To this aim, primary data collected by Barilla was used to calculate the direct water footprint of wheat processing, while secondary data taken from the Ecoinvent database [21] was accounted for to calculate the amount of water related to the energy required for processing wheat into semolina and transportation of semolina to the factories. The average blue WF per product was calculated on the basis of the respective amount of semolina, originating from different mills, present in the final product.

As Barilla also purchases semolina from third party mills for the Italian, American, Greek and Turkish production, the corresponding water consumptions was assumed equal to that of Barilla-owned mills.

3.3. Processing phase

The water footprint of pasta production in plants was calculated as the sum of the direct water use in pasta manufacturing and the indirect use of water related to the energy needed to process and package pasta. Direct and indirect water consumption were calculated separately for the 3 plants in Italy, 2 plants in the USA, and plants in Greece and Turkey (Fig. 5). The final water footprint was calculated by weighing the consumption of each plant in relation to its pasta production. Barilla's primary data was used for water consumption, while secondary data was considered for energy consumption and the packaging process.

3.4. Packaging

The water footprint of the packaging was calculated considering primary and secondary packaging of the 500 g pasta format. This hypothesis is cautionary since the use of paperboard (for every 580 kg) is higher in the 500 g format than in the 1000 g format. Tertiary packaging used to transport bulk ingredients has been excluded due to its insignificant contribution to the global WF. The data used for this analysis comprises Barilla's primary data on packaging amounts and secondary data on packaging materials production (Mayr Melnhof, Plastics Europe, Ecoinvent databases).

3.5. Distribution

The water footprint of the pasta distribution is negligible and thus excluded from our study.

3.6. Cooking

The water footprint associated with cooking, although limited, is the second largest impact in terms of volume after durum wheat cultivation. The amount of water used in the cooking stage is relevant both in direct terms, related to consumption of water, and indirect terms, associated with greenhouse gas emissions generated by the use of energy required for heating. The amount of water usually recommended is equal to 10 times the amount of pasta being cooked in order to correctly moisturise the pasta during when cooking: therefore 500 g of pasta require 5 l of water. Our balance should account for only the volume of water evaporated as the remainder returns to the system. However, due to the difficulty to clearly subdivide the two quantities, the whole volume of 10 l/kg is used in our analysis.

4. Results

The overall balance of the water footprint for the production of durum wheat semolina dried pasta in 1 kg paperboard blue box produced by Barilla is shown in Table 1. Several comments may be called for. Firstly, the majority of the water footprint is due to wheat cultivation (semolina component), and green water is the main component in any country, ranging from 72.3% of the total WF for the USA to 91.2% for Turkey. The blue component is relevant in the case of the USA due to the abundant use of water from irrigation. Green water consumption is about 1100 l/kg, with the only exception of Turkey where this value increases to 2600 l/kg, possibly due to larger evapotranspiration demand and less efficient cultivation techniques. The other phases of pasta production impart minor impact. In particular, plant and packaging phases affect only the blue water balance with 3–6 l for 1 kg of pasta, while milling activities involve a negligible amount of water, with the exception of Greece where this component gives a contribution, even if very low. The grey water amount is generally much greater than the blue water one, except for the USA. On average, blue and grey water represents the 8.6% and 16% of green water, respectively. Excluding the amount of water used for cooking, which is assumed to be equal for any country, the total water footprint ranges from 1.336 l/kg in the case of Italy to 2.847 l/kg in Turkey, this excursion being the results of varying climates and agricultural techniques adopted in different countries.

Table 2 reports the water footprint due to all pasta produced by Barilla. The global impact is about 1.450 million cubic metres of virtual water. The largest contribution comes from Italian activities (about 55% of the total WF in 2011), while the USA (23.6%), Turkey (16.4%) and Greece (5%) follow. In spite of USA concurring for only one fourth of WF, its contribution to blue WF is very high (61% in 2011), while those of Turkey and Greece are negligible. From the temporal point of view, one notices the negative trends of Barilla's water footprint in Italy and Greece and positive trends in the USA (but not for blue WF) and Turkey (the most substantial).

Interestingly, Barilla's pasta water footprint also can also be analysed from the perspective of the virtual water fluxes related to different countries. Figs. 6 and 7 refer to 2011, while Tables 3 and 4 summarise the virtual water flows, both for the trade of wheat and Barilla pasta, in 2009–2011 for

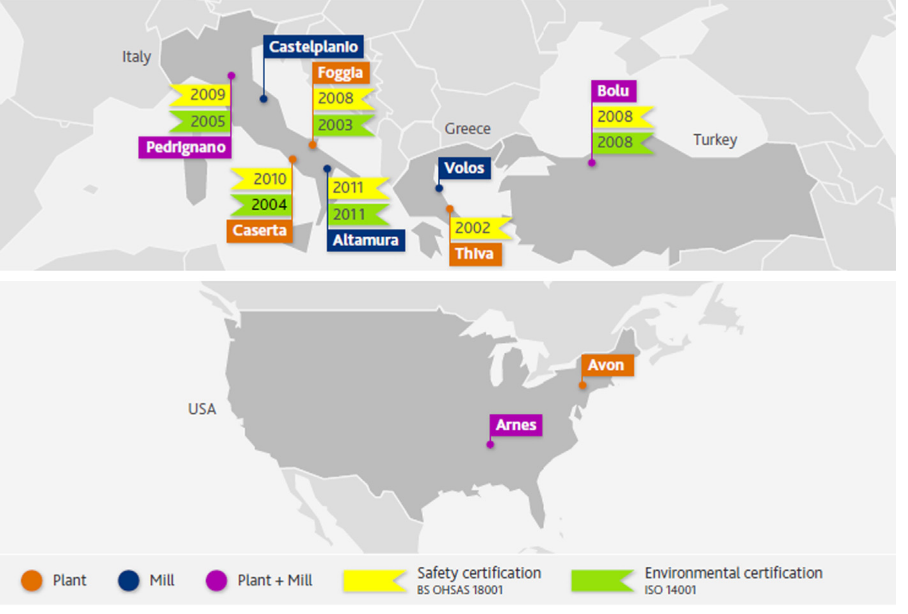


Fig. 5. Location of the mills and production plants owned by Barilla.

Italy and the USA (the cases of Greece and Turkey are reported in Appendix—Tables IA and IIA). In the case of Italy, a substantial amount of consumed virtual water is imported from abroad: the percentage of imported water ranges from 34.0% in 2009 to 37.6% in 2010 and 25.7% in 2011. The abrupt decrease in imported virtual water related to durum wheat in 2011 is, at least partially, ascribable to the programme to implement the cultivation of a high-quality variety of durum wheat (*Aureo*) in Italy rather than in the USA. Likewise, the export of total virtual water in 2011 has, for the first time, exceeded the import flux; confirmation of this trend in the following years will demonstrate the adequacy of Barilla's water-saving policy. Moreover, being Italy a strong virtual water importer [15], this trend entails that pasta-related trade will not contribute to the Italian virtual water deficit. The remaining portion of wheat is imported from abroad: the main countries contributing to the virtual water import are the USA (e.g., it contributed 24% of total import in 2010), Canada (21%), Mexico (18%), and France (16%). As for the reverse flux (i.e., export of virtual water in pasta), 63.2% of pasta produced in Italy is for domestic use, while Barilla exports its pasta mainly to France (28.0%), Germany (21.7), Japan (6.5%), and Switzerland (6.2%).

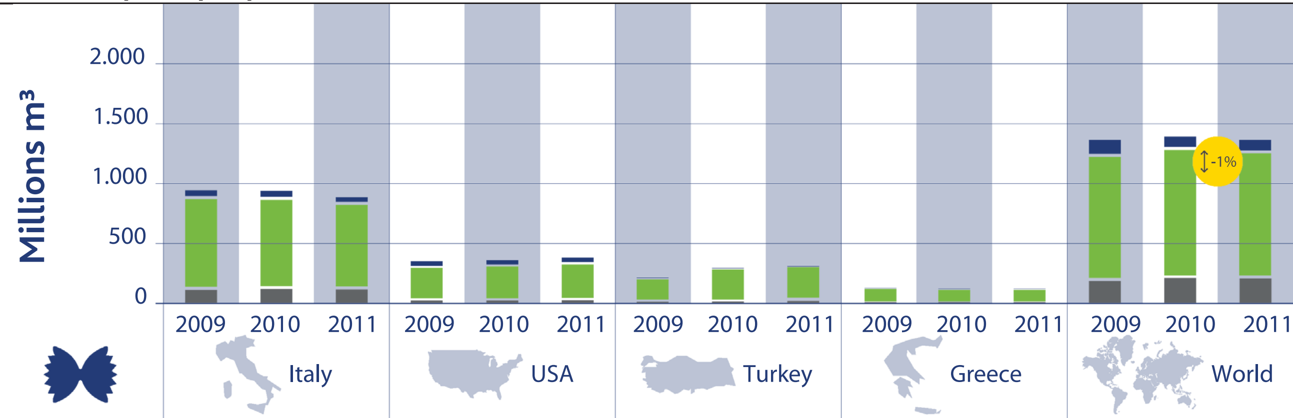
In the case of Greece, there is a remarkable downward trend in the domestic wheat-related WF, partially compensated by an increase in imported virtual water. Contrariwise, the pasta-related virtual water export remains almost the same over three years (only a small reduction occurs after 2009). Globally, Barilla contributes to Greece's water balance with a net export of virtual water, despite the downward trend of export surplus: in 2009 imported water was 7.2% in comparison to exported water, in 2010 it stood at 35.6%, and 52% in 2011. For its pasta production in Greece, Barilla imports a small amount of wheat only from two countries: France and Bulgaria, while pasta is mainly consumed locally (69%) and exported to Italy (14%), Sweden (13%), and the Balkans (4%). Greece's case is characterised by Barilla's tendency to “localise” production.

Looking at Turkey, we find that this case also shares several aspects in common with the previous other countries. Similar to the Italian case, Turkey is taking on the role of virtual water exporter in relation to Barilla activities. The net export already started in 2010, with net volumes of 10–15 million cubic metres. Nearly all wheat used by Barilla in Turkey comes from domestic production, while only a very small fraction (about 2.2% in 2010) is imported from Spain. Furthermore, pasta production is

Table 1
Water footprint of durum wheat pasta produced by Barilla. The values refer to the water footprint of 1 kg of pasta and are differentiated according to the producing country and production phases.

		litres/1 kg Durum wheat pasta	Durum wheat	Milling process	Pasta production	Packaging	From field to distribution	Total litres/kg	Cooking
ITALY		Green	1.105	–	0	0	1.105	1.336	–
		Blue	47	–	4	2	53		10
		Grey	178	–	0	0	178		–
USA		Green	1.146	–	0	0	1.146	1.584	–
		Blue	237	–	1	2	240		10
		Grey	198	–	0	0	198		–
GREECE		Green	1.388	–	0	0	1.388	1.536	–
		Blue	5	1	2	2	10		10
		Grey	138	–	0	0	138		–
TURKEY		Green	2.596	–	0	0	2.596	2.847	–
		Blue	6	–	1	2	9		10
		Grey	242	–	0	0	242		–

Table 2
Barilla's overall water footprint for pasta production.



	Italy 2009	Italy 2010	Italy 2011	USA 2009	USA 2010	USA 2011	Turkey 2009	Turkey 2010	Turkey 2011	Greece 2009	Greece 2010	Greece 2011	World 2009	World 2010	World 2011
Grey	104	109	106	39	42	43	14	18	20	7	6	7	164	175	176
Green	703	694	658	215	252	247	150	190	217	78	68	67	1.146	1.204	1.189
Blue	42	42	32	59	41	52	1	1	1	1	1	1	102	84	85
Total	849	845	796	313	335	342	165	209	238	86	75	75	1.412	1.463	1.450

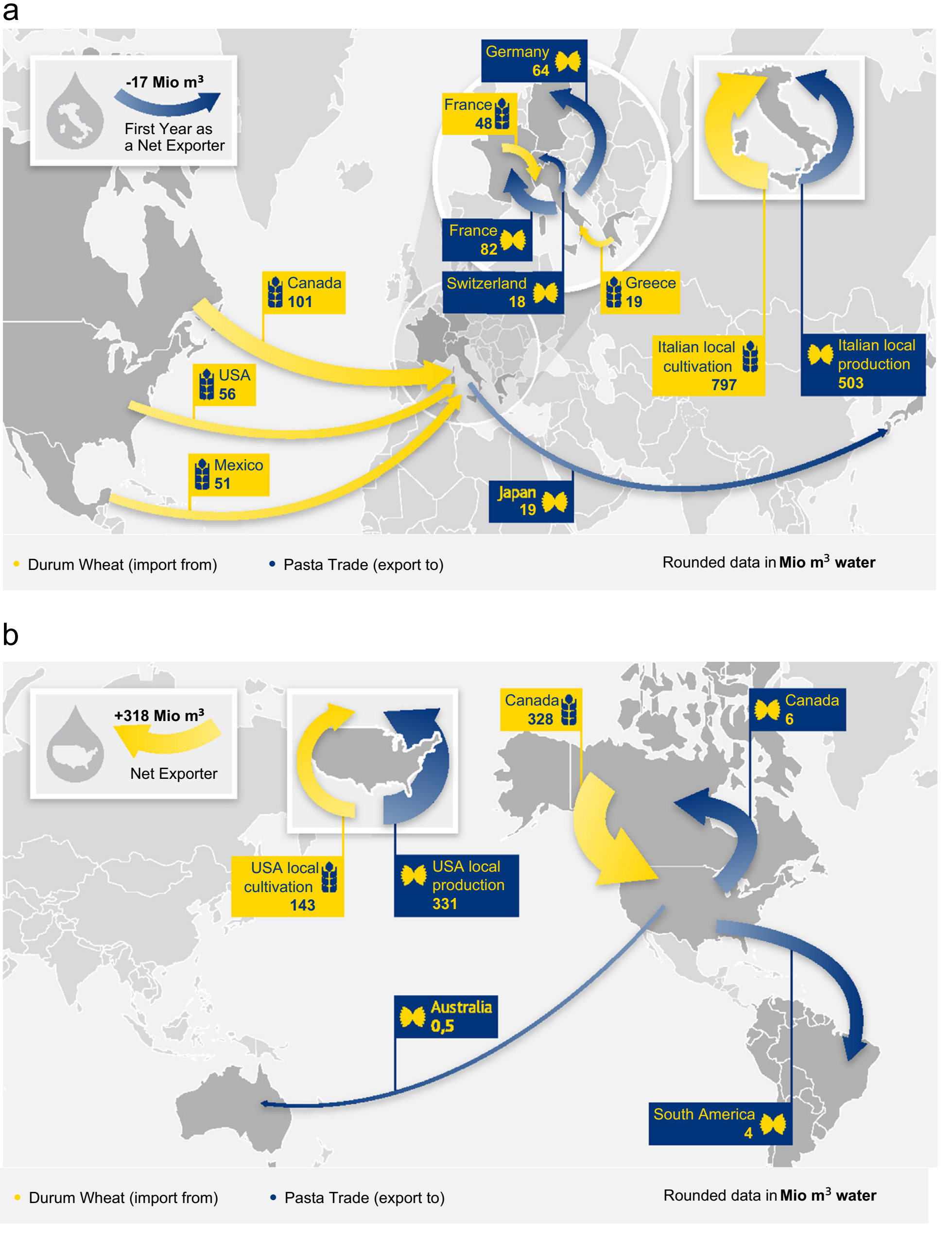


Fig. 6. Main virtual water fluxes related to durum wheat and pasta trade from/to Italy. Data refers to 2011 Barilla production.

mainly for the Turkish market (92.5%) with minor exports toward the Balkans (2%) and the Middle East (1.4%).

The major peculiarity relevant to the case of the USA (see Fig. 6b and Table 4) is the strong surplus of imported green water in respect to water used locally. For instance, in 2011 water used locally was 20.0% of imported green water. Finally, Barilla-related wheat and pasta trade entails a high net import

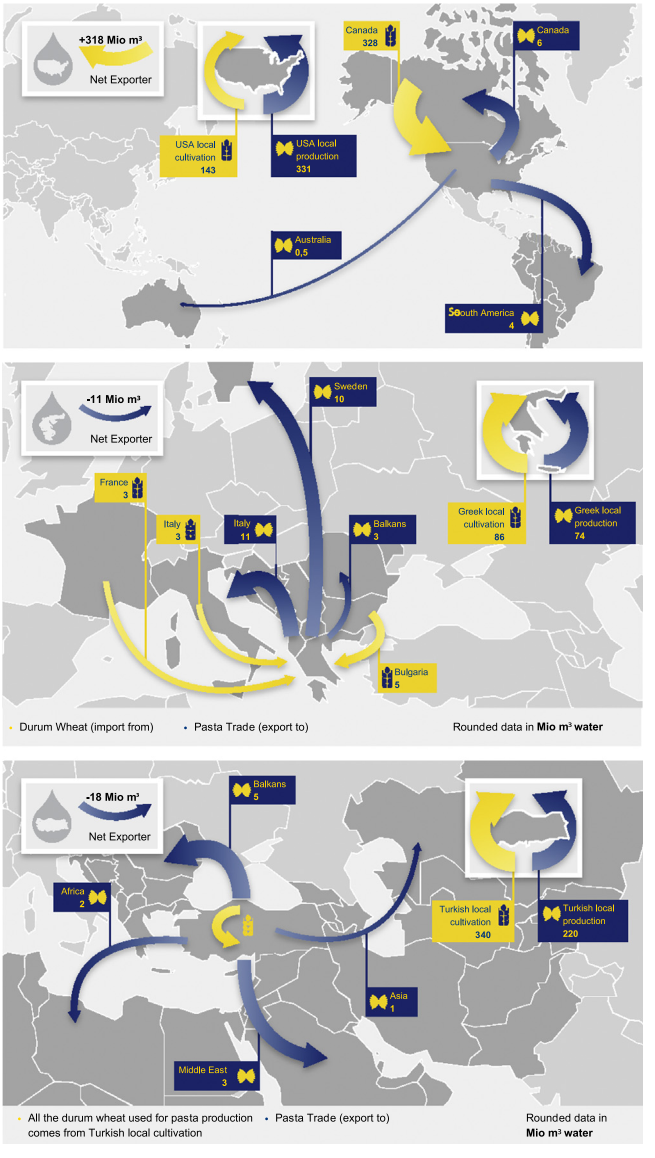


Fig. 7. Main virtual water fluxes in 2011 from/to USA (upper panel), Greece (central panel), and Turkey (lower panel).

of virtual water (in USA), in the order of hundreds of millions of cubic metres. This trait that the USA has as importer is in open contrast with the role of the USA in the global virtual water trade (i.e., considering all crop and animal products), where the USA stands as the largest exporter of virtual water.

Lastly, a few interesting points emerge if all fluxes of virtual water related to wheat and pasta trade (not restricted to Barilla products only) are considered. As expected, data corresponding to the USA shows that this country is a big exporter of wheat-related virtual water while remaining a net exporter. This balance also includes the pasta trade, though pasta trade in itself would entail a net import of water. Similar to the USA, Greece and Turkey are exporters of virtual water with respect to wheat/pasta. However, in contrast to the USA, the positive balance between export and import of

Table 3
Virtual water fluxes related to durum wheat and pasta trade related to Barilla production in Italy.

Virtual Water Fluxes thousands m^3 Barilla Italy 2009/2010/2011			Net flux (total import – total export)					
			+53 Mio m^3		+111 Mio m^3		-17 M o m^3	
			2009		2010		2011	
			Input	Output	Input	Output	Input	Output
Durum Wheat	Italian local cultivation		707.141		697.748		796.757	
	Import from	France	15.578		28.046		47.643	
		Greece	–		27.558		19.452	
		Australia	120.254		66.700		–	
		Mexico	41.687		64.548		50.670	
		USA	138.562		101.999		55.772	
		Canada	34.585		98.340		101.449	
		Others	14.069		33.859		–	
		Tot. import	364.735		421.051		274.986	
	Total amount		1.071.876		1.118.798		1.071.743	
Pasta	Italian for local consumption			536.831		534.353		502.887
	Export to	France		87.513		87.109		81.979
		Germany		68.063		67.748		63.759
		Japan		20.497		20.403		19.201
		Switzerland		19.299		19.210		18.079
		Others		116.578		116.040		109.207
		Tot. export		311.950		310.510		292.225
	Total Italian production			848.781		844.862		795.112

Table 4
Virtual water fluxes related to durum wheat and pasta trade related to Barilla production in the USA.

Virtual Water Fluxes thousands m^3 Barilla USA 2009/2010/2011			Net flux (total import – total export)					
			+150 Mio m^3		+269 Mio m^3		+318 Mio m^3	
			2009		2010		2011	
			Input	Output	Input	Output	Input	Output
Durum Wheat	USA local cultivation		280.955		130.423		142.656	
	Import from	Canada	159.380		279.126		328.303	
		Tot. import	159.380		279.126		328.303	
	Total amount		440.334		409.549		470.958	
Pasta Trade	USA for local consumption			302.640		325.002		330.828
	Export to	Canada		5.932		6.370		6.484
		S. America		3.494		3.752		3.819
		Australia		420		451		459
		Tot. export		9.845		10.573		10.762
	Total USA production			312.485		335.575		341.591

Table A1
Virtual water fluxes related to durum wheat and pasta trade related to Barilla production in Greece.

Virtual Water Fluxes thousands m^3 Barilla Greece 2009/2010/2011			Net flux (total import – total export)					
			-25 Mio m^3		-15 Mio m^3		-11 Mio m^3	
			2009		2010		2011	
			Input	Output	Input	Output	Input	Output
Durum Wheat	Greek local cultivation		111.852		91.440		85.915	
	Import from	France	1.173		2.780		3.520	
		Canada	769		–		–	
		Italy	–		–		3.507	
		Bulgaria	–		5.533		5.533	
		Others	–		–		–	
		Tot. import	1.942		8.313		12.560	
	Total amount		113.794		99.754		98.475	
Pasta Trade	Greek for local consumption			58.630		51.087		50.904
	Export to	Italy		12.122		10.563		10.525
		Sweden		11.261		9.812		9.777
		Balkans		3.415		2.975		4.965
		Others		–		–		–
		Tot. export		26.798		23.350		23.267
	Total Greek production			85.427		74.437		74.171

Table A2
Virtual water fluxes related to durum wheat and pasta trade related to Barilla production in Turkey.

Virtual Water Fluxes thousands m^3 Barilla Turkey 2009/2010/2011			Net flux (total import – total export)					
			+10 Mio m^3		-10 Mio m^3		-18 Mio m^3	
			2009		2010		2011	
			Input	Output	Input	Output	Input	Output
Durum Wheat	Turkish local cultivation		279.105		443.416		340.238	
	Import from	Greece	22.695		–		–	
		Spain	–		5.199		–	
		Tot. import	22.695		5.199		–	
	Total amount		301.799		448.614		340.238	
Pasta Trade	Turkish for local consumption			152.487		193.196		220.022
	Export to	Balkans		3.241		4.107		4.677
		Middle East		2.366		2.998		3.414
		Africa		1.242		1.574		1.792
		Asia		969		1.228		1.399
		Others		4.516		5.721		6.515
		Tot. export		12.335		15.628		17.798
	Total Turkish production			164.822		208.823		237.819

Greece and Turkey occurs both for wheat and pasta trade, whereas Italy exports a large amount of water related to pasta trade but imports an even larger amount of water in the wheat trade. As a result, the concurrence of both wheat and pasta trades makes Italy an importer of virtual water, even if Barilla is going against this tide in an attempt to reduce Italy's water footprint.

5. Conclusions

Water footprint evaluation of a company is becoming a key point for business strategy. Key factors in the evaluation of a company's environmental impact include clear and detailed accounting of the water footprint relevant to all phases, from production of raw materials to distribution of the final goods, breakdown into green/blue/grey components, and the inclusion of both the operation and supply-chain water footprints.

With this approach in hand, we focused on the case of Barilla's pasta production. Barilla's main position as leading player in the world pasta market makes this a well representative analysis for the case of large-sized food companies. Our analysis has brought three key findings to light. Firstly, wheat cultivation lends the greatest contribution to the total water footprint. Therefore, the majority of effort to reduce the WF should be devoted to this phase of pasta production. In this sense, the introduction in Italy of a new variety of high-quality durum wheat (*Aureo* wheat)—similar to the Desert Durum® variety, specifically developed using traditional methods and with higher resistance to water stress conditions—is an important step forward. In fact, it allows a decrease of durum wheat import from the desert south west of the United States, which requires constant irrigation. Such a strategy could lead to a saving of approximately 40 million cubic metres irrigation water per year. This shift from farming in the USA to Italy has yielded a decrease of approximately 1000 t of CO_2 eq. previously produced by transports.

Secondly, this study shows that the water footprint of 1 kg of Barilla pasta ranges between 1.336 and 2.847 l of water. The large variation of the pasta water footprint indicates the importance in understanding the spatial variability of local environmental conditions and agricultural techniques adopted during the wheat cultivation phase.

Thirdly, relevant virtual water fluxes are involved in pasta and durum wheat trade among countries, with the external water footprint representing about 30% of the total footprint in the case of Barilla Italy, characterised by a sharp decrease from 2009 to 2011, thus testifying the initial results of the Aureo wheat cultivation programme in Italy.

This study exposed the importance of the origin of raw material used by Barilla in order to control the water impact of its production. Following this track, Barilla aims to further reduce its water footprint by promoting better farming practices and new cultivars able to reduce the use of irrigation water. Moreover, Barilla is promoting new studies aimed to contextualise the virtual water balance involved in its production in relation to effective water availability of every durum wheat cultivating country.

Conflict of Interest

None

Appendix

See Tables A1 and A2.

References

[1] M.M. Aldaya, A.Y. Hoekstra, The water needed for Italians to eat pasta and pizza, Agricultural Systems 103 (2010) 351–360.
[2] J. Allan, Perspectives on countries and regions, (1994)., in: P. Rogers, P. Lydon (Eds.), Water in the Arab World: Perspectives and Prognoses, Harvard University Press, Cambridge, MA, 1994. (Translated into Arabic).

[3] K. Andersson, T. Ohlsson, P. Olsson, Screening life cycle assessment (LCA) of tomato ketchup: a case study, Journal of Cleaner Production 6 (1998) 277–288.
[4] A.E. Ercin, M.M. Aldaya, A.Y. Hoekstra, Corporate Water Footprint accounting and impact assessment: the case of the Water Footprint of a sugar-containing carbonated beverage, Water Resources Management 25 (2011) 721–741.
[5] P. Gerick, The changing water paradigm—a look at twenty-first century water resources development, Water International 25 (1) (2000) 127–138.
[6] J. Hall, Environmental supply chain dynamics, Journal of Cleaner Production 8 (2000) 455–471.
[7] A.Y. Hoekstra, The water footprint of food, in: Water for food, The Swedish Research Council for Environment, 2008, pp. 49–60.
[8] A.Y. Hoekstra, P.Q. Hung, Virtual water trade: a quantification of virtual water flows between nations in relation to international crop trade, Value of Water Research Report Series, vol. 11, UNESCO-IHE, Delft, 2002.
[9] A.Y. Hoekstra, A.K. Chapagain, M.M Aldaya, M.M. Mekonnen, The Water Footprint Assessment Manual. Setting the Global Standard, Earthscan, London, 2011.
[10] J. Liu, S. Orr, Water Footprint overview in the governmental, public policy, and corporate contexts, in: J. Lundqvist (Ed.), On the Water Front: Selections from the 2009 World Water Week in Stockholm, International Water Institute, Stockholm, 2010.
[11] M.M. Mekonnen, A.Y. Hoekstra, The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft Netherlands, 2010.
[12] B.G. Ridoutt, S.R.O. Williams, S. Baud, S. Fraval, N. Marks, The water footprint of dairy products: case study involving skim milk powder, Journal of Dairy Science 93 (11) (2010) 5114–5117.
[13] J. Rockstrom, W. Steffen, K. Noone, A. Persson, F.S. Chapin, E.F. Lambin, et al., A safe operating space for humanity, Nature 461 (2009) 472–475.
[14] D.A. Rondinelli, M.A. Berry, Environmental citizenship in multinational corporations: social responsibility and sustainable development, European Management Journal 18 (1) (2000) 70–84.
[15] S. Tamea, P. Allamano, J.A. Carr, P. Claps, F. Laio, L. Ridolfi, Local and global perspectives on the virtual water trade, HESSD 9 (2012) 12959–12987.
[16] UNESCO, Water for People, Water for Life: The United Nations World Water Development Report, UNESCO/Oxford: Berghahn Books Publishing, Paris, 2003.
[17] UNESCO, Water, a shared responsibility, The United Nations 934 World Water Development Report 2, UNESCO Publishing/ Oxford: Berghahn Books Publishing, Paris, 2006.
[18] United Nations, Water Scarcity, 2011. Retrieved on February 5, 2012 from ⟨www.un.org/waterforlifed ecad e/scarcity. shtml⟩.
[19] WWF, A Water Scarcity Risk—A Typology. World Wildlife Fund, Godalming, 2007.
[20] Water Footprint Network, ⟨www.waterfootrint.org⟩, 2012 (accessed 26.11.12).
[21] EcoInvent database, ⟨www.ecoinvent.ch⟩, 2012 (accessed 26.11.12).
[22] J.A. Allan, Food-Water Security: the Role of Food Supply Chains and the Agents who Operate them, in: Proceedings of the International Conference on Food Security in Dry Lands, Doha, Qatar, November 14th–16th 2012, ⟨www.fsdl.qa/Portals/0/ pdf/FIN_FULL_ALLAN.pdf⟩ (accessed February 2013).
[23] Barilla Center for Food and Nutrition, Water Economy, Parma, Italy, 2011.