2014

WATER FOOTPRINT OF ITALY

The" Water Footptint of Italy" Report has been realized within the OnePlanetFood Programme of WWF Italy

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FOREWORD

For a "less unsustainable" water use in the Anthropocene epoch

As the very important study "Millennium Ecosystem Assessment" pointed out in 2005 (www.maweb.org), prior to the twentieth century, global demand for fresh water was small compared with natural flows in the hydrologic cycle. With population growth, industrialization, and the expansion of irrigated agriculture, however, demand for all water-related goods and services has increased dramatically, putting the ecosystems that sustain this service, as well as the humans who depend on it, at risk.

While demand increases, supplies of clean water are diminishing due to mounting pollution of inland waterways and aquifers. Increasing water use and depletion of fossil ground water adds to the problem.

These trends are leading to an escalating competition over water in both rural and urban areas. Particularly important will be the challenge of simultaneously meeting the food demands of a growing human population and expectations for an improved standard of living that require clean water to support domestic and industrial uses.

Societies have benefited enormously through their use of fresh water. However, due to the central role of water in the Earth system, the effects of modern water use often reverberate throughout the water cycle. Key examples of human-induced changes include alteration of the natural flow regimes in rivers and waterways, fragmentation and loss of aquatic habitat, species extinction, water pollution, depletion of ground water aquifers, and "dead zones" (aquatic systems deprived of oxygen) found in many inland and coastal waters. Thus, trade-offs have been made - both explicitly and inadvertently - between human and natural system requirements for fresh water services. The challenge for the twenty-first century will be to manage fresh water to balance the needs of both people and ecosystems, so that ecosystems can continue to provide other services essential for human well-being.

The founder of economy Adam Smith writes in his classic book, "The Wealth of Nations" published in 1776,that not all that is very useful commands high value (water, for example) and not everything that has a high value is very useful (such as a diamond).

As Pavan Sukhdev writes in the Interim Report on TEEB (The Economics of Ecosystems and Biodiversity), the most important international program dedicated to give value to biodiversity and ecosystems (www.teebweb.org), this example expresses two major learning challenges that society faces today.

Firstly, we are still learning the "nature of value", as we broaden our concept of "capital" to encompass human capital, social capital and natural capital. By recognizing and by seeking to grow or conserve these other "capitals" we are working our way towards sustainability.

Secondly, we are still struggling to find the "value of nature". Nature is the source of much value to us every day, and yet it mostly bypasses markets, escapes pricing and defies valuation. This lack of valuation is an underlying cause for the observed deg- radation of ecosystems and the loss of biodiversity.

At the time of Adam Smith, more than two centuries ago, land was plentiful, energy was not a major factor of production, and the scarce input to production was financial capital. Now the situation is completely changed and the most important indicator of economy, the GDP, does not capture many vital aspects of national wealth and well-being, such as changes in the quality of health, the extent of education, and changes in the quality and quantity of our natural resources.

Now the scientific research on global environmental change demonstrates that the functioning of the Earth's biophysical systems are now so dominated by human activities that our planet has moved into a new epoch in the Geological Time Scale, the Anthropocene.

Human land-use has transformed more than 40% of land surface, exceeding the last large scale physical transformation at the end of the last glacial period, more soils is eroded as result of human land use than natural geomorphic processes, carbon dioxide levels in the chemical composition of atmosphere now is near 400 ppm for the first time 3 million years, as a result of human activities, and worldwide water demands use by humankind is about 30% of that accessible supply (agriculture accounts for 70% of the global demand, industries for 20%, cities and towns for about 10%).

Humanity's habitation of our Earth in this new epoch is thus precariously balanced.

In its most relevant publication, "Living Planet Report" series, WWF warns that humanity's footprint exceeds the Earth's biocapacity. Humanity's demand on the planet has more than doubled over the past 50 years as a result of population growth and increasing individual consumption.

The last "Living Planet Report 2012" (the new one, 2014, will be published within this year) defines five systemic interventions for creating a sustainable society: 1) preserving natural capital, 2) redirecting finances, 3) better production, 4) wise consumption and 5) equitable governance mechanisms. In "Living Planet Report 2008" for the first time in this series, WWF, with the support of two experts of water such as Arjen Hoekstra and Mesfin Mekonnen, gave an important contribution to widespread the concept of water footprint, that calculates the volume of water required to produce goods and services consumed by a given population.

In Italy WWF utilized this important indicator to establish a new approach dedicated to give value to fresh water ecosystems and their services (for promoting a green economy that put at the center of our economic system the natural capital) and to reconsider for the institutions, private sector, civil society, the crucial role of water ecosystems for our wellbeing and our development.

We pay particular attention to the role of the water cycle in the food production (for this WWF Italy has a specific program named Our Planet Food and leads by my colleague Eva Alessi who gave a strong support for the realization of this report), for obtaining a serious reduction of its intensive use in all food production activities.

The realization of this important report has been possible thanks to the valuable contribution of a multidisciplinary group of young researchers, Marta Antonelli and Francesca Greco (leading authors and coordinators of the report), Martina Sartori, Silvia and Claudia Tavernini Consalvo (authors). To them, we deserve our most sincere and heartfelt thanks.

We hope that the report constitutes a valuable tool for institutions, private sector and all citizens, to fully understand the central role of water in our lives.

Gianfranco Bologna
(Scientific Director of WWF Italy)

River kingfisher or (*Alcedo atthis*); © Fred F. Hazelhoff / WWF-Canon

EXECUTIVE SUMMARY

BASIC CONCEPTS

The Water Footprint considers not only the place where water comes from but it also adds a qualitative component to it.

Water gets divided into three components: blue, green and grey.

The management, environmental impacts and the opportunity costs of each of these differ greatly from one to the other.

Blue Water consists of surface water bodies (rivers, lakes, estuaries, etc.) and in underground aquifers. The blue water footprint therefore accounts for the consumption of surface and ground water of a certain basin. Here consumption is intended as a withdrawal that does not come back intact to the same place from which it was taken. It is, therefore, displaced somewhere else .

Green Water is the rainwater contained into the plants and the soil as humidity, without becoming part of any surface or underground water body. The green water footprint focuses on the use of rainwater, specifically on the soil's evapo-transpiration flow used in agriculture and forestry output and it is importannt to understand the value of rainfed agriculture in terms of non-impact on blue water resources.

Grey Water refers to all the water polluted by any production process. It represents the quantity of fresh water necessary to dilute the load of pollutants given their well-known natural concentrations and the current water quality local standards.

The Water Footprint is the sum of green water, blue water and grey water required for the production of any good or service

To what extent do our food consumption choices impact the environment, and water systems in particular? How much of this water originates from abroad and what are the main sources? **To what extent can we improve our food consumption patterns through more-informed choices so that the burden on the environment is lessened?** How can we promote water accountability in supply chains? **Is it possible to inform citizens about the impacts on ecosystems and water resources of the products they consume in Italy?** Is it possible to improve our internal water footprint, by improving the *quality* of the water used for food production? **These challenges and possible solutions are discussed in the report. Future trends will be explored with particular attention to water saving, irrigation efficiency and rainfed agriculture in the Italian context. Identifying a pattern towards water accountability and ways for improving our water footprints, calling for a joint effort of government, citizens, the private sector, and financial institutions, is the ultimate aim of this report.**

In January 2012, the WWF Italy has launched the **One Planet Food Program** dedicated to promoting dietary patterns with low environmental impact and to improve the relation of food to the sustainability of natural systems and biodiversity on Earth. In order to achieve our ambitious targets for change, an holistic approach is needed: we need in fact to address both demand side (food consumption) and supply side (food production) issues within the food supply chain.

It is a complex challenge that requires an integrated approach and efforts from the scientific community, civil society, producer, government, business and other organisations. The One Planet Food Program strategy is ambitious in approach and is based on a stakeholder engagement process which will allow WWF, and a critical mass of other key stakeholders, to work together and drive forward a number of agreed objectives: consumption of resources - primarily water -, pollution and the emission of greenhouse gas arising from the production of food are at sustainable levels and the adverse impact of food production in key areas of biodiversity impacted are restored.

In recent years, the problem of water consumption and its management has become increasingly central issues in the debate on global sustainability, especially vis-à-vis the intensifying **water scarcity at the global level**. Adequate quality of water resources is not only a prerequisite for the human society welfare, but it is also fundamental for the natural ecosystems that provide essential benefits to human societies and life on earth as a whole.

This theme will also be addressed by WWF in the context of the EXPO 2015 (to be held in Milan). WWF - **as the "Civil Society Participant"** – will be engaged in a series of initiatives aimed at highlighting the impact that the food chain can have on planetary ecosystems and biodiversity.

Water is a critical sustainable development challenge. Globally, the per capita availability of fresh water is steadily decreasing. This trend will continue with population growth, rising consumption levels, also in developing countries, and the impact of climate changes.

WWF has identified the **water footprint** as an important indicator to assess the total amount of water used in production processes and in consumer goods, especially food, starting a process of analysis and increasing awareness on how and where this precious resource is used. As the ecological footprint concept, the water footprint of a nation brings to light an *invisible* consumption of water resources, highlights the dependency on resources from other countries as well as the impacts on our own national resources for the production of goods for national consumption or export

The "*Water Footprint of Italy*" Report provides a comprehensive overview of the amount and sources of water that are utilized, both within the nation and outside, for the production of goods and services consumed within the Italian territory. **The amount of water utilized to produce any food and other products is called *virtual water*. It is "virtual" because is not visible to the final users of the final product, but it has been utilized for its production along the entire supply chain**

This report will provide facts and figures about the Italy's water use and consumption. The focus of this report will be on the **agricultural sector** that is the **biggest water user both globally and in Italy**. The findings of the study highlight that a new thinking and a more active engagement towards more sustainable water resources use and management are needed both at the policy and business level. **Making visible the invisible, advocating for accountability and responsibility, increasing awareness are among the main aims of this report**.

OVERVIEW OF THE MAIN RESULTS

Water footprint doesn't refer only to the water withdrawal within a country: it distinguishes between water use for making products for domestic consumption and water use for producing export products. It also includes data on water use outside the country to support national consumption. The national water footprint accounting consists of two components: **water footprint of national production** and **water footprint of national consumption**

The **water footprint water footprint of national production** is defined as the total freshwater volume or polluted within the territory of the nation. It can be calculated by summing up the water footprints of all water consuming or polluting processes taking place in the nation. Part of the total domestic volume of freshwater consumed or polluted in a nation is exported with export products.

The **water footprint of national consumption** is defined as the total amount of fresh water that is used to produce the goods and services consumed by the inhabitants of the nation. It consists of two components: the *internal* water footprint, i.e. the water use inside the country, and the *external* water footprint, i.e. the water use in other countries.

Many countries, including Italy, have significantly externalized their water footprint, without looking at whether the imported products are related to water depletion or pollution in the producing countries. The water footprint of national consumption is the sum of water that is used to produce the goods and services produced and consumed by the inhabitants of the nation and water in the goods and services produced and imported from other countries but consumed by the inhabitants of the nation.

Water appropriation for Italy's production of goods

The water footprint of national production is defined as the total freshwater volume consumed or polluted within the territory of the nation as a result of activities within the different sectors of the economy.

The total water footprint of Italy's national production amounts to about 70 Billion m³ of water per year. This equals to 3,353 litres per person per day. Agriculture is the thirstiest economic sector in Italy – as well as in other Mediterranean countries – unlike the majority of European and North American countries, where industrial and economic sectors are the dominant water-users – and is mainly related to the production of agricultural products (85%), which includes the use of water for **crops production (75%)**, grazing and animal water supply (10%).

The remaining 15% of the water footprint of production is split between industrial production (8%) and domestic water supply (7%). In the composition of the water footprint by water sources, green water (i.e. the rainwater 'embedded' in soil and plants) is the major component (69%), followed by grey water (reflecting water pollution) (22%) and blue water (freshwater from aquifers, rivers and lakes) (9%). **Crops are produced employing mainly green water**, that is, in rainfed conditions. With respect to consumption, production processes generate a larger amount of polluted water

After more than 60 years of intensive agriculture and land use change, the exploitation and the pollution of water resulted in a decline of Italian freshwater habitats and a loss of ecosystem services. This is particularly evident in those regions, such as those in the Po river watershed, where economy is stronger and water has to be shared between different users (i.e. farmers, cities, industries, ecosystems). **Affecting both the quality and the quantity of Italian freshwater resources, agriculture appears to be a major threat for future national water security**.

In this context, the water footprint analysis can help better understand the picture of water scarcity at both national and local levels, and to highlight the link between water and food security

Water appropriation implicit in Italy's consumption of goods

Italy's total water footprint of national consumption, defined as the total amount of freshwater that is used to produce the goods and services consumed by the inhabitants of a nation, is about 132 Billion m³ of water per year. This amount is equal to 6,309 litres per person per day. Food consumption alone (including both agricultural and animal-based products) **contributes to 89% of the total daily water footprint of Italians.** The consumption of water for domestic purposes (bathing, cleaning, drinking, etc.) is only 4% of the water we consume daily, whereas the water 'embedded' in industrial products accounts for 7%.

Regarding the composition of the water footprint by water sources, 75% is sourced from green water (that is, the water that originates from rainfall and stays in the root zone to support plant growth), 8% from blue water (surface and groundwater bodies) and 17% from grey water (the water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards). **Green water plays such a dominant role because 100% of the total green water (99 Million m³) is consumed by agriculture**. **Animal-**

based products (including milk, eggs, animal fats, and meat**) account for almost 50% of the total water footprint of national consumption**. The consumption of meat alone contributes to 1/3 of the total water footprint. A second important portion of the water footprint is generated by the consumption of vegetable oils (11%), cereals (10%) and milk (10%).

Italy is one of the countries with the highest water footprint in Europe. Its water footprint is **25% above the European Union average**, **which amounts to 1,836 m^3/yr per capita**, and is higher than most of its neighbouring countries, such as France and Germany. **At a global level, Italy's water footprint is 66% above the world average, which amounts to 1,385 m^3/yr per capita**. With respect to the major non-EU economies, Italy ranks among the most water consuming countries, after the USA, Canada and Australia

The dependency on other countries' water resources

The water footprint of national consumption can be further distinguished between internal and external water footprints. The internal water footprint is defined as the use of domestic water resources to produce goods and services consumed within Italy. The internal component is thus related to the consumption of water through the consumption of goods produced in Italy.

The *external* water footprint of Italy is, instead, defined as the volume of water resources used in other nations to produce goods and services consumed in Italy. The *external* component accounts, therefore, only for the amount of water from outside Italy that is consumed as "embedded" in the imported goods. The latter is a proxy of how much Italy relies on foreign water resources to secure its needs for food and industrial products.

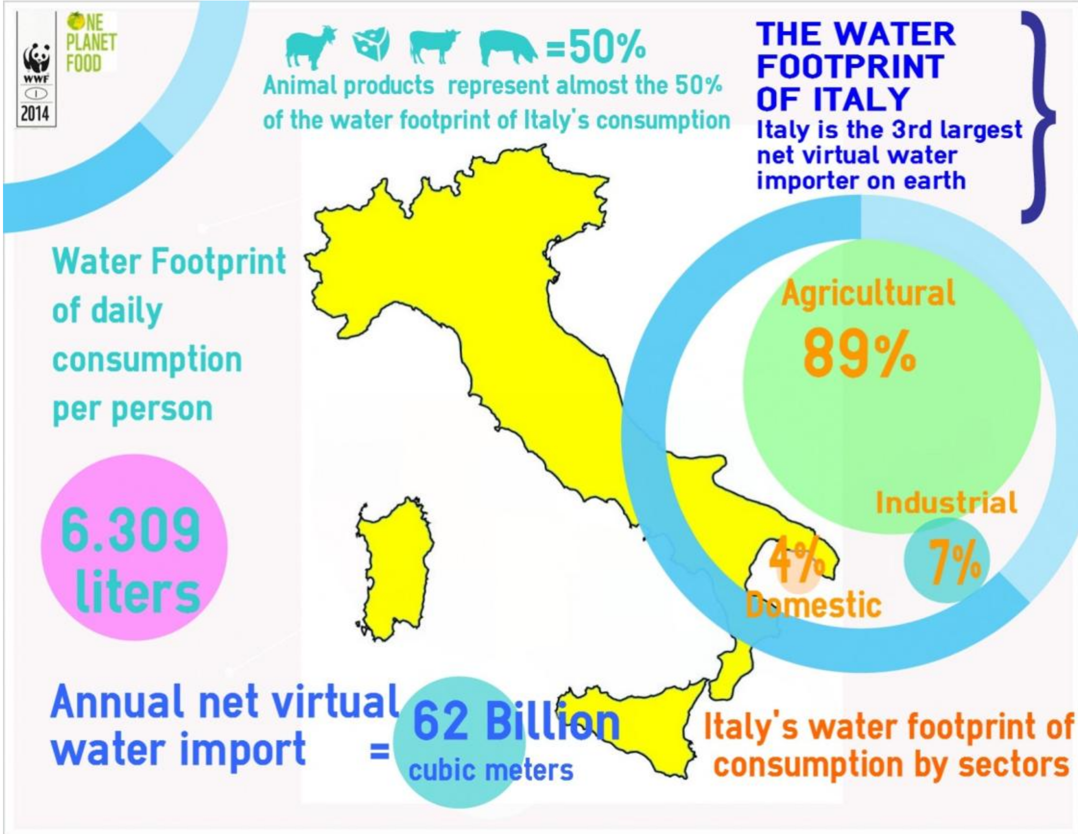
63% of the virtual water content of the agriculture goods consumed by Italians are imported, as well as 65% of virtual water content of the industrial products.

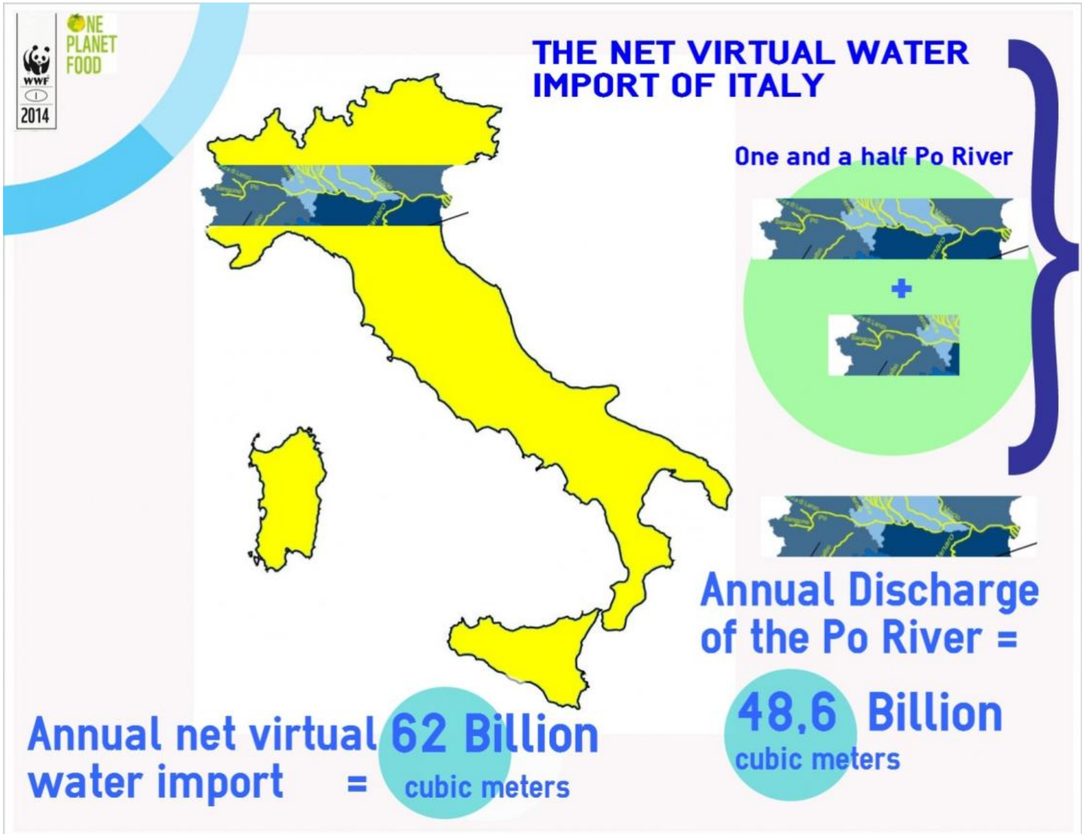
The ratio of the *internal* water footprint of Italy over the total water footprint of the Italian national consumption equals 37%. **This means that Italy relies on foreign water resources to meet its population's requirements to a considerable extent**

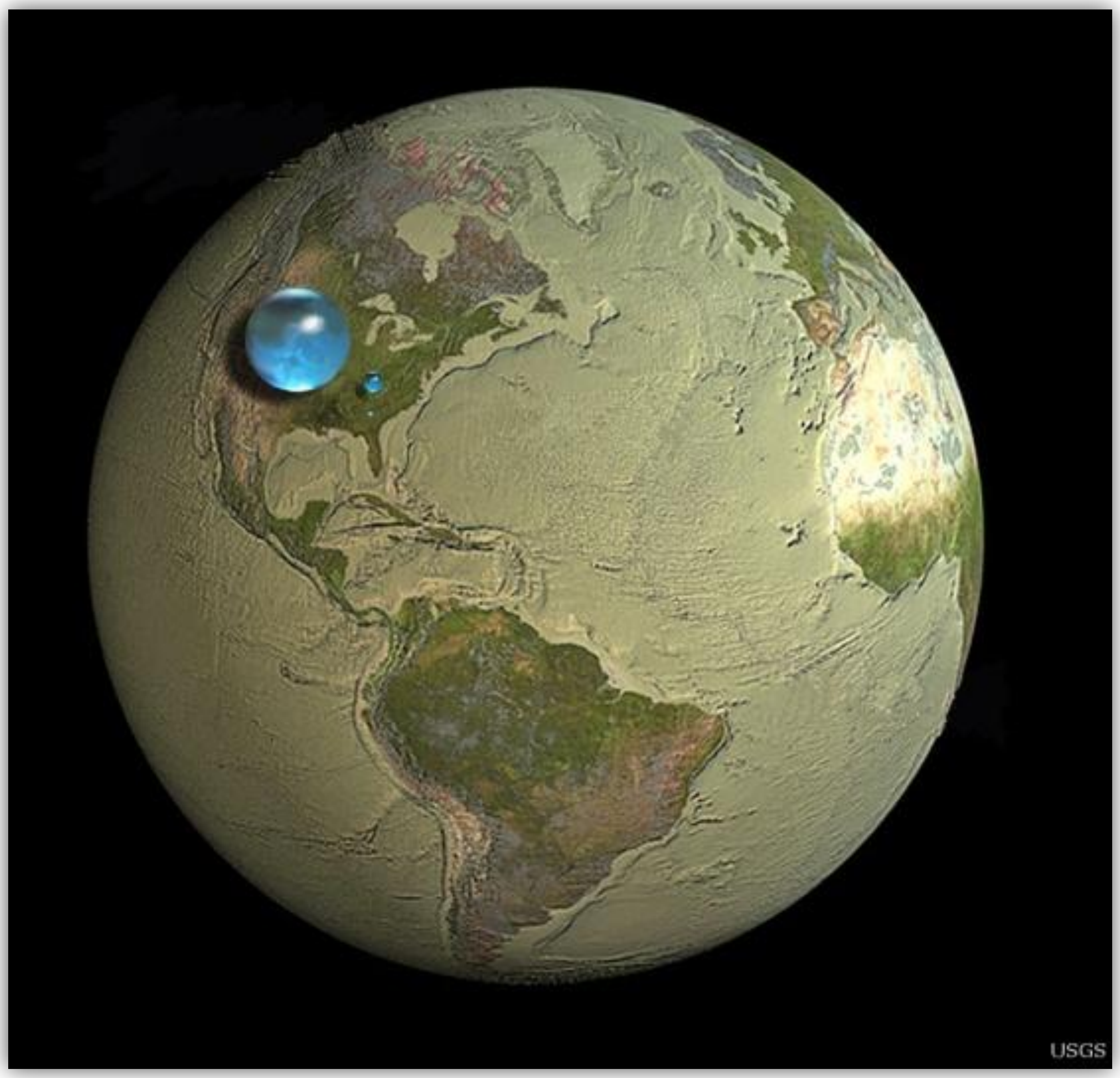
Italy is ranked as the 3rd net virtual water importer in the world (about 62 Billion m^3/year), after Japan and Mexico, and immediately before Germany and United Kingdom. More than 50% of the water is virtually imported by means of the water 'embedded' in food products originating from ten different countries. Some of them (India – 4%, Argentina – 4%, USA – 4% and Brazil – 7%) rank among the biggest net virtual water 'exporters' of the world; others (France – 9%, Germany – 6%, the Netherlands – 3% and the Russian Federation – 4%) are water-abundant countries. About 11% of Italy's virtual water 'imports' originates from water-scarce countries, i.e. Spain (6%) and Tunisia (5%) thus contributing exacerbating water scarcity.

These data are reported in order to increase awareness and call for a more effective consideration of water resources among the actors operating in supply chains (especially in the agro-business sector), decision makers, and citizens

These challenges and possible solutions are discussed in the report. Future trends will be explored with particular attention to water saving, irrigation efficiency and rainfed agriculture in the Italian context. Identifying a pattern towards water accountability and ways for improving our water footprints, calling for a joint effort of government, citizens, the private sector, and financial institutions, is the ultimate aim of this report.


ONE PLANET FOOD
WWF
2014
=50%
Animal products represent almost the 50% of the water footprint of Italy's consumption
THE WATER FOOTPRINT OF ITALY
Italy is the 3rd largest net virtual water importer on earth
Water Footprint of daily consumption per person
6.309 liters
Agricultural 89%
Industrial 7%
4% Domestic
Annual net virtual water import = 62 Billion cubic meters
Italy's water footprint of consumption by sectors


ONE PLANET FOOD
WWF
2014
THE NET VIRTUAL WATER IMPORT OF ITALY
One and a half Po River
+
Annual Discharge of the Po River =
48,6 Billion cubic meters
Annual net virtual water import = 62 Billion cubic meters



This image (source: *United States Geological Survey*, USGS) shows our planet earth without water. The three blue spheres represent, in decreasing size order, salt water from the oceans, freshwater included the glaciers, and water for human consumption. The tiny blue sphere therefore represents how tiny and precious is the water available for human consumption, compared to the size of our “Blue Planet”.

CHAPTER 1. GLOBAL WATER ISSUES

1.1 WATER, BIODIVERSITY AND ECOSYSTEM SERVICES

Only 2,5% of all water on Earth is fresh water. Most of it (79%) is unavailable being locked up in ice caps and glaciers. 20% is represented by groundwater. Lakes, reservoirs, rivers and wetlands, represent less than 1% of the available water. And however, these biotopes together with the surrounding wetlands (e.g. marshes, riparian zones, petlands and floodplains) are essential for human existence, in spite of the limited quantity of water they are made of. Due to water, all around the world civilisations have developed near rivers and lakes for centuries, because freshwater ecosystems deliver a wide range of services that are indispensable for human life.

Water supply, fertile soil and food production (notably fish), together with other products such as raw materials and genetic resources, are the so-called provisioning services of (freshwater) habitats. Also medicinal (i.e. drugs, pharmaceuticals, test organisms) and ornamental (i.e., aquarium fish, shells) resources are included in this group of services. Water bodies and associated wetlands work as regulators, e.g. controlling the quality of surrounding soils or mitigating the climate. Freshwater ecosystems provide flood control, carbon sequestration and storage and act as natural buffer zones to the surrounding environment. Good quality waters act as pest and disease control. All these services, including those nonmaterial benefits that humans receive from ecosystem, are called regulating services. Again, the provision of habitat for different species and the maintenance of the gene-pools viability represent the habitat services of freshwater ecosystems.

Finally, inland waters and surrounding areas give a lot of non-material benefits, the so-called cultural services. Canals and rivers have been reliable ways to transport people and commodities for ages. Freshwater biotopes have touristic and recreational use. Recreational fishing, swimming, or aesthetic enjoyment of the open water are all cultural benefits provided by water bodies. In many parts of the world rivers have been considered sacred since the beginning of human history (e.g. the Nile, the Ganges) and water bodies and wetlands have been the source of inspiration for artists throughout the centuries.

Each one of these services is linked to different underlying ecological processes[1]. For example, water purification relies on nutrient processing and photo- and chemosynthesis, whereas carbon sequestration is regulated by photosynthesis performed by phytoplankton and aquatic vegetation. On the whole, all terrestrial and costal ecosystems depend to some extent on freshwater biotopes, being influenced by inputs of water and nutrients from lotic and lentic freshwater habitats. Therefore it is evident that when considering both the marketed and non-marketed benefits of freshwaters, the total economic value of water bodies and wetlands is impressive. In spite of that, today freshwater ecosystems are at higher risk of extinction than terrestrial ones[2]. Even though freshwaters have always been severely impacted by human exploitation, over the past 30 years their species richness has reduced more than either terrestrial or marine biodiversity[3].

Population growth, increasing economic development and agriculture are the primary reasons for changes and loss of inland water bodies and wetlands. Land conversion and infrastructure development have reduced the number of freshwater habitats and the abundance of water. Increasing ground- and surface water withdrawal for agriculture and human consumption, decreasing river flows due the building of dams for electricity production, changing in river flows patterns and timing have altered the ecological character of many freshwater biotopes.

The use of nitrogen and phosphorus in fertilizers together with the adoption of pesticides due to intensive agricultural practices have led to a continuous degradation of water quality, often resulting in poor access to water for basic human needs. The nutrient load can favour the development of algal blooms, which can harm drinking water and make recreational areas useless. Toxic compounds can enter the aquatic food web and accumulate in organisms, including those for human consumption. And the increasing concentration of pollutants has also determined strong environmental deterioration, reducing species richness (i.e., fish, invertebrates, algae, plants, etc) and changing biodiversity, with a decline of native and sensitive species and an increase of more tolerant, sometimes invasive taxa.

Moreover, the extensive use of water for irrigation has strongly reduced the quantity of available resource, both for human population use and the maintenance of ecosystems. Inadequate water quality and quantity are the causes of the increasing incidence of waterborne diseases, loss of livelihood and forced resettlement in many regions. On the whole, poor quality and scarcity of water are key factors limiting economic development, in particular in lower-income countries.

Global climate change is expected to further impact water availability. The actual growing demand for water will increase due to the higher temperatures and lower precipitation expected as a result of climate change. At the same time, extreme

[1] Palmer and Richardson (2009)
[2] Sala *et al.* (2000)
[3] UNESCO (2003)

hydrological events, such as floods, will become more common. Changing climate and changing water availability will lead to the degradation and loss of many wetlands and their species, thus reducing the provision of ecosystem services. Today, the assumed capacity of ecosystems to continuously supply services to humanity cannot be taken for granted anymore

1.2 PHYSICAL AND ECONOMIC WATER SCARCITY

Water scarcity has variously been defined. In this report, we shall employ a conceptualisation that identifies four types of water scarcity [4]:

Little or no water scarcity – Water resources are abundant relative to use (withdrawal < 25% of water from rivers).

Physical water scarcity – More than 75% of river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This type of water scarcity is faced, for instance, by the Middle East and North African economies.

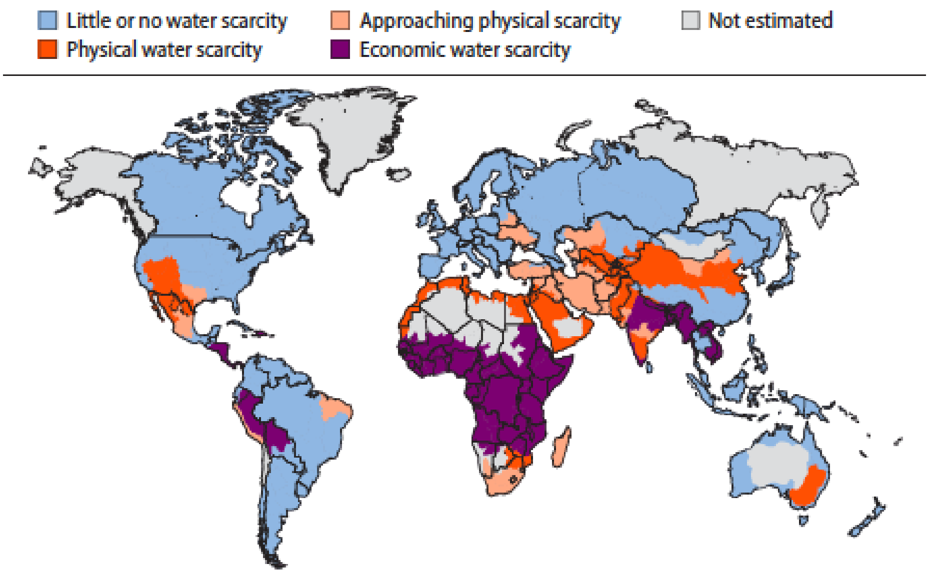
Approaching physical water scarcity – More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future as a result of over-exploitation of water bodies (see West Asia, for instance).

Economic water scarcity – Human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human requirements. In this area, malnutrition is usually present (see Africa).


Po River, Italy. © Mauri Rautkari / WWF-Canon

[4] Molden (2007)

Figure 1. Map of water scarcity



Source: Molden (2007)

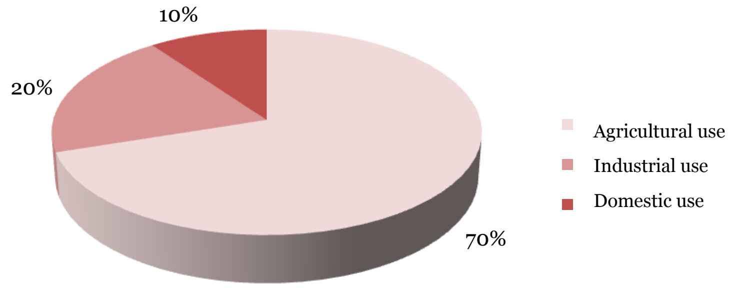
It has been estimated that by 2025, 1.8 billion people will experience absolute water scarcity, and 2/3 of the world population could be under water stress conditions.

1.3 GLOBAL TREND AND FACTS AND FIGURES ABOUT WATER

Global water use by sector

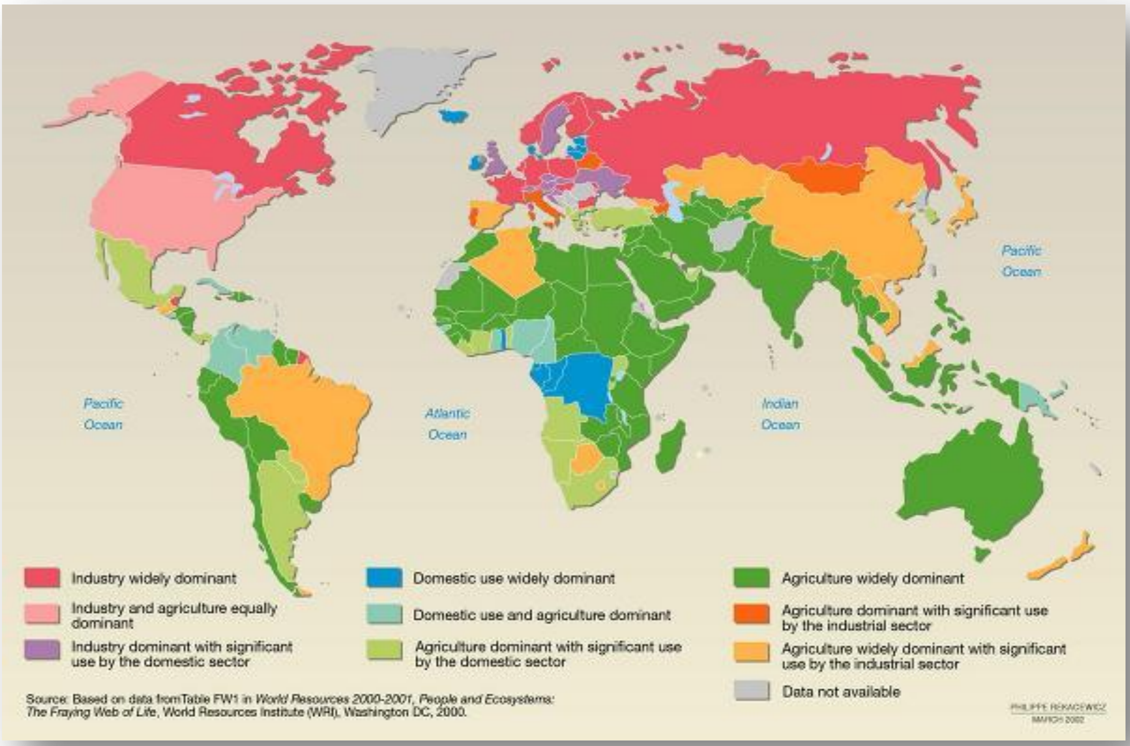
70% of the global water withdrawals go to agriculture (FAO, 2013). **In Italy, water withdrawals and still dominated by the agricultural sector, unlike the majority of the countries in Europe, which are dominated by the industrial or domestic use**. The only four European countries where agricultural utilization is dominant are: Italy (dominant), Portugal (dominant), Spain (largely dominant) and Greece (dominant with significant use by the domestic sector).

Figure 2. Water use by sector[5]



Source: UN-Water. FAO 2012

Figure 3. Global water use by sector



Source: WRI, 2000

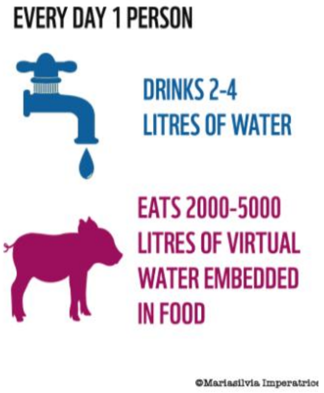
5 FAO (2013)

Increasing demands for water resources

Global water resources are currently under major stress, both in terms of quality and quantity. Water use has been growing at more than twice the rate of population growth over the last Century[6]. The demand for agricultural freshwater (from surface and groundwater bodies) is projected to increase at least by 20% by 2050, even under the assumption of productivity or technology improvements[7]. The sectors competing for water resource not only are industry, agriculture and domestic use, but also ecosystems and ecosystems services, which account for between 25 to 46% of mean annual flow globally[8].

Climate change

Another driver for an increased competition for land and water resources is climate change, which is expected to modify precipitation patterns, evapotranspiration and temperature, while increasing the number and severity of extreme events. Over the period 2000 to 2006, over 2000 water-related disasters worldwide happened[9]. These resulted in more than 290,000 deaths.



More people, more food

The world' population is expected to soar from 6.5 billion in 2005 to 9.6 billion by the year 2050 and 10.9 billion in 2100[10]. Rising populations and higher incomes are expected to call for 50% more food in 2030 and 70% in 2050[11]. In developing countries, where population growth is more intense and often coupled with poverty and malnutrition, the increase will reach up to 100% by 2050[12].

More income, more animal proteins

The demands for high-value animal protein are positively correlated to the level of income of a country. Annual meat consumption is projected to increase from 36.4 kg per capita per year in 1997-1999 to 45.3 kg per capita per year in 2030[13]. The environmental impact of an increased livestock production over the coming decades will be significant, as feeds require vast amounts of land and water to be grown.

More energy

Water is a fundamental input factor for energy production. By 2035, global energy demand will grow by one-third with respect to 2011 levels, especially in the world's emerging economies [14]. Energy demands from hydropower and other sources is projected to increase by an overall 60% by the year 2030[15]. The production of feedstock for biofuels competes with food production for land and water resources, and is also far more water intensive than other forms of energy[16].

6 http://www.unwater.org/fileadmin/user_upload/unwater_new/docs/water_scarcity.pdf
7 De Fraiture *et al.* (2007)
8 Pastor *et al.* (2013)
9 UN –Water factsheet 2014, Emergency Disasters Database
10 UNDESA (2013)
11 Bruinsma (2009)
12 These figures are relative to 2009 levels (FAO, 2011)
13 World Health Organisation (2013)
14 IEA (2013)
15 These data are relative to 2004 levels (WWAP 2009).
16 Gerbens-Leenes *et al.* (2012)

Investments needed

As the world's remaining cultivable land lies in developing countries and is managed by smallholder communities that achieve very low yields, investing in the agricultural sector has been recognised as crucial for ensuring future demands for food. Investments are especially needed in rainfed agriculture. Unlocking the potential of soil water could reduce the pressure on surface and groundwater bodies for irrigation.

Water and sanitation

The United Nations estimates that there are 2,5 billion people – roughly 37% of the world's population – who still don't get access to adequate sanitation. Water is not only a resource, but also a cause of death if not delivered within proper standards of purity and safety: 80% of illnesses in developing countries derive by poor water quality and hygienic standards. The enforcement of good hygiene, access to sanitation and to safe water supply could save 1,5 million children a year.

Water and gender

Water scarcity has negative effect especially on women, due to a gendered division of domestic labour that imposes on them the entire burden of water collection in the majority of developing countries. These water-related tasks deny women the right to employ their time for their personal and professional development, such as access to education and income-generation activities.

Water and pollution

Around 2 million tons of human waste each day is discharged into water bodies, and in developing countries 70% of industrial wastes are not treated and therefore pollute watercourses and aquifers. Agriculture as well is polluting our water: food sector only produces a percentage of organic water pollutants ranging from 40% in high-income countries and 54% in low-income countries.

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CHAPTER 2. THE WATER-FOOD NEXUS

2.1 VIRTUAL WATER

Virtual water is the water used in the production of commodities in all the different phases of the supply chain, and that is thus 'virtually' contained in it. Identified by Professor Tony Allan in the early 1990s, the concept brings a wider approach towards water resources that considers not only the *direct* (visible) water use but also the *indirect* (invisible) consumption of water as 'embedded' in the products we use every day.

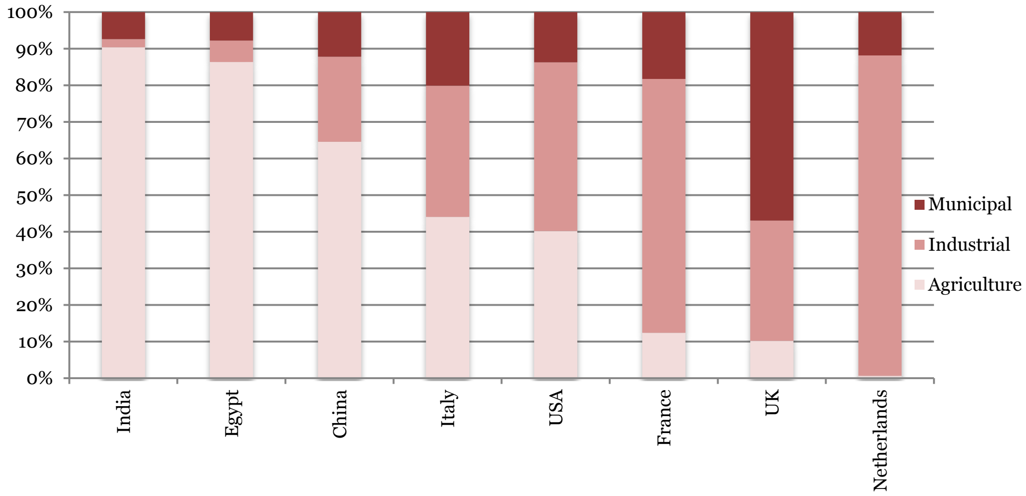
First of all, the use of the concept of virtual water sheds light on the role that water plays in underpinning our food security. The water used to produce food accounts for the overwhelming majority of the water used by individuals - about 90% of their daily consumption. Water resource security and food security are in fact inextricably linked, as agriculture is the most water-intensive economic sector. Agricultural production is in fact the dominant consumptive use of water resources[17], especially in developing countries. On a global average, 70% of water

[17] Shiklomanov (1997); Oki and Kanae (2004); Hoekstra and Chapagain (2008); UNESCO (2009)

consumption occurs in the agricultural sector. In some water-scarce countries, such as the Middle East and North African, this percentage reaches up to 90%. In Italy, agricultural production accounts for 44% of total freshwater withdrawal[18]. Industrial consumption instead tends to increase with income. Depending on the source, amount and location of water consumption, our production and consumption patterns may affect other countries' water ecosystems.

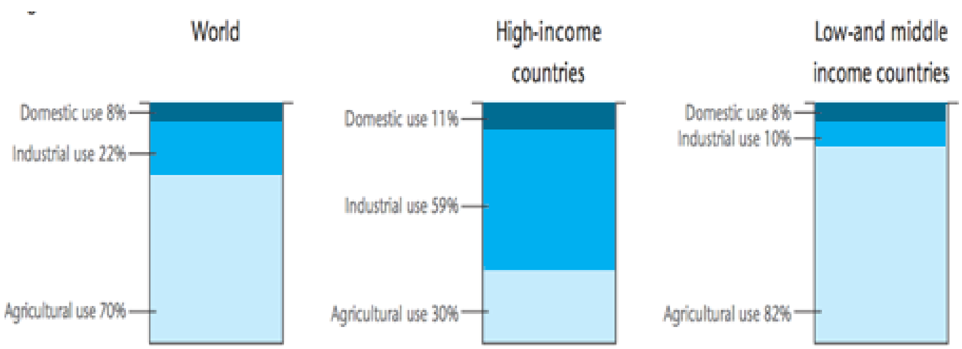
By accounting for the water "embedded" in commodities, the concept of virtual water has enabled researchers to assess the implications of international trade in terms of water resources (see "virtual water trade" for more details). Most of the world's economies rely in fact on water from outside their countries to meet their requirements for food. The water footprint indicator deployed in this report originated from the concept of virtual water originated.

Figure 1. Water withdrawal by sector (% of total water withdrawals)[19]



Source: Authors (based on FAO 2013)[20]

Figure 2. Competing water uses for main income groups of countries



Source: UN Water (2005)[21]

[18] (FAO 2013)
[19] Data are referred to 4-year time spans over the period 1998-2012 depending on data availability.
[20] (FAO 2013). AQUASTAT database.

2.2 VIRTUAL WATER "TRADE"

The term virtual water "trade" refers to the water "exchange" of water, in virtual form, which takes place as a result of commodity trade. When a commodity is exported, its virtual water content is in fact implicitly 'exchanged' as well. Vice versa, when a good is imported, the water used in its country of production is "imported" in virtual terms. Virtual water 'flows' associated with trade can be estimated as the volumes of water actually used by the country, which exported that good[22].

Virtual water "trade" has enabled water-deficit countries, such as the MENA and many others, to cope with increasing needs of water for food production and has enabled them to overcome the limits of local hydrological endowments. Water is not a major determinant of trade as water resources generally account for a tiny share of production costs in agriculture, and tend to be either under-priced from a societal point of view or not priced at all[23].

Therefore, virtual water "trade" follows the rules and trends of global commodity trade, and is thus not influenced by water-related considerations. This is the reason why a number of water-scarce countries in the world are net virtual water "exporters", whereas some water-abundant countries are net virtual water "importers"[24]. The largest share of the virtual water flows between countries (over 75%) is related to international trade in crops and derived crop products, whereas trade in animal products and industrial products contributed 12% each to the global virtual water "flows"[25].

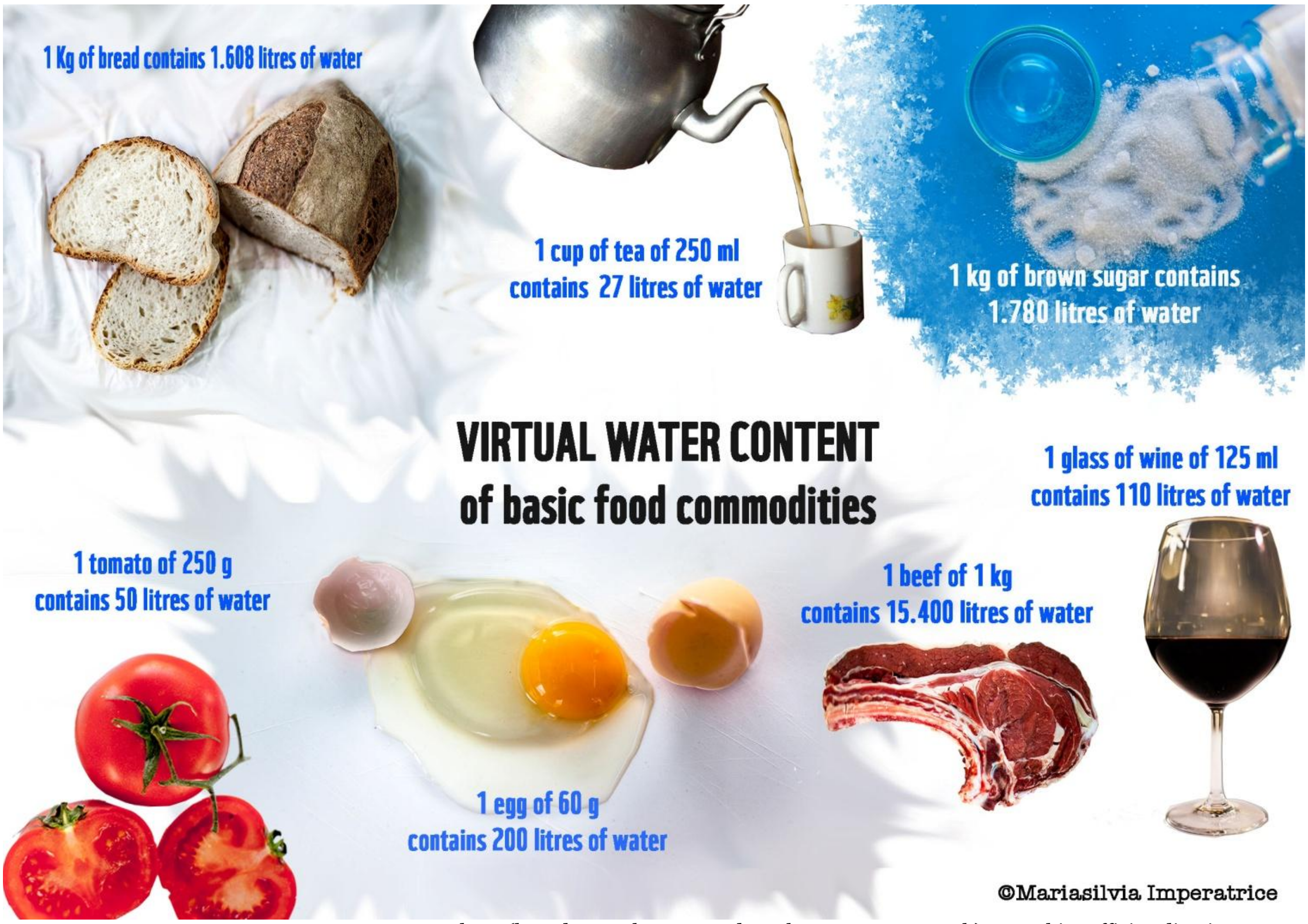
2.3 THE VIRTUAL WATER CONTENT OF A PRODUCT

The term refers to the volume of water used to produce a commodity over its whole supply chain (production, process, distribution, retail and consumption), measured at the place where the product was actually produced (Figure 3). **It has been estimated that, on a global average, one apple costs 125 litres of water, a cup of coffee 132 litres, a pizza margherita 1,260 litres, a kilo of beef over 15,000 litres.** Animal-based products are those with the highest virtual water contents.

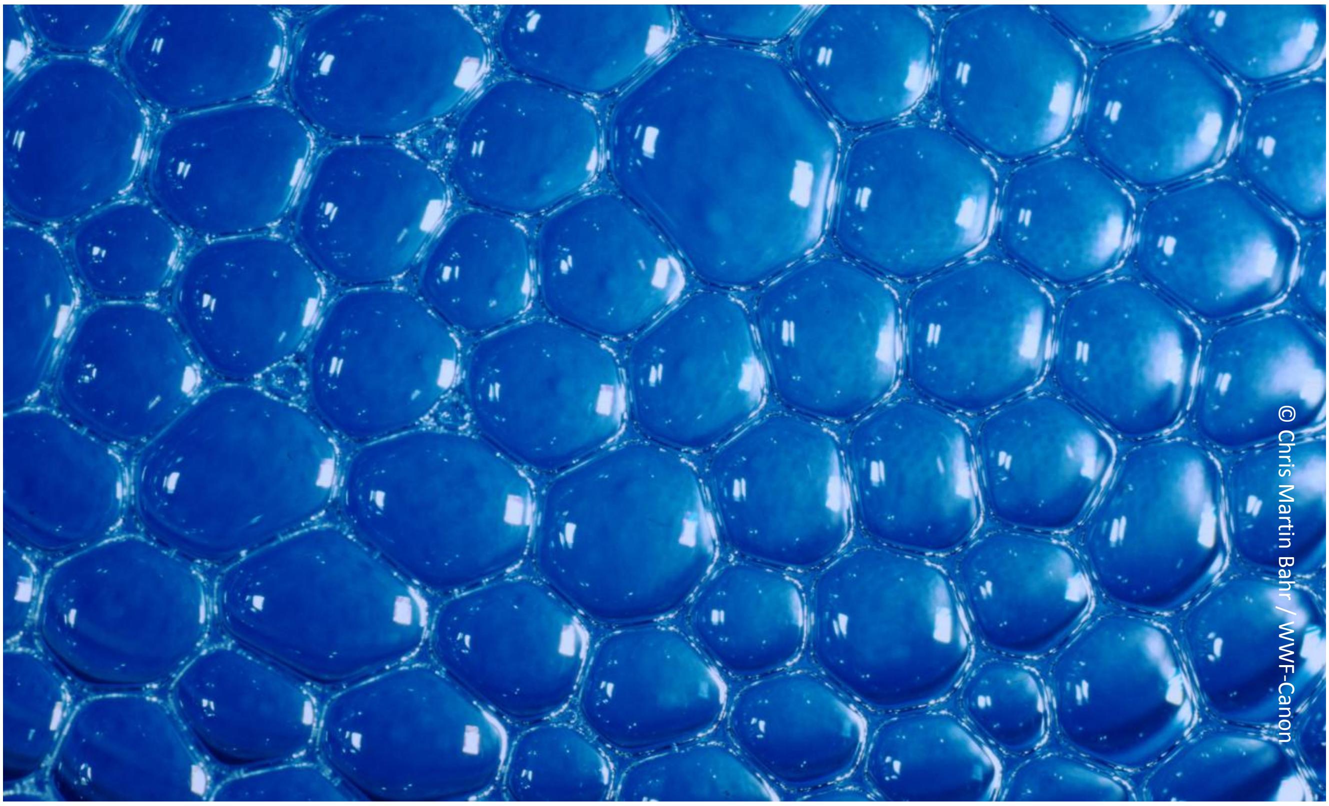
The concept of virtual water thus helps accounting for the invisible consumption of water that lies behind our food consumption choices and habits.

[21] http://www.unwater.org/downloads/Water_facts_and_trends.pdf
[22] Zimmer and Renault (2003)
[23] Reimer (2012)
[24] Roson and Sartori (2010)
[25] Mekonnen and Hoekstra (2011)

Figure 3. Virtual water content of basic food commodities



Source: Authors (based on Mekonnen and Hoekstra, 2010a, 2010b); graphic: ufficio editoria WWF-Images by Martina Albertazzi and WWF Canon



2.4 THE COLOURS OF WATER: GREEN AND BLUE WATER RESOURCES

Food is produced through photosynthesis, the process by which plants make carbohydrates from carbon dioxide and water, using the energy captured from sunlight.

Water is absorbed by the roots from the store of infiltrated rain in the soil and becomes soil moisture.

Soil water has a productive role in the biosphere as transpiration, and a non-productive role as direct evaporation from soil. This water has been referred to as green water as opposed to blue water, i.e. the water stored in surface and groundwater bodies[26].

Green and blue water are both involved in food production. The former sustains global rainfed agriculture as well as ecosystems and ecosystem services; the latter has a variety of uses: it can be diverted to irrigate crops but also meet the industrial and domestic needs of society.

Green water is highly correlated to a country's precipitation pattern, soil profile and climatic conditions. It is the majority of water in humid temperate and humid tropical temperate regions. It is invisible to users as it is accessible only to plants and cannot be directly manipulated by human management. Blue water availability is not rain-dependent as much as green water but it is dramatically limited in supply.

Blue water in irrigated agriculture yields the lowest economic value among all other use options[27]. Farmers, however, have to compete for blue water as it performs other fundamental societal functions, such as domestic supply, industrial use and energy production. Compared to blue water, the opportunity cost of green water use is low.

Green water, as it represents the most important source of agricultural water globally. Recent estimates have showed that 84% of the water used in agriculture is green, as well as over 90% of the water 'embedded' in internationally traded crops[28]. Global water and food security are, therefore, mainly reliant upon this source of water.

On the other hand, irrigated agriculture provides up to 40% of global food production from just 18% of cropland[29].

On the whole, due to the current rates of agricultural water exploitation necessary to sustain an increasing world population with different diet requests, water exploitation is expected to grow of a third to meet the food demand of 2050[30].

Nowadays, the over-damming, the diversion and the withdrawn of water has severely affected the flows of the major rivers all over the world (e.g., Colorado, Jordan, Nile, Rio Grande), determining a loss of distinctive freshwater habitats (e.g.. oxbow lakes, marshes, pools) naturally present along the rivers' courses. Together with a severe reduction of water availability, agriculture is also responsible of water and soil pollution. The massive use of fertiliser and pesticides has lead to a severe deterioration of freshwater resources in many overworked farmland areas. When water evaporates from cultivated soils it leaves deposit of mineral salts on the surface. Salts are also drown from lower to upper levels making the soil unusable. In water stressed regions the over-exploitation of aquifers has increased freshwater salinity and declined water tables.

[26] Falkenmark (1995); Falkenmark and Rockström (2004)
[27] Zehnder *et al.* (2003)
[28] Fader *et al.* (2011)
[29] Khan and Hanjra (2008)
[30] Rockström *et al.* (2009)

While it is clear that the lack of available freshwater is already a limiting factor for socio-economic development in many areas of the world, in general it is only the liquid runoff water, the blue water, that is perceived as indispensable for humanity. But, as reported above, the largest food productions originates from rain-fed land use and green water is not only needed to sustain croplands but also other terrestrial systems such as forests, woodlands, and wetlands, and to maintain them resilient to change.

These ecosystems support society with services (see chapter 2.3), which are essential for human well-being. They produce food, raw materials, genetic resources. They are also responsible for carbon sequestration, climate regulation, waste decomposition. And their internal dynamics are strictly connected with water flow patterns. Vegetated land act as regulator in atmospheric water cycle, by redirecting liquid water to vapour that is later recycled in rainfall. Plant rooting structures regulate water infiltration in the soil, limit soil erosion thus helping in regulating river flow seasonality and flooding events. Again, terrestrial ecosystems regulate freshwater quality through biochemical and microbiological processes. Liquid water transports nutrients, organisms and seeds between ecosystems, creates habitats and sustains life of animals and plants[31].

Thus the further use of both blue and green water for agricultural practices may have different negative implications for humanity and the environment: while the limited availability of blue water will have a direct impact on human development, the withdrawals of green water for crop production will determine a loss of ecosystem diversity and consequently the reduction of welfare-supporting ecosystem services.

Greater flamingo (Phoenicopterus ruber); © Martin Harvey / WWF-Canon

[31] Rockström *et al.* (1999)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CHAPTER 3. THE WATER FOOTPRINT

3.1 SOME PRELIMINARY DEFINITIONS

The water footprint concept was developed by Arjen Hoekstra in the early 2000s. It allows the water use (direct and indirect) of an individual, community or enterprise to be calculated. The water footprint is defined as the total volume of freshwater used to produce the goods and services consumed by that individual, community or business.

The Water Footprint differs from the concept of virtual water because, although virtual water is retained as the final measuring unit in its volumetric calculations (cubic meters), the water footprint also provides a geographical connotation, combines it with a qualitative analysis and finally, associates these information with time-series. The water footprint is therefore a multi-dimensional indicator, allowing comparison between countries, across years and between different sectors (industry, domestic and agriculture).

Regarding the qualitative connotation of the water footprint, the first important analytical step is to understand the difference between its components, i.e. between green water, blue water and grey water.

BASIC CONCEPTS

The Water Footprint relates not only to the place where water comes from, it also adds a qualitative component to it.

Water is divided into three components: blue, green and grey.

The management, environmental impacts and opportunity costs of each of these differ greatly.

BLUE WATER consists of surface water bodies (rivers, lakes, estuaries, etc.) as well as the water in underground aquifers. The blue water footprint therefore accounts for the consumption of surface and ground water of a certain basin. Here consumption is intended to mean withdrawal that is not returned intact to the same place from which it was taken.

GREEN WATER is the rainwater contained in plants and the soil as humidity; it does not become part of any surface or underground water body. The green water footprint focuses on the use of rainwater, specifically on the soil's evapo-transpiration flow used in agriculture and forestry output. It is important to understand the value of rainfed agriculture in terms of its non-impact on blue water resources.

GREY WATER refers to all water polluted by a production process. It represents the quantity of fresh water necessary to dilute the load (could 'load' be changed to 'volume'?) of pollutants, given their well-known natural concentrations and the current local water quality standards.

The Water Footprint is the sum of green water, blue water and grey water required for the production of any good or service.

The second main differentiation of the water footprint is, as previously mentioned, its geographical connotation. The geographical connotation of the water footprint is operated by the separation between the consumption and production sites. Where the production and consumption sites coincide, there is an internal water footprint. When consumption is obtained from any production site external to a nation, this will be called the external water footprint of that nation. The different trends in the water footprints of consumption and production of a nation have different economic and political implications; these will be explored in depth in the following paragraphs.

Consumption

The water footprint of national consumption is the sum of the 'Internal water footprint' (the consumption of local water resources in a given period of time) and the 'External water footprint' (the consumption of external water resources, as a result of the import of virtual water).

Production

The water footprint of national production is the sum of the Internal water footprint (the consumption of local national water resources in a given period of time) and the water resources used to produce goods intended for exports.

The third and final component of the water footprint is time. Although virtual water indicates how much water has been used in the production of a given product, it does not provide a timescale. Virtual water therefore does not provide a time-series to compare the consumption or production of water over time. The water footprint provides the time-series, calculated year by year, from each country, for a given product, a given sector and a given nation, thus enabling analysis and comparison.

3.2 RELEVANCE TO THE POLICY

"Water problems are often closely linked to the structure of the global economy. Many countries have outsourced so massive their water footprint, importing from other places those goods that require a large amount of water to be produced. This puts pressure on water resources in the exporting countries where too often in short supply mechanisms aimed at wise management and conservation of water resources. Not only governments, but also consumers, businesses and every civilized community can make a difference, so that we can achieve a better management of water resources".

(Arjen Hoekstra)

Governments, producers and consumers, all have an equal responsibility for water accountability worldwide.

Consumers, for example, can decide to engage in certain behaviors related to environmental sustainability, when they make their choices.

Food producers can improve their water use and water accountability, triggering a mechanism of good practice, competitiveness with other brands, and starting a real change in the system of the international food regime. Water accountability, in this sense, can also contribute to economic gain for private companies: reducing irrigation water usually means lowering production inputs and costs as well, obtaining the same production quantity with more water efficiently. At the same time, if producers are not sensitized and challenged by scientists, technicians, governments and citizens themselves, to improve their water footprints, and if they are not pushed to provide citizens with more sustainable products, a real change will be difficult to envisage.

Governments can encourage the accountability of water use in the private sector and among citizens, by including it in their national and international environmental strategies and goals.

NGOs and civil society also have a role in the long path towards water sustainability worldwide, and the WWF is in the front line regarding water footprint and water accountability, together with the Water Footprint Network.

Despite the early stage of this mission, a route has been already set by the " Alliance for Water Stewardship" and the UN Global Compact's CEO Water Mandate. The latter was founded by the UN Secretary General in July 2007. Its mission is to assist companies in the development, implementation and disclosure of water sustainability policies and practices. These international initiatives take the same view as this report.

There is space to be optimistic, but at the same time, the harsh reality of the water-world today should not be forgotten. Environmental considerations have always been considered as costs to the private sector: in the light of climate change and the need for overall efficiency in every part of the production process (energy, water, land), water accountability and efficiency could be seen as part of the solution and no longer as part of the problem.

TRY TO VISUALIZE IT...

The drinking water supply of a city consists of a pipeline network. Let's take this network as our conceptual map and try to imagine that, next to each water tap in our houses, there is also another one that is much bigger.

This invisible **"virtual water tap"** provides us with the water needed for our food, services and industrial products.

The sum of the volumes delivered by the two water taps - the running water tap and the virtual water tap - in each house, represents the total water consumption of our city.

4% Domestic use

96% Virtual water

Citizens can also play an important role in the environmental sustainability of food-products as well as in all our goods and services, not only by preferring 'water-aware' choices in terms of water accountability and water saving worldwide, but also by changing their food-patterns in terms of their personal dietary choices. A lifestyle that not only places a watchful eye on the water content of each product consumed, but that also considers the provenance of that good, privileging local and seasonal food, usually also has less impact in terms of its water footprint

3.3 CALCULATION METHODOLOGY

With regard to the concept of water footprint, apart from its remarkable conceptual and theoretical work, the "Water Footprint Network" has also provided a standard calculation methodology with the aim of obtaining a standard process that can be applied worldwide on the ground. The Water Footprint Network has provided a standardized equation for the calculation of each of the three qualitative components: blue, grey and green (see Annex for details).

$$WF = WF_{blue} + WF_{green} + WF_{grey}$$

Regarding the calculation of the water footprint for a country (WFP, m^3/yr), this is equal to the total volume of water used, directly or indirectly, to produce the goods and services consumed by the inhabitants of that country. A national water footprint has two components: the internal and the external water footprint, as follows:

$$WFP = IWFP + EWFP$$

In terms of computation and scientific method, in order to provide water footprint data for all of the countries in the world, some standardizations have to be applied at the country-level. Moreover, a number of assumptions are made for the calculation of the grey water. It is up to each individual researcher in each country or region, to help the Water Footprint Network to collect more accurate and direct data, in order to improve the national data collected by the Network. For example, data on average crop yield per primary crop (ton/ha) per country during 1997-2001 have been taken from the on-line database of FAO[32]. Therefore, all calculations are produced using old datasets, despite the fact that crop yield does not vary significantly over a decade or two. This report is a call to scientists who are willing to participate in this "world mapping" challenge and who can contribute more up-to-date data. Much work still needs to be done!

[32] FAOSTAT (2004)

CHAPTER 4. WATER RESOURCES IN ITALY

4.1 OVERVIEW OF ITALY'S WATER RESOURCES: AVAILABILITY AND USE

Italy appears highly vulnerable to the decrease in water availability, having a freshwater consumption per capita of 92 cubic metres per year, 7.6% more than the average of the 27 countries of the European Union in the period 1996-2007[33]. Lying at the centre of the Mediterranean, Italy shows climate trends that, in combination with global warming, will result in a gradual drying up. This emphasizes its sensitivity to climate change [34]. Due to the high variability of its climatic, topographic, geological and productive features, in the North, despite increased demand there is abundant availability of water, while in the South, between the low rainfall and high temperatures, this availability is halved compared to the real need. Apulia, Sicily and Sardinia receive 40-50% less rainfall than the wettest regions, where it covers just 10-20% of their water needs. For the whole national territory, water use is as follows: 44-60% for agriculture, 25-36% for industry and 15-20% for domestic use[35].

[33] Antonelli e Greco (2013)
[34] Giorgi (2006)
[35] Antonelli e Greco (2013); Giorgi (2006)

4.2 PATTERNS AND TRENDS OF AGRICULTURAL PRODUCTION IN ITALY

According to the 6th Agricultural Census conducted by ISTAT in 2010 (the most recent census available), soil use in Italy was the following: 21.9% non cultivated areas, 15% grassland, 30.8% forest and 32.2 arable land.

In 2011, the agri-food sector in Italy performed a total revenue of 127 Billion Euros. Exports accounted for 30.2 billion Euros and imports were 40.5 billions Euros. Regarding agriculture, there is a generic fall in the production among all main cultures, and a consequent rise in imports. More in details, the main cultivated cultures show the following trends: **the production of durum wheat was around 4 Million tons in 2013 and imports will increase of +6% in 2014 according to recent forecasts[36]. Common wheat (soft wheat) accounted for 3.4 million tons.** From the point of view of geographical distribution, there has been a sharp decline in central Italy (-15%), an increase of 8% in Northern Italy and an increase of 4% in Southern Italy. Imports fall by 1%, exports rose by 2%. **The production of barley in Italy in 2013 reached 684,000 tons, with a decline in sown areas of 22% in one year. Imports also increased compared to 2012 by 22%.**

The production of oats was 227,000 tons, with a decrease of 22% compared to 2012 and rye production dropped by as much as 74% compared to 2012.The production of maize in 2013 accounted for 7.1 million tonnes, with a 10% decrease compared to 2012. Imports grew by 18% on the same year. Only the production of sorghum and sunflower is in a positive trend: in Italy sorghum in 2013 accounted for 232,000 tons, with a 47% rise compared to 2012 . The harvests of sunflower grew by 20% compared to 2012, reaching a total of 223,000 tons.

4.3 MAIN PROBLEMS OF IRRIGATED AGRICULTURE: MAIN CULTURES AND THEIR LOCALIZATION

Historically, irrigation represents between 70% and 80% of all water use, with some countries using 90% or more for irrigation. This percentage is changing as more and more countries face water shortages. Future scenarios are expected to be worse due to climate change, which might intensify the problem of water scarcity and the irrigation requirements in the Mediterranean region[37].

In Italy about 50% of the water available is used for agriculture and irrigation; this sector is the main water consumer. The largest fraction of the water used by agriculture is derived from rivers.

[36] Coldiretti (2013)
[37] IPCC (2007); Goubanova and Li (2006); Rodriguez Diaz *et al.* (2007)

Currently, the agricultural area is used as follows: 54% for the cultivation of arable crops (cereals, pulses, potatoes, vegetables, etc.); 19% for the cultivation of olives, grapes and citrus fruits; and 27% for permanent grassland. 83% of Italian agricultural production comes from irrigated lands. The regions with the largest share of utilized agricultural area devoted to arable crops are Emilia-Romagna, Lombardy and Sicilia; those with the largest share devoted to permanent crops are Puglia, Sicily and Calabria. The most important area devoted to permanent pasture is Sardinia[38].

In Italy 217,449 farms are engaged in the rearing of livestock. The most abundant type of farming is of cattle, which accounts for 32.9% of the companies in Lombardy, Piedmont and Veneto. The sheep farms are mainly in Sardinia, while herds of horses are located mainly in Lombardy, Piedmont and Veneto. Other types of farming are much less common: 51% of the pig farms are in Lombardy, while 82.2% of the companies with buffalo are concentrated in Lazio and Campania[39].

The Po river (652 km long) is the longest Italian river and 10th longest in Europe. It originates in the mountains of the Monviso group (2020 m a.s.l.), flows through the Padania Plain and terminates in a delta projecting into the Adriac Sea around 70 kilometres south of Venice.

There are a large number of lakes on the North bank of the Po. In particular, the four major Italian lakes (Garda, Maggiore, Como and Iseo), accounting for a water volume close to 70% of the total surface fresh water in Italy, feed the four main tributaries (Ticino, Adda, Oglio and Mincio) of the Po. On the South bank, streams and rivers drain from Apennine, Maritime and the Western Alp ridges, where only a few small residual glacial lakes and reservoirs are present at high elevation.

In total, the Po river drains a basin of 71,057 km^2 with an average volume of annual precipitation of 78 km^3. The human population in the area is around 17 Million. 43% of the basin is exploited for intensive agriculture and husbandry of 3.2 Million cattle and 6.0 Million pigs. More than 70% of Italian livestock production (i.e. pig and cattle) takes place in Piedmont, Lombardy, Veneto and Emilia-Romagna, regions all located on the Po river watershed. With regard to the basin energy consumption, employment and agricultural production amount to 48%, 46%, and 35% respectively of the national total. Most of the products (mainly food, pharmaceutical, textiles and plastic goods) for internal consumption and export are produced in this area. On the whole, the economy of the Po river basin accounts for about 40% of the Italian gross domestic product[40].

Due the severe exploitation of the area, the Po river basin has been severely modified over the last 40 years and most of the biodiversity of the floodplain has changed accordingly. The original wetlands (e.g. oxbow lakes, bogs, meadows) have been lost or strongly reduced due to the worsening of the environmental conditions.

Agriculture is the sector mainly responsible for changing the ecological and hydrological cycles[41]. 41% of Italian cultivated land is located in only four regions: Emilia-Romagna, Lombardy, Sicily and Puglia. In the lowland Po plain, the main crops include maize, winter wheat, rice, barley, oats, rye and sorghum, pastures, tomatoes and sugar. 17 billion cubic meters per year of water, representing approximately 50% of the annual Po river discharge, is used for irrigation. Due to the presence of irrigation canals and dams for hydroelectric power, drought has become a regular event in some reaches of the Po, in particular during summer.

[38] ISTAT (2010)
[39] IPCC (2007); Goubanova and Li (2006); Rodriguez Diaz *et al.* (2007); ISTAT (2010)
[40] Viaroli *et al.* (2010)
[41] Viaroli *et al.* (1996)

Moreover, 5 billion cubic meters per year 80% of which are withdrawn from groundwater, are used for industrial and civil purposes.

While the intense exploitation of water resources is currently sustainable, it is potentially highly problematic during drought periods. Today, to meet the growing demands of water for agricultural, industrial, municipal and environmental uses, the Po River experiences moderate blue water scarcity for at least two months of the year.

Together with water scarcity, pollution has also become a strong concern in the Po river watershed. Phosphorus inputs impacted inland waters between the '60s and the '80s while nitrate contamination has been a major hazard for surface and ground waters since the 1990s. More recently, high concentrations of pesticides, aromatic hydrocarbons, heavy metals and pharmaceuticals have been found in the sediments along the Po river[42].

4.4 THE WATER FOOTPRINT OF NATIONAL CONSUMPTION

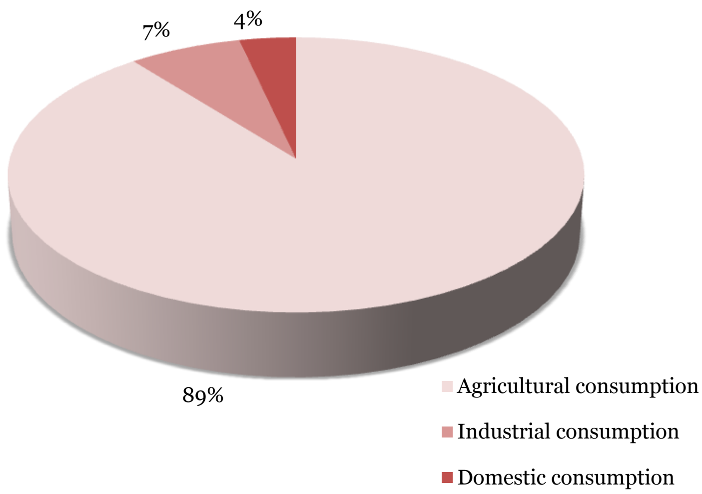
The water footprint of national consumption is defined as the total amount of freshwater that is used to produce the goods and services consumed within the nation. The water footprint of Italy, which is the focus of this section, is therefore the water that is appropriated to meet the requirements of goods and services consumed within its territory. The water footprint of consumption is the sum of two components: intermediate (firms' demand) consumption and final (consumers' demand) consumption.

Italy's total water footprint of national consumption is 132,466 Million m^3 of water per year [43]. This amount is equal to 6,309 litres per person per day. Food consumption alone (including both agricultural and animal-based products) contributes to 89% of the total daily water footprint of Italy (Figure 1).

This large amount of water is that "embedded" in the food products we buy, eat and also waste every day. As previously shown in fact, any product has a specific virtual water content, which is determined by the conditions in which the good is produced and is generally higher for animal products and lower for agricultural products. Interestingly, the consumption of water for domestic purposes (bathing, cleaning, drinking, etc.) accounts for only 4% of our daily water footprint of consumption, although it is generally the sole type of consumption we are aware of. The water 'embedded' in industrial products accounts for 7%. The water 'embodied' in food products can be either blue or green, whereas domestic and industrial water can only be blue.

[42] Calamari *et al.* (2003)
[43] La fonte di dati principale per le analisi presentate in questa sezione è: Mekonnen e Hoekstra (2011)

Figure 1. Total water footprint of national consumption by sector (%)

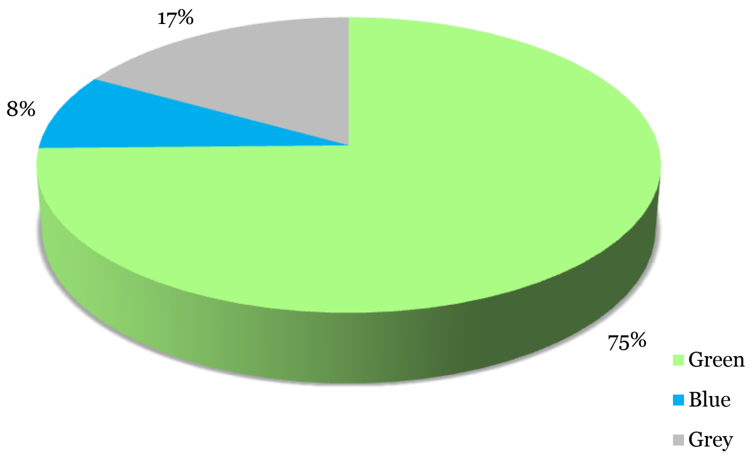


Source: Authors (based on Mekonnen and Hoekstra 2011)

The composition of the water footprint by water sources is illustrated in Figure 2: 75% is sourced from green water, 8% from blue water (surface and groundwater bodies), and 17% from grey water (the water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards).

Green water plays an essential role in underpinning our water footprint of consumption as well as global food security, as crops are generally grown in rainfed conditions.

Figure 2. Total water footprint of national consumption by water source (%)



Source: Authors (based on Mekonnen and Hoekstra 2011)

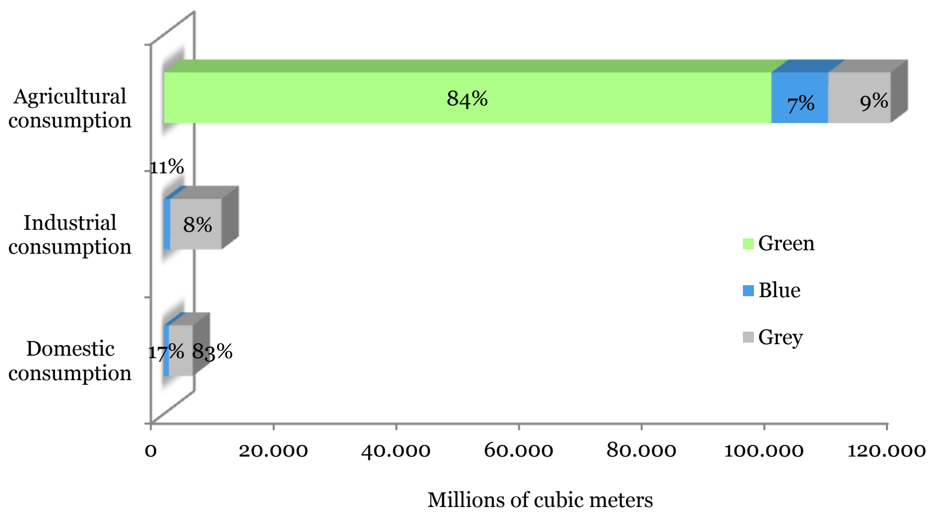
Tabella 1. Water footprint (WF) of national consumption (Mm³/yr)

WF of national consumption	Green	Blue	Grey	Total by sector
Agriculture	98,962	9,255	10,157	118,374
Manufacture	0	1,024	8,370	9,394
Domestic use	0	807	3,892	4,699

Source: Authors (based on Mekonnen and Hoekstra 2011)

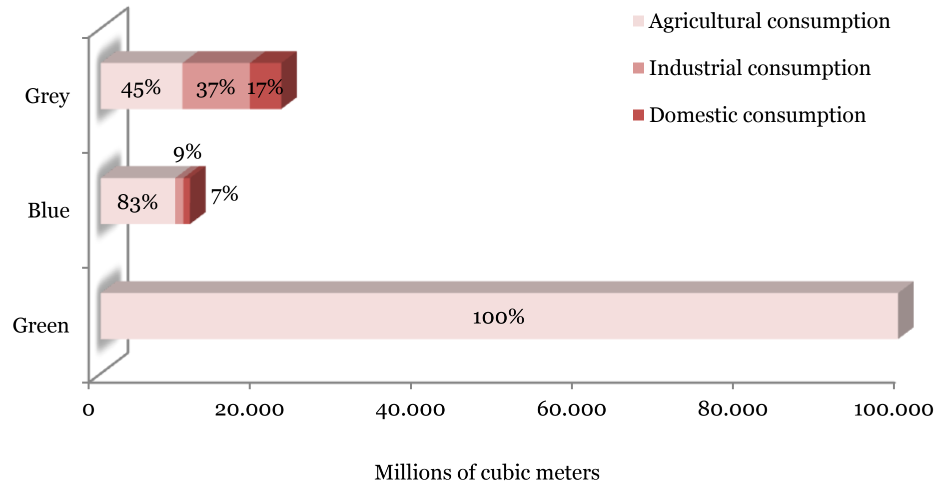
As showed in Figure 3, agriculture consumes mainly green water (84%). It is the water resource used by non-irrigated agriculture. The consumption of blue water (surface and groundwater) is the lowest share in all sectors: 7% in agriculture, 11% in manufacture and 17% in domestic water consumption. In absolute values, agriculture is the sector that consumes the highest amount of blue water, equal to 9,255 Mm³/yr, followed by manufacture (1,024 Mm³/yr) and domestic uses (only 807 Mm³/yr) (Figure 4). In percentage terms, grey (polluted) water is a significant component both of manufacture and domestic water consumption (89% and 83% respectively), whereas it is relatively lower in the agricultural sector. The quality of water is in fact highly affected by domestic and industrial activities. In absolute terms, grey water is at its highest levels in agriculture's water footprint and is highly connected to the use of chemical fertilizers and pesticides.

Figure 3. National water footprint of consumption (%) by sector and source of water



Source: Authors (based on Mekonnen and Hoekstra 2011)

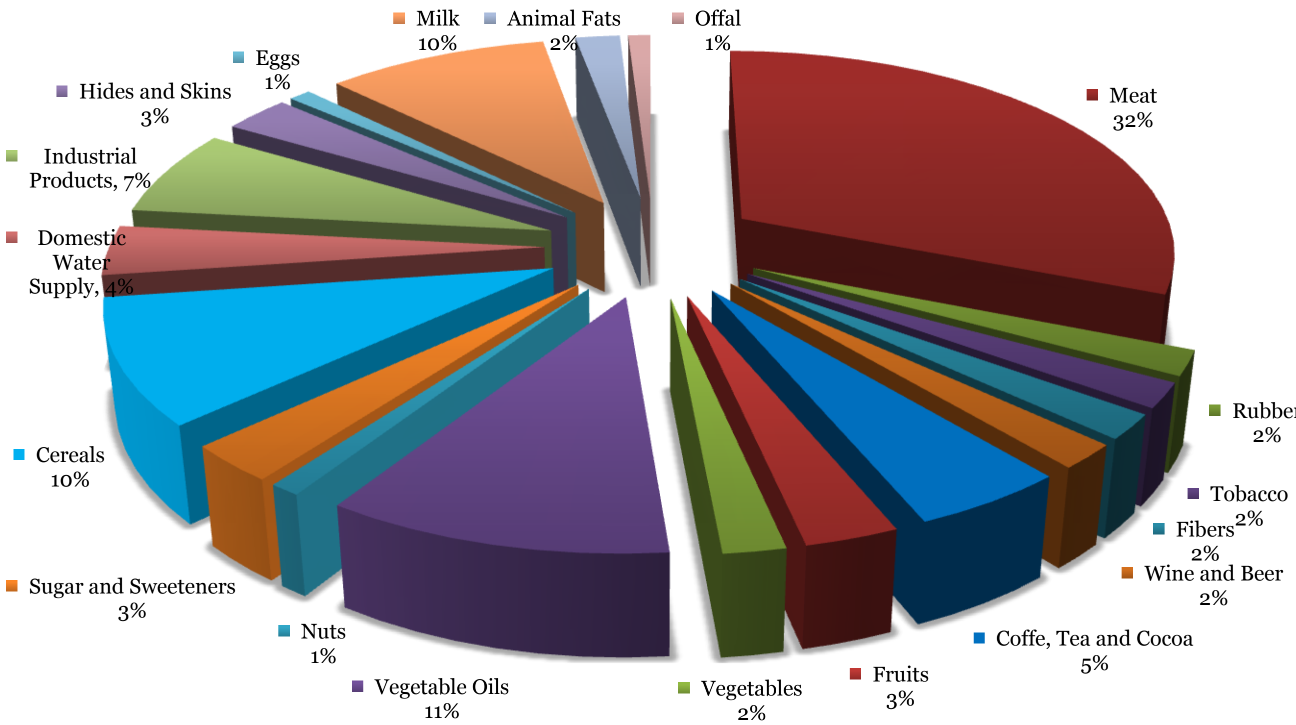
Figure 4. National water footprint of consumption by size, water sources and sector (%)



Source: Authors (based on Mekonnen and Hoekstra 2011)

The pie below (Figure 5) illustrates the water footprint of national consumption by product category, in percentage terms. It shows that animal-based products (including milk, eggs, animal fats, and meat) account for almost 50% of the total water footprint of consumption of Italy. The consumption of meat alone contributes to one third of the total water footprint. A second important portion of the water footprint is generated by the consumption of vegetable oils (11%), cereals (10%) and milk (10%).

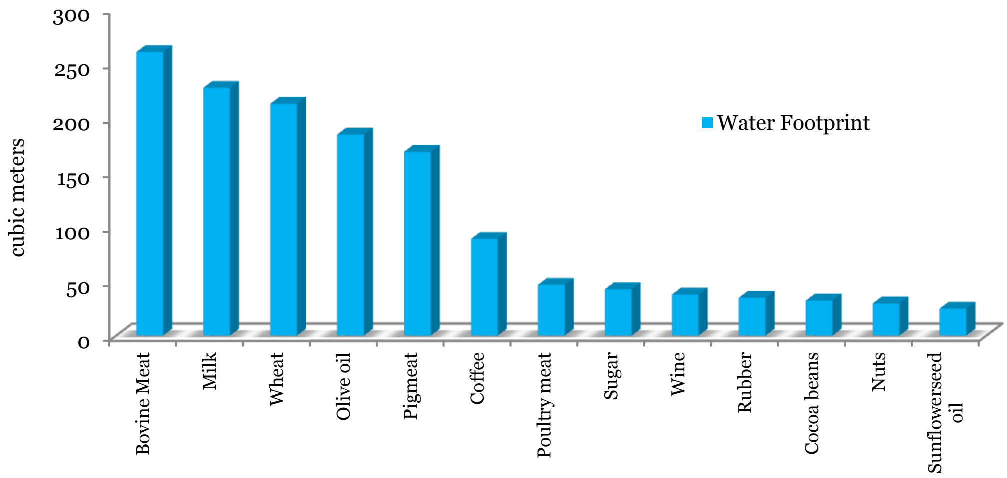
Figure 5. Water footprint of national consumption (%) by product category (1996-2005)



Source: Authors (based on Mekonnen and Hoekstra 2011)

In per capita terms, the crops and agricultural products (excluding livestock products) that contribute the most to Italy's water footprint of consumption are mainly wheat, olive oil and coffee (Figure 6). These three products alone make up almost 21% of the Italian per capita water footprint of consumption. The highest contribution to the water footprint is, however, related to the consumption of livestock products, as already highlighted by Figure 1, and in particular from bovine meat and milk. Together with pig meat, these products are responsible for about 29% of the total per capita water footprint of Italy. If we consider these six products together, they account for 50% of Italy's total water footprint of consumption.

Figure 6. Agricultural and food products with the highest water footprint of national consumption (m3/yr/cap)



Source: Authors (based on Mekonnen and Hoekstra 2011)

Livestock products are the most water-intensive food products, as the production of meat requires large volumes of water for feed production: 98% of the total volume of water consumed at the global level is used for producing animal feeds. Drinking water for the animals, service water and feed mixing water account instead only for 1.1%, 0.8% and 0.03%, respectively[44].

Three are the main factors explaining why the water footprint of animal products is so high. A first explanatory factor is the feed conversion efficiency. The more feed is required per unit of animal product, the more water is necessary to produce the feed. A second factor is the feed composition, in particular the ratio of concentrates versus roughages, and the percentage of valuable crop components versus crop residues in concentrates. A third factor is the origin of the feed. The water footprint of a specific animal product varies across countries due to differences in climate and agricultural practice in the regions from where the various feed components are obtained. Since sometimes a relatively large fraction of the feed is imported while at other times feed is mostly obtained locally, not only the size but also the spatial dimension of the water footprint depends on the sourcing of the feed. In this context, it is relevant to consider from which type of production system an animal product is obtained: from a grazing, mixed or industrial system. Animal products from industrial production systems generally

[44] Mekonnen and Hoekstra (2011)

have a smaller total water footprint per unit of product than products from grazing systems, with the exception of dairy products (where there is little difference). However, products from industrial systems always have a larger blue and grey water footprint per ton of product when compared to grazing systems (with the exception of chicken meat). It is the lower green water footprint in industrial systems that explain the smaller total footprint. Given the fact that freshwater problems generally relate to blue water scarcity and water pollution and to a lesser extent to competition over green water, this means that grazing systems are preferable over industrial production systems . Therefore, the type of production system (grazing, mixed, industrial) is important because it influences all three factors..

KEY DEFINITIONS

Water footprint of national consumption: total volume of freshwater that is used to produce the goods and services consumed within the nation

***Internal* water footprint of national consumption:** use of domestic water resources to produce goods and services consumed within the nation

***External* water footprint of national consumption:** volume of water resources used in other nations to produce goods and services consumed within the nation under consideration

Water footprint of national production: total freshwater volume consumed or polluted within the territory of the nation as a result of activities within the different sectors of the economy

Green water: precipitations that seep and stock in non-saturated soils to take the form of moisture, or more simply, rain-fed water

Blue water: surface and groundwater bodies

Grey water: water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards.

Green water footprint: volume of green water (rainwater) consumed, which is particularly relevant in crop production

Blue water footprint: consumption of blue water resources (surface and ground water) only

Grey water footprint: volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards

Virtual water trade: implied exchange of water through conventional trade

Virtual water imports: acqua incorporata nei beni importata da un paese attraverso le importazioni di prodotti

Virtual water exports: water implicitly ‘exported’ by a country through the exports of goods

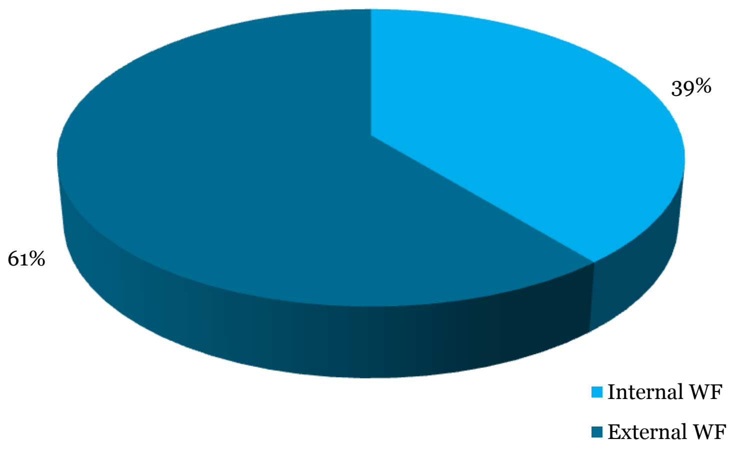
Net virtual water importer: the difference between the virtual water imports and exports of a country is positive

4.4.1 The Internal and External Water footprint of national consumption

A further interesting analysis comes from the distinction between the internal and external components of the water footprint of national consumption. The internal component is related to the consumption of water that takes place locally in order to produce the goods and services required by society. The external component accounts, instead, for the amount of water from outside the country that is consumed as "embedded" in the imported goods. The latter is therefore a proxy of how much a country relies on foreign water resources to secure its needs for food and industrial products.

On average, the ratio of the internal water footprint over the total water footprint of national consumption equals 39.3% (60.7% for external water footprint). This means that Italy relies mainly on foreign water resources to meet its internal demand, which are accessed in the global market through the imports of agricultural, livestock and industrial products.

Figure 7. Internal and external water footprint (WF) of national consumption (%)



Source: Authors (based on Mekonnen and Hoekstra 2011)

At the per capita level, the water footprint linked to the consumption of agricultural products, i.e. associated with the import of food, is largely external (1,291 against 767 m^3/yr/cap), as well as the water footprint linked to the consumption of industrial products (107 against 56 m^3/yr/cap). Data are expressed in per capita term, so they may be interpreted as the impact of each Italian on domestic and foreign water resources.

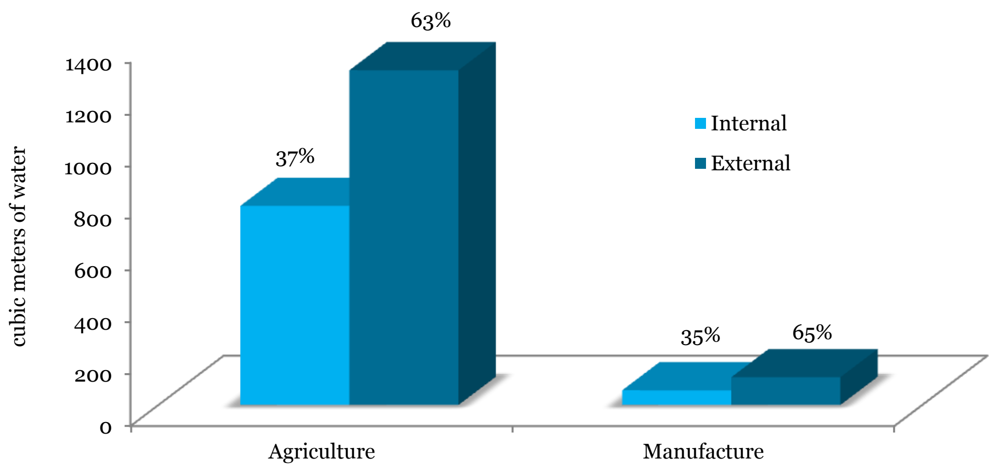
Table 2. Internal versus external per capita water footprint (WF) of national consumption (m3/yr/cap)

WF by sector	Internal	External	Total
Agriculture	767	1,291	2,058
Manufacture	56	107	163
Domestic	82	N/A	82
Total	906	1,398	2.203

Source: Authors (based on Mekonnen and Hoekstra 2011)

There are no significant differences among agriculture and manufacture in terms of the origin of water resources: in both sectors, about 2/3 of the total virtual water consumed comes from foreign water resources. Domestic water consumption has, by definition, only the internal component.

Figure 8. Per capita internal and external water footprint of consumption (m3/yr/cap)



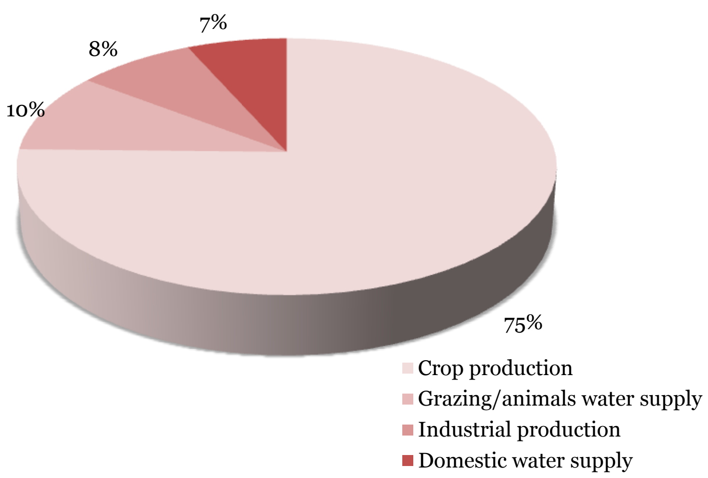
Source: Authors (based on Mekonnen and Hoekstra 2011)

4.5 THE WATER FOOTPRINT OF NATIONAL PRODUCTION

The water footprint of production refers to the total freshwater volume consumed or polluted within the territory of the nation as a result of activities within the different sectors of the economy. It differs from the water footprint of consumption as the latter accounts for the total (internal and external) freshwater that is used to produce the goods and services consumed within the nation (the goods consumed within a nation are partially imported), whereas the water footprint of production is the sum of the domestic water resources utilized by the production activities of the nation. This explains why the water footprint of production is not further distinguished between the internal and the external components: the freshwater use is only internal.

The total water footprint of Italian production amounts to 70,393 millions of cubic meters per year. Agriculture is the thirstiest economic sector in Italy, as well as in most of the world's economies. Crop production and grazing and animal water supply are responsible for 75% and 10% of the total water footprint of national production, respectively (Figure 9). The remaining 15% of the water footprint of production is split between industrial production (8%) and domestic water supply (7%).

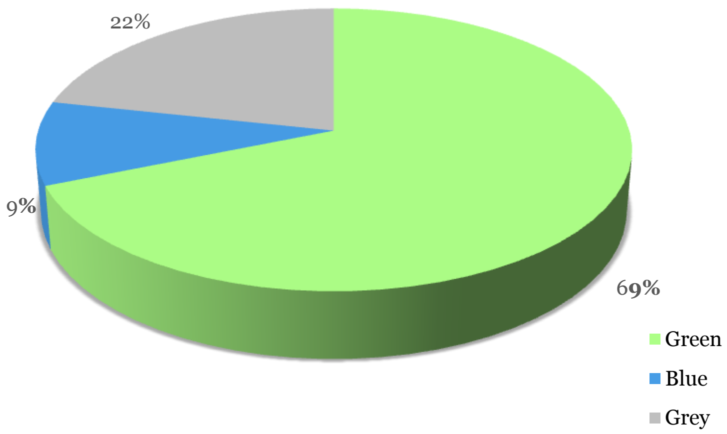
Figure 9. Total water footprint of national production by sector (%)



Source: Authors (based on Mekonnen and Hoekstra 2011)

Green water is the main source of water used in Italy (69%), followed by grey water (22%) and blue water (9%) (Figure10). With respect to consumption, production processes generate a larger amount of polluted water.

Figure 10. Total water footprint of national production by water colour (%)



Source: Authors (based on Mekonnen and Hoekstra 2011)

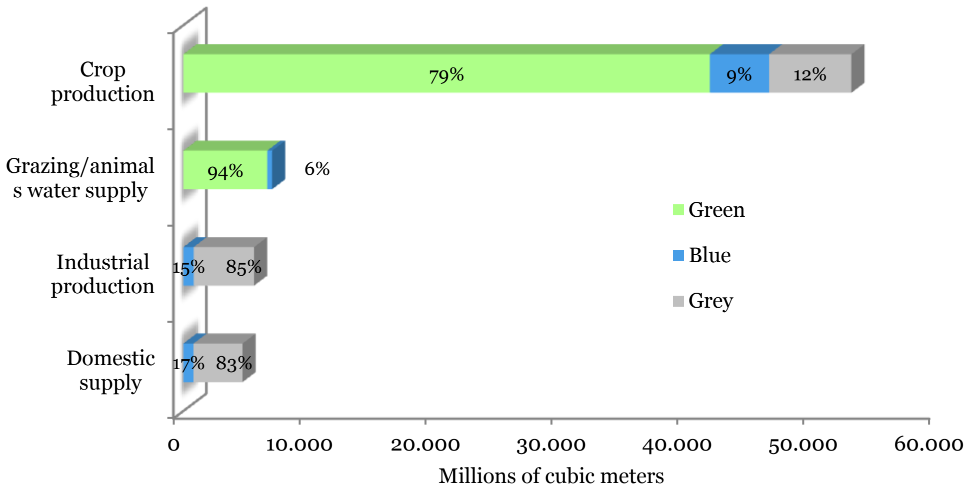
Crops and livestock products are produced employing mainly green (rainfed) water (79% and 94%, respectively, Figure 11), while manufacture and the domestic sector show a high grey water footprint (85% and 83%, respectively).

Table 3. Water footprint (WF) of national production (Mm^3/yr), by sector

Water Footprint by sector	Green	Blue	Grey	Total by sector
Crop production	41,793	4, 707	6,532	53,032
Grazing / animal water supply	6,655	393	0	7,048
Manufacture	0	815	4,797	5,612
Domestic supply	0	807	3,892	4,699

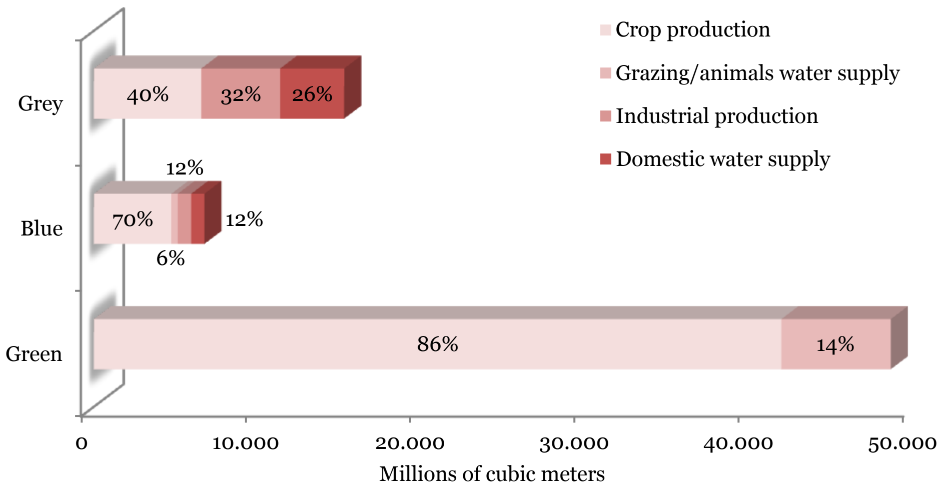
Source: Authors (based on Mekonnen and Hoekstra 2011)

Figure 11. National water footprint of production by size, water sources and sector (Mm³/yr)



Source: Authors (based on Mekonnen and Hoekstra 2011)

Figure 12. National water footprint of production by size, water sources and sector (Mm³/yr)



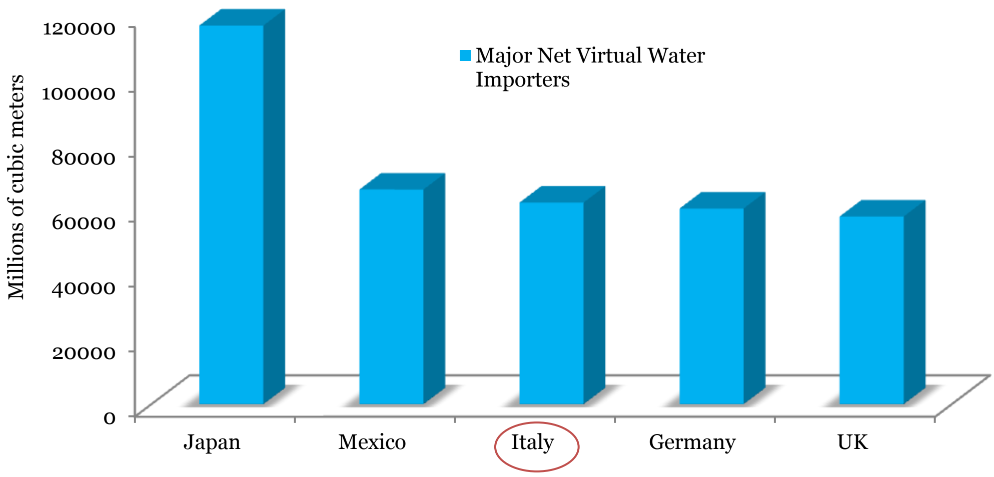
Source: Authors (based on Mekonnen and Hoekstra 2011)

4.6 VIRTUAL WATER "IMPORTS" AND "EXPORTS"

Virtual water "trade" refers to the implicit exchange of water through conventional trade. Water is in fact an essential factor of production in all traded commodities, therefore, when a country imports (or exports) a product, it also "imports" (or "exports") the water that was needed to produce it in the country of origin. We distinguish between virtual water imports and exports. A country is said to be a net virtual water importer when it 'imports' more than it 'exports' in terms of virtual water.

Italy is ranked as the 3rd net virtual water importer in the world (62,157 Mm³/year), after Japan and Mexico, and immediately before Germany and the UK.

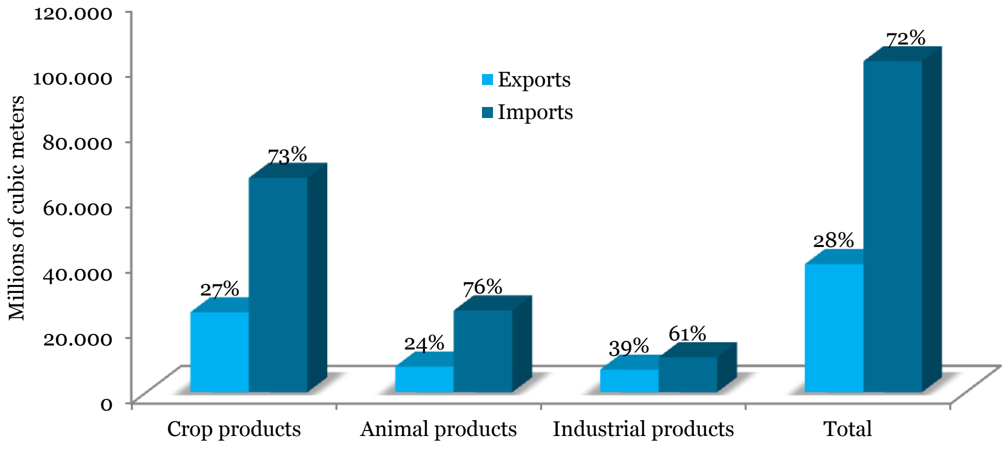
Figure 13. Major net virtual water importers of the world (Mm³/yr)



Source: Authors (based on Mekonnen and Hoekstra 2011)

Italy's 'net virtual water importer status' appears clearly from Figure 14 where, regardless the product category analysed (crops, animal-based and industrial products), virtual water imports are always larger than virtual water exports.

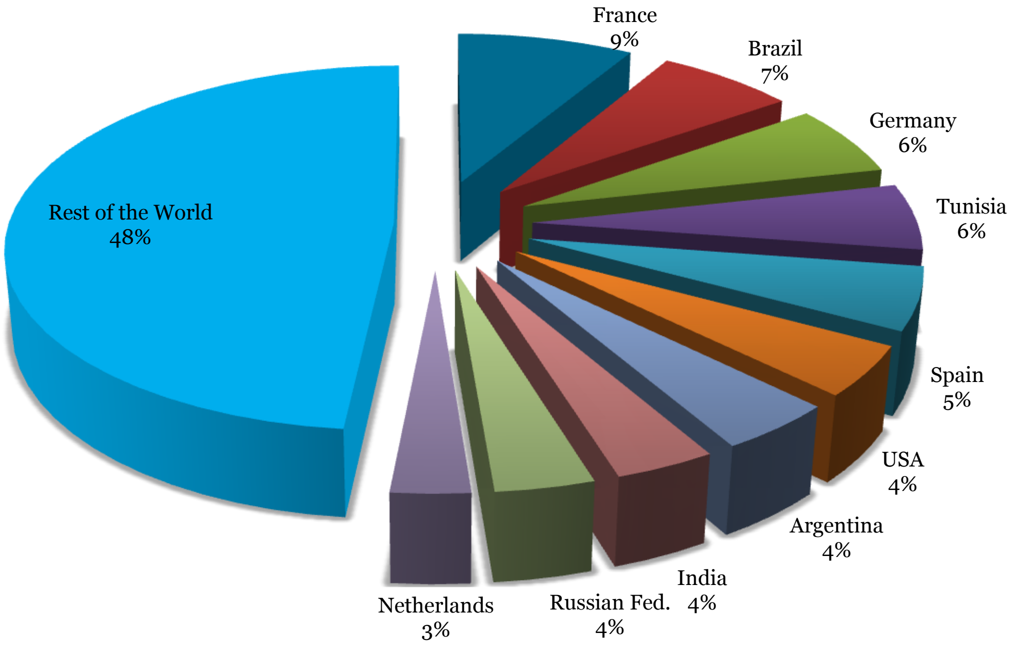
Figure 14. Virtual water exports and imports by product category (Mm³/yr)



Source: Authors (based on Mekonnen and Hoekstra 2011)

Figure 15 illustrates where the Italian virtual water imports come from. More than 50% of the water is virtually imported by means of the water 'embedded' in food products originating from ten different countries, of which four are among the major European economies (France, Germany, Spain and the Netherlands). Some of the 10 major partners (India – 4%, Argentina – 4%, USA – 4% and Brazil – 7%) rank among the biggest net virtual water "exporters" of the world; others (France – 9%, Germany – 6%, the Netherlands – 3% and the Russian Federation – 4%) are water-abundant countries. About 11% of Italy's virtual water 'imports' originates from water-scarce countries, i.e. Spain (6%) and Tunisia (5%) thus contributing exacerbating water scarcity.

Figure 15. Percentage of virtual water imports of Italy, by major countries



Source: Authors (based on Mekonnen and Hoekstra 2011)

Figure 16. Composition by water sources of net virtual water imports

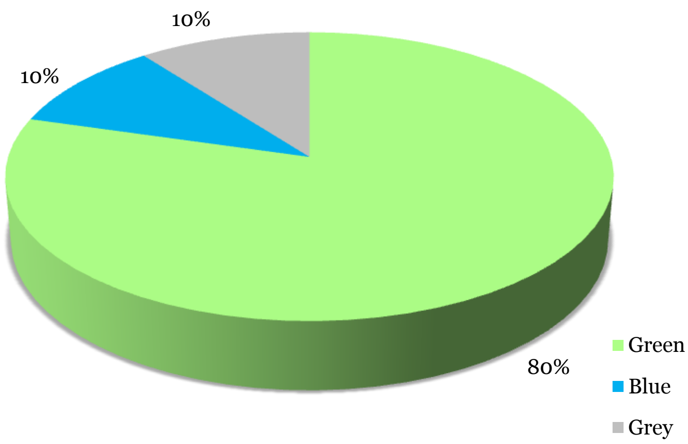
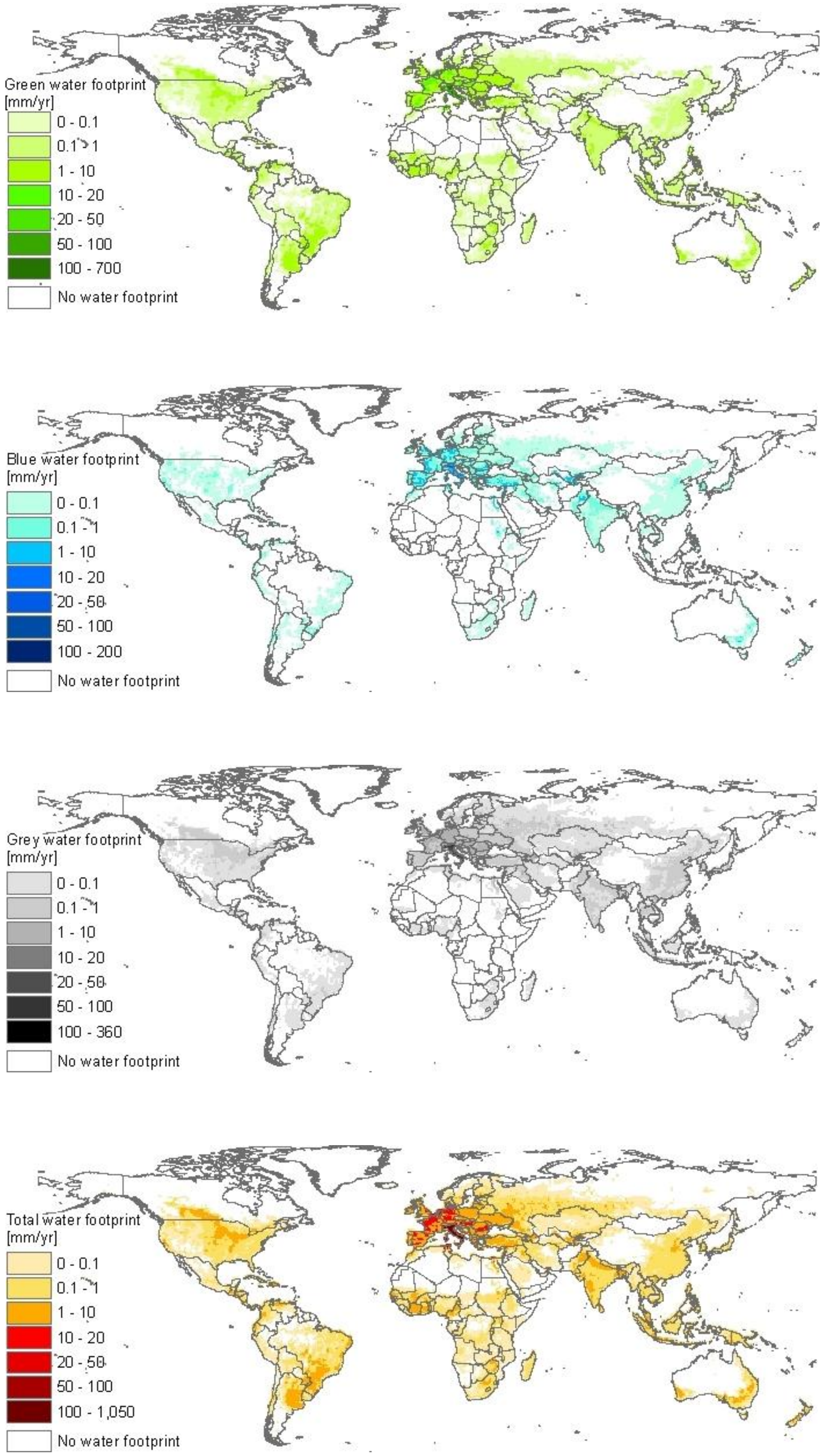


Figure 17. Origin of the Italian virtual water "imports"



Source: Mekonnen and Hoekstra 2011

The composition of virtual water exports (Table 4) shows that Italy virtually exports, through the exports of food products, mainly green water (59%), followed by grey water (23%) and then blue water (18%).

Table 4. Virtual water exports (Mm³/yr)

Water footprint by sector	Green	Blue	Grey	Total by sector
Crop products	16,849	5,418	2,218	24,485
Animal products	6,229	1,045	582	7,856
Industrial products	0	642	6,277	6,919
Total by color	23,078	7,105	9,077	39,260
% of Total	**59%**	**18%**	**23%**	100%

Source: Authors (based on Mekonnen and Hoekstra 2011)

The order does not change if we look at the water sources of virtual water imports (Table 5): Italy virtually imports mainly green water (72%) through the import of crops and animal product, followed by grey water (15%) and blue water (13%). In absolute terms, each source of water virtually imported is always greater than those virtually exported (compare the fifth row of Table 5 and 4).

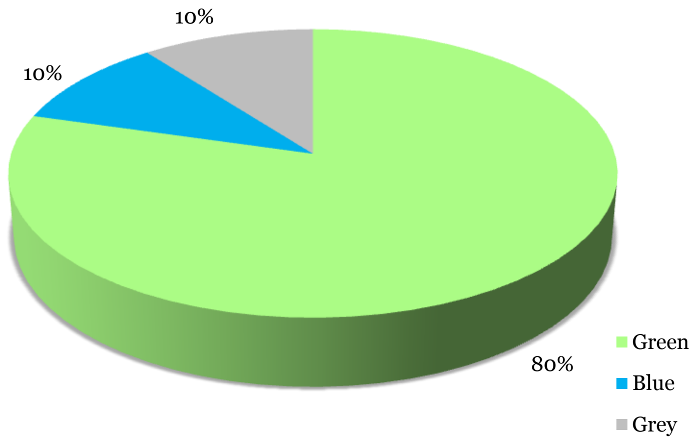
Table 5. Virtual water imports (Mm³/yr)

Water footprint by sector	Green	Blue	Grey	Total by sector
Crop products	51,072	10,221	4,376	65,668
Animal products	21,394	2,312	1,342	25,048
Industrial products	0	851	9,849	10,701
Total by color	72,466	13,384	15,567	101,416
% of Total	**72%**	**13%**	**13%**	100%

Source: Authors (based on Mekonnen and Hoekstra 2011)

The net virtual water imports are obtained by subtracting from the virtual water imports the virtual water exports. The composition in terms of water sources is shown in Figure 16. Being Italy a large importer of food products, which are produced mainly through green water resources, 80% of the net virtual water imports are green (about 49,388 Mm3/yr); the remaining 20% is equally split between blue water (around 6,278 Mm3/yr) and grey water (around 6,490 Mm3/yr).

Figure 17. Composition by water sources of net virtual water imports



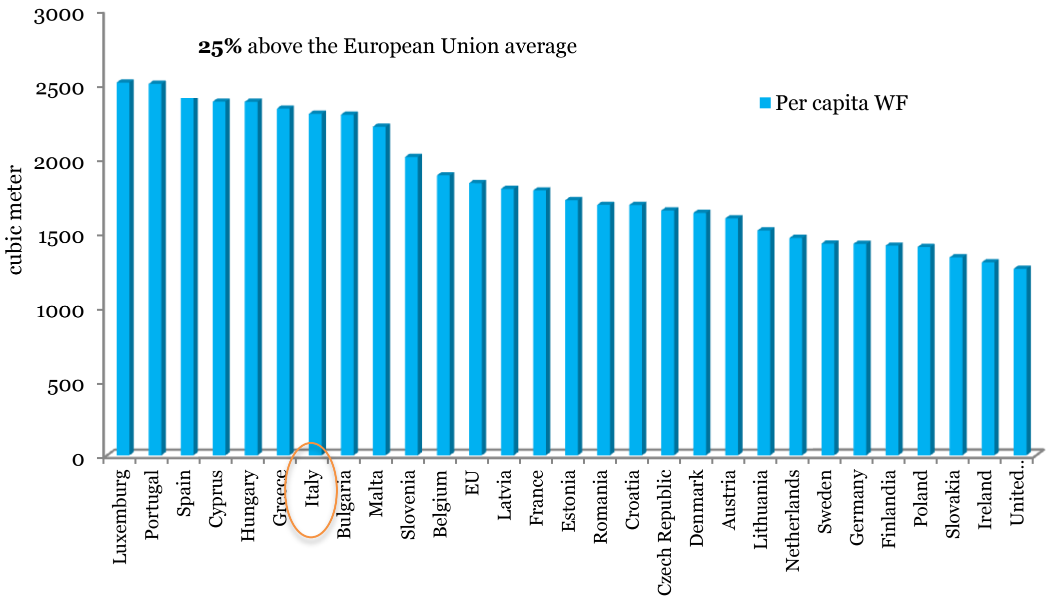
Source: Authors (based on Mekonnen and Hoekstra 2011)

4.6.1 A comparison with the water footprint of other countries

Italy's total water footprint is 132,466 Mm^3 of water per year: this amounts to 2,303 m^3 per person, or 6,309 litres per person per day.

Italy is one of the countries with the highest water footprint in Europe. Its water footprint is (see Figure 17), which amounts to 1,836 m^3/yr per capita, and is higher than most of its neighbouring countries, such as France, Germany, Austria, Slovenia and Croatia. Countries such as Portugal, Spain, Greece and Cyprus exhibit a higher water footprint than Italy's, which can partly be explained by warmer climate conditions.

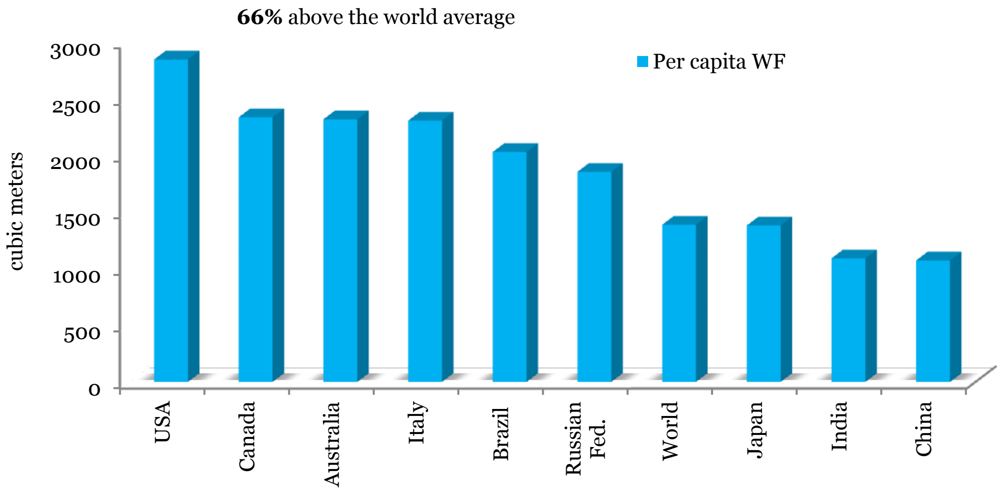
Figure 18. Yearly per capita consumption and production water footprint (WF) of Italy compared with other European member states (m^3/yr/cap)



Source: Authors (based on Mekonnen and Hoekstra 2011)

At a global level, Italy's water footprint is 66% above the world average, which amounts to 1,385 m^3/yr per capita. With respect to the major non-EU economies, Italy ranks among the most water consuming countries, immediately after the USA, Canada and Australia.

Figure 19. Yearly per capita consumption and production water footprint (WF) of Italy compared with the major economies (m^3/yr/cap)



Source: Authors (based on Mekonnen and Hoekstra 2011)

THE WATER FOOTPRINT OF ITALY IN A NUTSHELL

Italy's total WF of consumption: 132.4 billion m^3 of water per year or 6,309 litres per person per day compared to the world's average of 1,385 m^3/yr per capita

89%: WF of consumption of agricultural products

Wheat, olive oil, coffee, bovine meat, milk and pig meat: 50% of the Italian WF of consumption

WF of consumption: 75% green, 8%, blue, 17% grey

60.7%: external WF/total WF. This is Italy's dependency ratio from external water

Italy's total WF of production: 70,393 millions of cubic meters per year

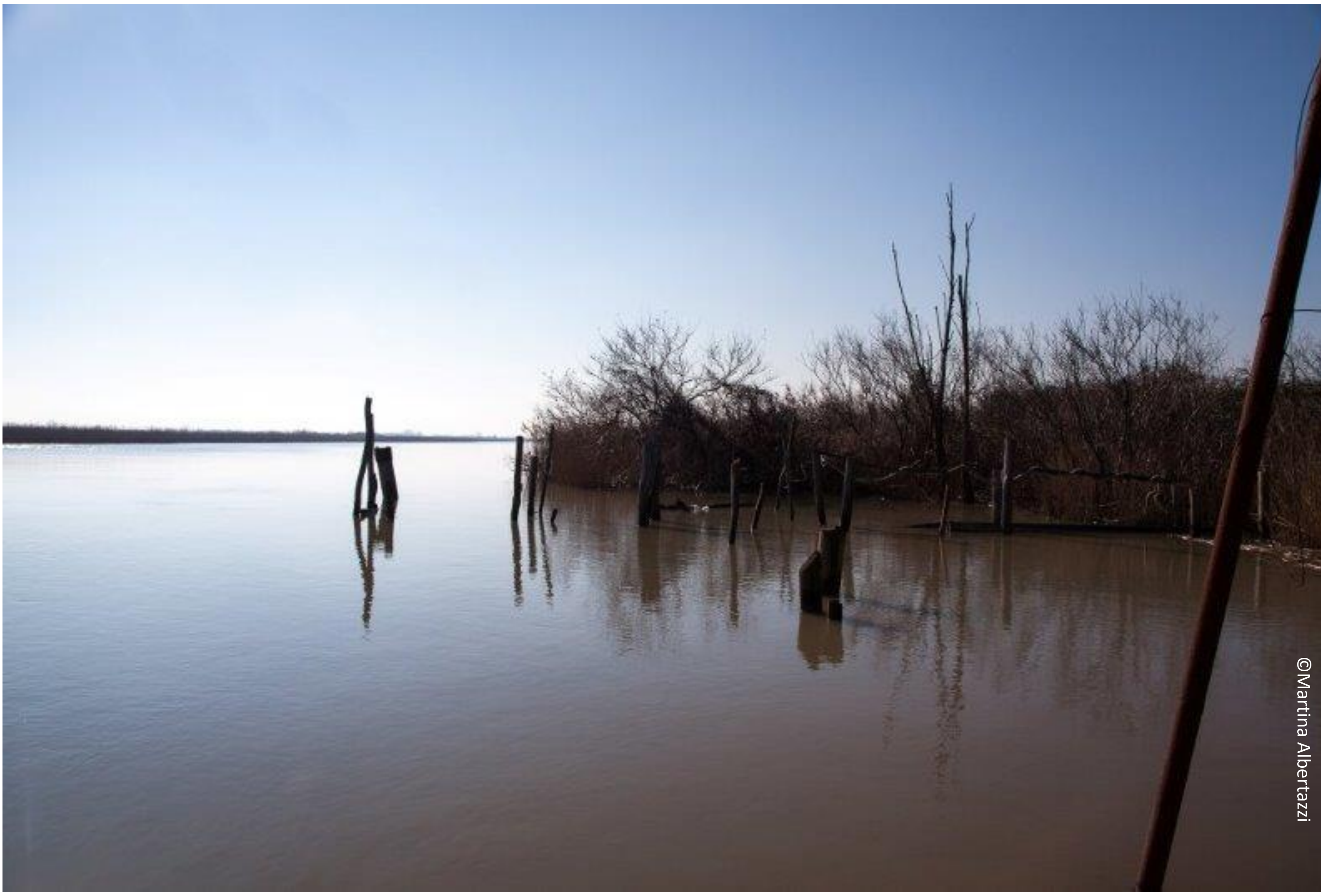
Agriculture is the thirstiest economic sector in Italy: crop production and grazing and animal water supply are responsible for 85% of the total WF of the Italian production

Italy's WF of production: 69% green, 9% blue, 22% grey

Italy is the 3rd net virtual water importer in the world, after Japan and Mexico: 62,156 Mm^3 of water per year

Italy's main virtual water partners are France and Brazil

Italy's WF per capita is 66% above the global average and 25% above the EU average



CHAPTER 5. CONCLUDING REMARKS

This report gives us a broader vision of water resources by bringing to light the real water that flows through our consumption of basic goods as well as our production. The water footprint analysis is a tool to account for this invisible consumption of water resources, which is much higher than our domestic water uses. Bringing to light this fact and being aware of it can make a big difference on the water resources of this planet. Every sector of society is involved, directly or indirectly, in water use. In particular, citizens, industry, agriculture and financial institutions can make a difference. Below, there is a (non exhaustive) list of what we can do, in each of these identified sectors.

CHAPTER 6. "WHAT CAN YOU DO?"

"WHAT CAN YOU DO?" - FOR FARMERS

In the agricultural sector, the main challenge is to maximize the efficiency and effectiveness of irrigation and exploit in full the unfulfilled potential of rainwater. What can we do? It is now possible, through the direct measurement of soil moisture, to assess when additional irrigation is required, while maintaining at the same time unchanged the quantity and quality of the product. Much can also be done regarding the efficiency of irrigation, which still, relies onto traditional methods. Drip irrigation is, for instance, a method for rationalizing irrigation schemes. This method allows to achieve an improved water efficiency and, to generate, as a consequence, economic saving for the food industry. The big challenge for the livestock sector is to promote green foraging: pasture and locally sourced hay, rather than concentrated feed, which usually also comes from abroad.

“WHAT CAN YOU DO?” - FOR INDUSTRY

Water efficiency in the industrial sector is now not only possible, but also necessary. Efficiency is important also in the light of the subsequent economic benefits that follow from it. Although industry represents only 7% of our daily water consumption, it is a sector characterized by a high grey water footprint that is, linked to pollution. The corporate social responsibility of an industry regarding its own water footprint extends to all stages of the supply chain, including the choice of raw materials. As a first step, goods and services with a low environmental impact should be preferred. The evaluation of the water footprint of production inputs is part of this choice. In the processing phase, efficiency and effectiveness of water use should be promoted and maximized. Finally, every company should provide consumers with its own water footprint, and a “water balance” statement, with the records of volumes of water used in the production process and a plan for their gradual reduction. This activity is called “corporate water accountability". Finally, this water accountability, already promoted at the international level by various institutions and public-private partnerships, can become a part of the ordinary corporate sustainability strategies.

“WHAT CAN YOU DO?” - FOR THE FINANCIAL SECTOR

In the financial sector the promotion of water efficiency is not immediately perceived as a priority. In fact, the financial institutions that provide credit to industry and producers - large, small and medium-sized enterprises – can have an important role and can significantly contribute to the promotion of water efficiency and good management of our water resources. Financial institutions can link environment-friendly behaviors to economic incentives. They could create, for instance, a set of standard rules for the access to privileged loan funds, targeting virtuous companies. The financial sector could put in place procedures for granting access to credit by giving priority to those companies that have the most sustainable water footprint in both their production inputs and products. At the same time, financial institutions could enhance access to credit to those companies, which propose a plan to reduce their water footprint of production gradually and strategically, through time, with specific and measurable indicators of success.

“WHAT CAN YOU DO?” - FOR CITIZENS

What can we do? Citizens, willing or not, are, by all means, the final consumers of virtual water and therefore the primary generators of their water footprint. As an individual consumer, as a group of consumers or as a nation as a whole. We consume water resource both in our daily domestic consumption and as ‘embedded’ in the products we use every day that have specific water footprints. Our role may seem silent, but on the contrary, is very clear and essential. In addition to saving water daily in our homes, we can promote better water management in the world and in our country, through simple, precise day-to-day strategies. We can choose food that does not have a high cost in terms of water. For example, we can avoid fruits and vegetables that are known to be irrigated (such as tomatoes) if they come from countries known to be desert-prone. We can prefer local and seasonal products, and also goods originating from water-rich areas. We can also - gradually or permanently - diminish the consumption of red meat, which is the most water-intensive food, especially if coming from factory farms. We can call for more transparent food labels and also for the promotion of water accounting to the companies that provide us with the goods we consume daily. We can drink tap water. We can actively help NGOs to promote better water footprint in our city, our region, our country.

ANNEX

The water footprint of a country (WFP, m^3/yr) is equal to the total volume of water used, directly or indirectly, to produce the goods and services consumed by the inhabitants of the country. A national water footprint has two components, the internal (IWFP) and the external (EWFP) water footprint:

$$WFP = IWF\ P + EWFP$$

The total volume of water use to produce crops in a country (AWU, m3/yr), is calculated as:

$$AWU = \sum_{c=1}^{n_c} CWU\,[c]$$

where CWU (m^3/yr), crop water use, is the total volume of water used in order to produce a particular crop.

$$CWU\,[c] = CWR\,[c] \times \frac{Production\ \ [c]}{Yield\,[c]}$$

Here, CWR is the crop water requirement measured at field level (m^3/ha), *Production* the total volume of crop c produced (ton/yr) and *Yield* the production volume of crop *c* per unit area of production (ton/ha).

The source is Chapagain A.K. and Hoekstra A.Y. (2004). The Water Footprint of Nations, Volume 1 IHE, The Netherlands.

The current study is based on information about water footprint calculations from Water Footprint Network kindly provided by prof. Arjen Hoekstra..

The consulted annexes of Water Footprint of Nations Vol 1 and Vol 2 were:

- VIII and IX (WF of National Consumption)
- I (WF of National Production)
- II and III (Virtual Water Flows)
- IV and V (Virtual Water Savings)

The estimates of production and consumption water footprints were elaborated using the methodology of: Hoekstra A.Y., Champaign A.K., Aldaya M.M. and Mekonnen M.M. (2011). The Water Footprint Assessment Manual, Setting the Global Standard. Earthscan. London, Washington D.C. 199

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