Water Footprint of Germany

Where does the water for our food come from?

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Summary

Calculation of the water footprint

In the past years the water use in German households as well as in the industrial sector has declined constantly. This trend is very welcome and has to be encouraged in the future. But this amount of water only represents a small portion of the water we use on a daily basis. A considerably higher portion is hidden in our food, clothes and other products that we use or consume in our everyday life, namely as so called virtual water. In combination with the information regarding the source of this water and the consequences of its extraction or consumption, we simplified speak about the water footprint. Until now, only estimations existed on the water footprint of Germany. WWF's goal for this study was therefore to analyse the water footprint of Germany, with an emphasis on agricultural products, their origin and the producing countries. The analysis of the vast data set is in the context of this study also the basis for recommendations for governments and companies to reduce the ecological, social and economical consequences of the water footprint.

Based on international trade data for vegetable and livestock products per country and their respective climatic conditions, the content of virtual water was calculated. The sum of all products produced and consumed within Germany as well as those imported from other countries makes the agricultural water footprint of Germany. Together with the use in households, business and industry it results in a total water footprint of 159.5 cubic kilometres of water per year. With a population of currently 82.2 million, each citizen consumes 5,288 litres of water each day, and only a small portion of it for drinking, cooking or other household activities.

The biggest amount of this water is hidden in the food or products that are consumed each day. About half of the German agricultural water footprint is made up by imported products or food. That means that by importing those goods, water in virtual form was also imported from the producing countries. Germany has thereby left its water footprint in those countries. The imported goods with the highest water footprint are - in descending order - coffee, cocoa, oilseeds, cotton, pork, soybeans, beef, milk, nuts and sunflowers. The biggest water footprint of Germany is left in Brazil, Ivory Coast, France, the Netherlands, the USA, Indonesia, in Ghana, India, Turkey and Denmark respectively, also in descending order.

The external water footprint of Germany worldwide

The impacts are depending on regional climatic conditions and production technologies, especially in the still further expanding irrigation agriculture. Exemplary for the impacts during the production of special goods, the cotton and rice production in different countries around the world are discussed.

In the producing countries different production standards are applied under the respective climatic, demographic and economic conditions. Exemplary, five countries are represented, where the export of virtual water – at least in certain regions – has negative consequences for the natural ecosystems as well as on the social and economic sectors:

- **Brazil:** Although Brazil is generally a water-rich country, it has nevertheless a huge problem regarding its water resources, especially water pollution and its consequences;
- **India:** The Indian agricultural sector is fundamentally influenced by cotton production, which is irrigated in the northern states, and therefore has severe impact on the river catchments and the environment. The enormous weaknesses in water management also lead to extensive social and economical problems for a growing population in the country.

- **Kenya:** Similarly high population growth and intensifying agriculture together with a weak or non-existing institutional structure for a sustainable water management determine the situation in Kenya, which additionally has to cope with high deforestation. Especially the threats for the Mau forest as the headwater region of the Mara River at the downstream spreading irrigation agriculture pose a threat for the annual migration in the Serengeti and the Masai Mara.
- **Spain and Turkey:** The situation of the EU member state Spain and the candidate country Turkey are quite similar with regard to their cultivation conditions. While Spain has shown a clear reversal of trend in irrigation agriculture towards more efficient technologies, over 90 percent of the land under irrigation in Turkey are still flooded. The connections to the European market, where Germany is one of the most important trading partners, are present in both countries, for Spain as an EU member state and Turkey up to now as candidate country. Especially serious damage derives in both countries from illegal water abstraction, which is punished only insufficiently by the public authorities and which is neither sanctioned nor punished.

Altogether, the climatic conditions as well as the soil characteristics define, which crops can be cultivated and thereby also narrow the selection in Middle Europe to those crops adapted to the climatic conditions there. Under these prerequisites, there is usually only one harvest possible for crops, compared to often all year round possible cultivation cycles in climatic more favourable regions in the tropics and subtropics. For the production of agricultural goods in those countries are not the climatic conditions like seasons and temperature changes restricting for cultivation like it is in Middle Europe, but the availability of and the secure access to water. To eliminate these restrictions, the fields are more often irrigated – but at the expense of the natural water household and nature, and it also raises the competition with other water users.

Recommendations of WWF and outlook

The German external water footprint is in absolute as well as in relative terms quite high. Therefore stakeholders in Germany but also in the producing countries have a special global responsibility, which we should meet. At the moment, this is directed firstly to the governments and the companies, and only secondly the consumers, since until now only little possibilities exist to reduce the personal water footprint by purposeful consumption.

In the most important production countries of the products imported to Germany with a high water footprint, the governments should guarantee an efficient and legal irrigation of the agricultural products by using incentives, but also sanctions and punishments. The allocation of the water resources for agriculture and industry, especially the blue groundwater and surface water, must not result in rivers, aquifers or freshwater ecosystems not getting sufficient amounts or qualities of water any more.

The German government should raise the financial means in development co-operation where improvements in the sustainable management of aquifers are aspired as well as in river catchment areas, especially in water-scarce regions, where water mismanagement is practised. At the European level, the consistent implementation of the EU Water Framework Directive for rivers and aquifers should be demanded – especially in the Mediterranean countries of Spain, Italy and Greece, but also in the EU candidate country Turkey as well as other riparian countries. Agricultural subsidies of the EU should only be paid in the case of proven responsible utilisation of the water resources.

Companies should measure and document their water footprint along their whole supply chain in order to better understand the risks connected to it. They also must reduce the impacts especially in current or future water-scarce regions and have to support together with other companies a more efficient and more sustainable water resources management, which also gives the local communities access to water and at the same time secures ecological flows. Also, the companies should engage for the development of water standards for products, which allow the consumers to choose between products with a high or low footprint in critical regions.

WWF works in some of the most important transition and developing countries where many of the products Germany imports come from (for example Brazil and India), as well as in Europe (e.g. Spain, Turkey) and the USA on the development of a more efficient water use in agriculture. Furthermore, WWF actively engages together with companies on the development of global water standards for products, the development of business and risk strategies for the use of the water footprint an also in the respective countries in the implementation of these concepts by the suppliers and exporters.

The water consumption and the demands we have on groundwater bodies and river systems will dramatically grow in the near future. Fundamental factors are the growing world population and the guarantee of their food security as well as economic growth and therefore a change in consumption patterns. In China for example more and more virtual water was used in the last 50 years for the feeding of its population, because with growing wealth the consumption of meat also rose [36]. Therefore it is more pressing that governments, businesses and consumers accept their responsibility now and invest in a better and more sustainable water management for the sake of the local population as well as the ecosystems depending on the water and their future services valuable also for people.

Bild

Fruit and vegetable market in Turkey. ©WWF

1 Introduction

The understanding that we have to economise the use of the resource water established itself in the German households as well as in the industry. In both fields the water use has continuously decreased in the last decades. While households used 144 litres of water per capita each day in 1991, in 2007 about 124 litres were sufficient on average [1]. In the industrial sector great amounts of water can also be saved thanks to technical innovations and the operation of water cycles [2].

This trend is very welcome and has to be encouraged in the future. But unfortunately, this amount of water only represents a very small portion of what we really use each day. The real per capita water use worldwide ranges between 1.918 (China) and 6.795 (USA) litres per day, the global average amounts to 3.397 litres [3]. Germany's water use lies clearly in the upper area of this margin. We are not aware of this enormous amount of water because the biggest part of it is hidden in our food, clothes and other products that we use and consume in our everyday live – as so called **virtual water**.

1.1 Virtual water and the water footprint

Virtual water is defined as the total amount of water that is used or polluted during the manufacturing process of a product, or that evaporates along the way. For the calculation of the virtual water content of a certain product, each step in the manufacturing process is included.

A kilogram of beef for example stands for 15.500 litres of virtual water. This sum comes about as follows: it usually takes three years till the cattle are ready for the slaughter and provides about 200 kilogram of boneless meat. During this space of time, it consumes almost 1,300 kilogram of grain and 7,200 kilogram of roughages like hay or silage. Added to that are 24 cubic meters of drinking water and another 7 cubic meters of water for the cleaning of the cots and others. Converted to a kilogram this means that each kilogram of beef contains 6.5 kilogram of grain, 36 kilogram of roughages and 155 litres of water. For the production of the fodder alone already 15.300 litres of water are needed. And this calculation does not include the water quantity that may be polluted during the upbringing of the cattle or during the production of the fodder plants [4].

The concept of virtual water was developed by the British scientist John Anthony Allan, who developed it in the 1990ies as a tool to find new solutions for water scarcity and impending conflicts in the Middle East [4]. To acknowledge the significance of this concept for trade and policy, Allan was honoured with the Stockholm Water Prize in 2008.

Virtual water consists of three components: green, blue and grey virtual water.

Green virtual water is the quantity of rainwater that is stored in the soil and will be taken up by the plants during their growth.

Blue virtual water characterises for industrial products and domestic water supply the amount of groundwater or water from lakes and rivers that is used for the production of a certain good but cannot be reverted afterwards. In agriculture, those water quantities are defined as blue water that are used for irrigation and are either taken up by the plants or evaporate. But also the water that evaporates from the irrigation canals or artificial storage reservoirs without reaching the fields are counted as blue water.

Grey virtual water is the water quantity that is directly polluted during the manufacturing process of a product and therefor cannot be used any more, or which is theoretically necessary to dilute polluted water to such an extend that agreed water quality standards are met again [5].

From an ecological point of view it is usually preferable if products contain more green water than blue one. Blue water is taken from surface or groundwater and therefore is no longer available in the natural water cycle. We already use 40 to 50 percent of the available blue water [6], with an upward trend. Especially in agriculture incentives are missing that would lead to an economical use of blue water. Water prices are subsidised in many countries so that the real costs are not passed on to the farmers. Often no water meters are installed at the water extraction points so that the real amount of water used cannot be established or even documented. Because of non-existent sanctions and appropriate punishment there is no effective penalty of the culprits or an out of it resulting learning effect: to manage more water efficient. “Water offences” are often regarded only as trifling offences by authorities and institutions. Here exists great need for action for the political decision-makers to eliminate such shortcomings on the one hand and establish effective controls on the other hand.

The **water footprint** (WF) is a further development of the virtual water concept by the Dutch scientist Arjen Y. Hoekstra. It informs how much water is consumed by the use of a product or service. By the estimation of the water footprint not only the level of the water consumption can be calculated, but also in which country this water was invested to produce these goods. So the water footprint has in contrast to the virtual water content also a geographic component.

The water footprint can be calculated for single persons, companies or countries and even for whole continents. It is an indicator, which considers the direct as well as the indirect water consumption of a consumer or producer and gives information about the region from which the virtual water contained in this product was taken.

To distinguish the virtual water content of a product from its water footprint, one has to notice that the amount of virtual water states the quantity that is used during the production of this good. The water footprint on the other hand shows how much water is lost by the consumption of this good as well as the origin of this water.

1.2 Aim of this study

This study intends to present the concept of virtual water and the water footprint to broad public attention. Since Germany imports a certain amount of the water consumed in everyday life, it is important to know which countries are affected by this virtual water trade and which products have the greatest water consumption. Conclusions of a number of studies show that the impacts of global trade on regional water systems are at least as severe as the consequences of climate change [7].

For WWF, the concept of the water footprint is an important instrument, which can promote the awareness about our water consumption and also help to reduce the water consumption and the connected negative consequences.

It is not the goal that companies or whole countries reduce their consumption per se. It is rather important that the reduction takes place where high virtual water consumption has the strongest negative consequences for people and nature. Therefore, this study does not only want to inform about where Germany leaves its water footprint and which consequences derive from that. Companies and governments should be addressed with this report to develop measures that implement the virtual water concept in the field in order to effectively reduce the water consumption and at the same time reduce the impacts of their actions in other countries.

2 Methods

Germany is a relative water-rich country and, in contrast to many developing and transition countries, relatively exemplary in the European context regarding the law making and implementation on the management of water catchment areas and aquifers. If nothing else, this is thanks to the requirements to implement the European Water Framework Directive.

The focus of this study therefore was placed explicitly on imported goods, their virtual water content and the connected possible consequences. The high water footprint values of goods produced and consumed in Germany in contrast are not further analysed within this study.

Germany imports a variety of products like meat, grain, tea, cotton and sugar from all parts of the world. To calculate the water footprint Germany leaves outside its borders, the water requirements of all agricultural products imported to Germany were analysed, based on the international trade data from PC-TAS of the International Trade Center for the years 2004-2006. Altogether, 503 crop and 141 livestock products were taken into account. The water footprint of a crop derives from the ratio of the water amount used for the production and the yield of this product. The used water quantity includes the evaporated water as well as the amount that was polluted during production and therefore cannot be used any longer.

The estimation of the water footprint of industrial goods is more difficult since a certain product often contains different raw material and needs numerous manufacturing processes. Based on the currently best available methods, a crude assessment of the industrial water footprint of Germany was made (see table 1, cf. [3]). The industrial footprint also includes products whose water footprint is based on their respective industrial value. The methods for the calculation of the industrial component of the water footprint still need improvement to better integrate them into the total water footprint. But this was not possible in the scope of this study. Therefore, its focus lies on the agricultural sector.
Further information on the calculation of the water footprint can be found at [3] and [8].

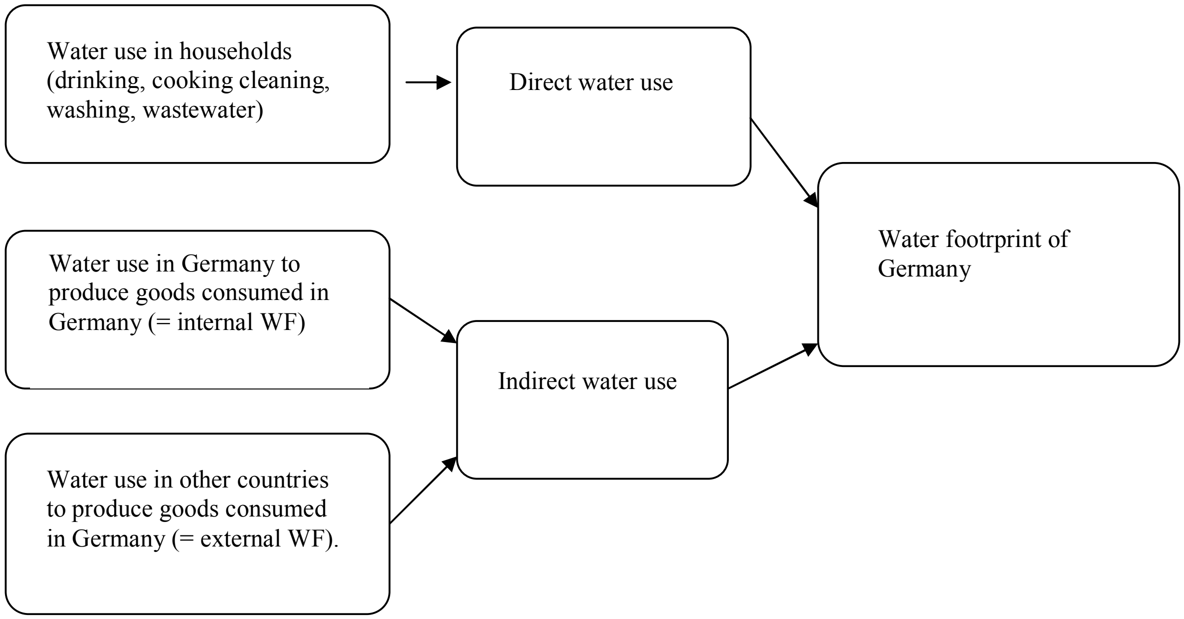

Figure 1: Scheme of the components that are taken into account for the calculation of the water footprint.

Figure 1 shows schematically which components make up the water footprint of Germany. On the one hand there is the direct water consumption that is used in households for cooking, cleaning and washing. The indirect water consumption is calculated adding the water quantity used during production that is taken from national water resources (internal water footprint, IWF) to the water quantity that is used for the production of goods in other countries, which then are exported to and consumed in Germany (external water footprint, EWF). Direct and indirect water consumption together make the total water footprint of Germany.

It has to be stated that the calculation of the water footprint Germany leaves in other countries couldn't differentiate in which hydrological catchment area the respective products were cultivated, which would be necessary for the detailed assessment of the actual ecological and social consequences. The available data therefore only allow general information at first about the amount of water taken from a certain country as agricultural good. Although it is not possible to make statements on how for example an especially valuable ecosystem is damaged by the cultivation of a certain product, the results allow important conclusions and forecasts. In countries with acute water scarcity and countries with insufficient political and legal framework concerning the management of water resources as well as insufficient application of these guidelines, it certainly can be estimated that the virtual water trade has massive impact on the water resources of this country as well as its ecosystems and population.

Bild

Grain harvest in Middle Europe © WWF

3 Germanys water footprint

3.1 Total water footprint

The total water footprint of Germany is 159.5 cubic kilometres (km³) or 159.5 billion cubic meters (m³) per year, whereof almost equal amounts of water are invested within and outside of Germany for the production of the goods consumed in Germany. That means that Germany serves only half of its current water consumption from natural resources (see table 1).

As a total, 117.6 km³ are used each year in agriculture, 36.4 km³ for the production of industrial products and only 5.5 km³ each year are used in households. Converted to the population this makes a daily water consumption of 5,280 litres per capita – that equals almost 27 filled bathtubs. Of this water amount, 3,900 litters are consumed as agricultural goods, 1,200 litres are hidden in industrial products and only 180 litres[1] can be related to everyday life. With the exception of the water used in households, these numbers include the water quantity consumed within Germany (internal water footprint) as well as the amount of water that was used for the production of goods for the German market in other countries (external water footprint).

As mentioned above is the German water footprint for agricultural products 117.6 km3. The internal water footprint is with 55.7 km³ slightly lower than the external water footprint for agricultural products of 61.9 km³ (table 1). These quantities are more than the volume of Lake Constance, Europe's second largest lake with about 48 km³.

The water for livestock and livestock products originates predominantly from Germany whilst the water footprint of crop products is mostly left outside of Germany (figure 2).

Table 1: Total water footprint of Germany

	Water footprint (km³/yr).			
	Internal	External	Total	% of total
Agricultural	55,7	61,9	117,6	73,7%
Industrial products	18,84	17,56	36,4	22,8%
Household water use	5,5	-	5,5	3,4%
Total (km³/yr)	80,0	79,5	159,5	100%
% of total	50%	50%	100%	

As one can see in figure3, the water footprint of crop products is mostly shaped by products that cannot be cultivated in Germany due to the climatic conditions, like cotton, coffee, cocoa or oilseeds. National water resources are mostly used for the cultivation of wheat, barley and fodder plants.

Crop products make up 71 percent of the agricultural water footprint of Germany. The production of livestock products is responsible for 29 percent of the water footprint. The water consumption in the agricultural sector therefore is clearly influenced by crop production. But in total, the use of blue water resources in agriculture only make less than 0.1 percent of the direct water consumption in Germany (Quelle??).

[1] These 180 litters are calculated from the 2.7 percent water use for public services (UBA ->Quelle) equalling 188 billion km³ divided by the total population of Germany, which is 81.17 million.

For one year, the consumption of coffee, tea, bread cotton clothes and other agricultural products add up to a water quantity of 1.016 m³ per capita.

Only 41.3 percent of the water amount for the production of crop products derives from national water resources, while the remaining 58.7 percent are imported. With the import of these goods the national water resources are preserved, but for the sake of the producing countries.

The consumption of livestock products in Germany mostly is at the expense of national water resources (figure 4). For pig breeding and milk production, almost equal amounts of water are used. Beef and poultry production also are important. But with a per capita consumption of 410 m³ each year in form of livestock products, this is 2.5 times less than the water consumption via crop products.

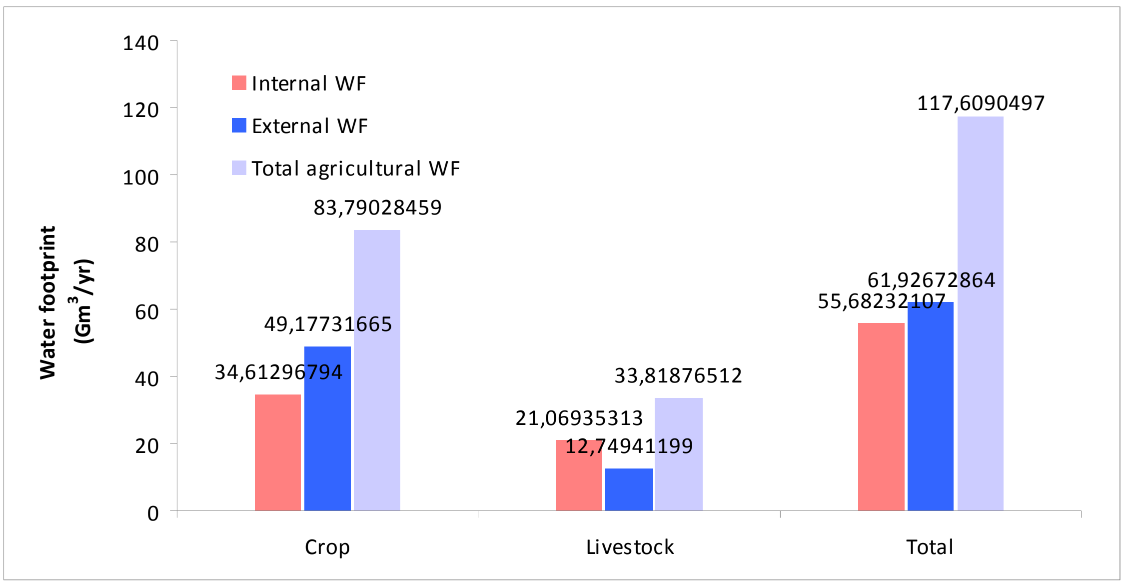

Figure 2: Sectioning of the agricultural water footprint Germany

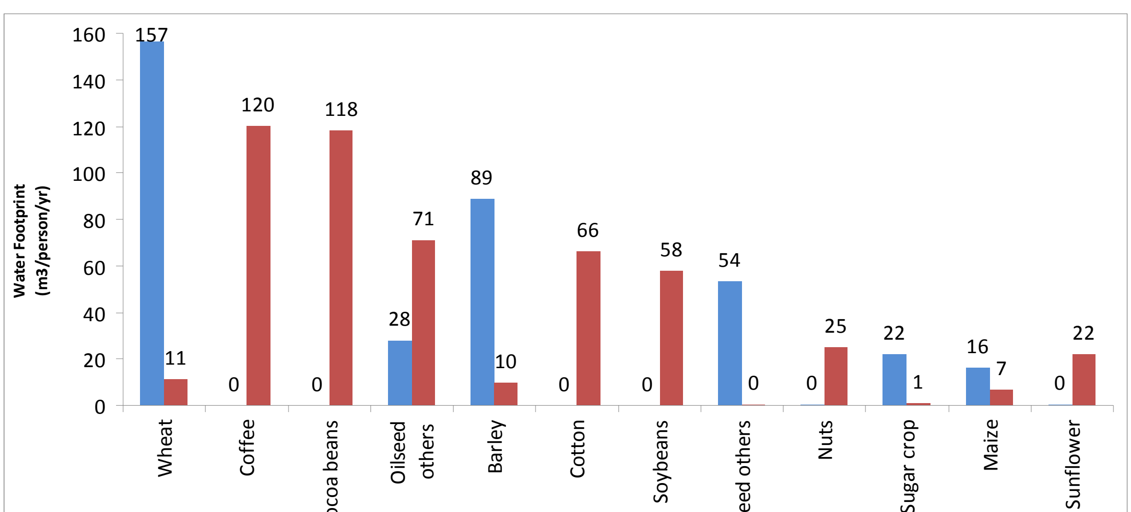

Figure 3: Contribution of crop products to the internal and external water footprint of Germany. Total water footprint related to crop products = 1.016 m³/person/year.

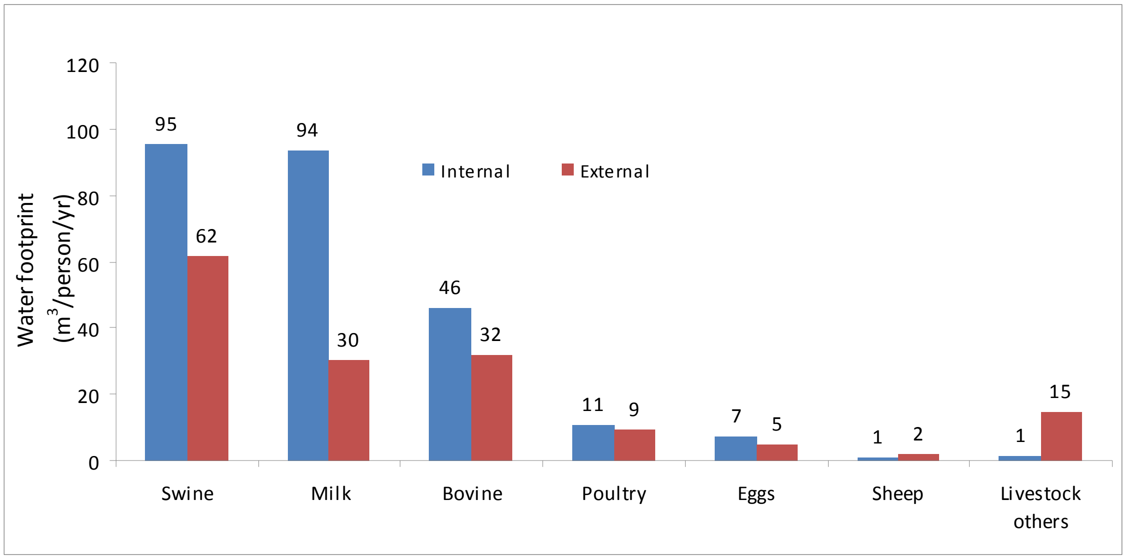

Figure 4: Contribution of livestock products to the internal and external water footprint of Germany. Total water footprint related to livestock products = 410 m³/person/year.

3.1.1 Germanys external water footprint

The calculation of the water footprint of agricultural goods shows that Germany imports a considerable portion of these products from other countries, especially concerning crop products (figures 2 and 5). In order to be able to make statements about possible negative consequences of these virtual water imports for the production countries, the most important import countries Germany leaves its water footprint in will be presented in the following, as well as the crucial products.

Table 2 lists the 15 most important production countries whose products make up the greatest part of the German water footprint of agricultural products. According to that, the greatest amount of virtual water is imported from Brazil, especially in form of coffee and soy. Therefore, chapter 3.3.1 gives an overview of the water situation on Brazil and the impacts of coffee and soy production.
In Ivory Coast and Germanys neighbouring countries France and the Netherlands also great amounts of water are used for the production of our food.

In table 3, the products are presented that have the greatest share on the external agricultural water footprint of Germany. A complete overview of all products considered in this study with their respective internal and external water footprint can be found in the Annex.

The strongest water footprint is made up by the import of coffee and cocoa. The import of cotton and swine products also embosses the external water footprint of Germany very much. In chapter 3.2 therefore the ecological consequences of cotton production in the world are presented, and chapter 3.3.2 gives a short overview of the consequences of cotton production in India.

Table 2: The 15 most important countries where Germany leaves its external water footprint

Country	EWF (Mm³/yr)	% of EWF	Most important import goods for Germany (EWF in Mm³/yr)

		(Mm³/yr)	
BRAZIL	5.729	9.25	Coffee (2654) Soybeans (1927) Livestock others (392) Bovine (310) Poultry (122) Cocoa beans (80) Oranges (56) Cotton (55)
COTE DIVOIRE	4.196	6.78	Cocoa beans (4064) Coffee (65) Bananas (36) Cotton (12) Nuts (9) Oilseed others (7) Coconuts (2) Fruit fresh others (1)
FRANCE	3.516	5.68	Oilseed others (887) Wheat (422) Barley (407) Maize (374) Milk (363) Bovine (226) Grapes (189) Swine (189)
NETHERLANDS	2.916	4.71	Swine (1332) Milk (546) Bovine (316) Layer (217) Poultry (169) Livestock others (99) Oilseed others (92) Vegetables fresh others (24)
USA	2.758	4.45	Soybeans (1923) Nuts (277) Sunflower (153) Oilseed others (86) Rice (79) Cotton (76) Groundnuts (36) Tobacco (23)
INDONESIA	2.634	4.25	Oilseed others (1222) Coffee (771) Coconuts (258) Cotton (127) Cocoa beans (124) Spices others (58) Tea (31) Pepper,White/Long/Black (22)
GHANA	2.253	3.64	Cocoa beans (2235) Oilseed others (6) Coffee (4) Cotton (3) Nuts (2) Fruit fresh others (1) Groundnuts (1) Bananas (1)
INDIA	2.181	3.52	Cotton (988) Oilseed others (716) Coffee (212) Nuts (106) Rice (46) Tea (28) Spices others (22) Bovine (13)
TURKEY	1.874	3.03	Cotton (760) Nuts (704) Grapes (193) Tobacco (38) Apricots (32) Spices others (28) Pulses (24) Apples (19)
DENMARK	1.850	2.99	Swine (1287) Milk (198) Barley (180) Wheat (53) Bovine (44) Livestock others (22) Poultry (22) Oilseed others (20)
BELGIUM	1.842	2.97	Swine (1409) Milk (127) Bovine (106) Livestock others (54) Layer (33) Poultry (24) Vegetables fresh others (22) Wheat (12)
SPAIN	1.827	2.95	Nuts (378) Grapes (369) Swine (327) Bovine (92) Cotton (62) Oranges (56) Peaches and Nectarines (52) Oilseed others (49)
ITALY	1.737	2.80	Grapes (388) Oilseed others (320) Bovine (248) Rice (120) Swine (116) Milk (84) Apples (68) Peaches and Nectarines (66)
ARGENTINA	1.504	2.43	Soybeans (599) Sunflower (487) Bovine (165) Groundnuts (118) Cotton (28) Apples (13) Pears (13) Tea (12)
NIGERIA	1.430	2.31	Cocoa beans (1386) Oilseed others (33) Cotton (4) Nuts (2) Vegetables fresh others (2) Spices others (1) Coffee (1)
Rest	23,683	38.24	
Total	**61,930**	**100%**	

Table 3: External water footprint of the most important agricultural goods imported to Germany

Product	EWF (Mm³/yr)	Share	Locations
Coffee	9913	16%	Brazil (2654) Colombia (1032) Indonesia (771) Peru (551) Kenya (488) Viet Nam (486)

Cocoa beans	9748	16%	Cote Divoire (4064) Ghana (2235) Nigeria (1386) Cameroon (646) Ecuador (502) Indonesia (124)
Oilseed others	5849	9%	Indonesia (1222) France (887) India (716) Malaysia (450) Canada (355) Czech Rep (328)
Cotton	5464	9%	India (988) Turkey (760) Pakistan (365) Uzbekistan (356) Bangladesh (348) China (262)
Swine	5098	8%	Belgium (1409) Netherlands (1332) Denmark (1287) Spain (327) France (189) Germany (117)
Soybeans	4769	8%	Brazil (1927) USA (1923) Argentina (599) Paraguay (198) Uruguay (51) Canada (19)
Bovine	2611	4%	Netherlands (316) Brazil (310) Austria (257) Italy (248) France (226) Argentina (165)
Milk	2512	4%	Netherlands (546) France (363) Austria (199) Denmark (198) Germany (174) Ireland (158)
Nuts	2077	3%	Turkey (704) Spain (378) Usa,Pr,Usvi (277) Iran (219) India (106) Italy (60)
Sunflower	1806	3%	Argentina (487) Hungary (250) Ukraine (234) USA (153) France (150) Russian Fed (132)
Grapes	1484	2%	Italy (388) Spain (369) Turkey (193) France (189) Greece (58) South Africa (39)
Livestock others	1228	2%	Brazil (392) Togo (191) Hungary (113) Netherlands (99) Italy (56) Belgium (54)
Coconuts	1094	2%	Philippines (689) Indonesia (258) Papua N.Guin (82) Mozambique (13) Vanuatu (13) Malaysia (9)
Wheat	937	2%	France (422) Canada (70) Denmark (53) Czech Rep (44) Russian Fed (43) Hungary (41)
Barley	807	1%	France (407) Denmark (180) Untd Kingdom (62) Czech Rep (40) Germany (28) Sweden (26)
Poultry	751	1%	Netherlands (169) Brazil (122) France (106) Hungary (79) Poland (57) Togo (55)
Maize	559	1%	France (374) Hungary (86) Brazil (26) Austria (12) Italy (11) Belgium (10)
Rice	532	1%	Togo (151) Italy (120) USA (79) Spain (47) India (46) Pakistan (28)
Others	**4692**	**8%**	
Total	**61930**	**100%**	

3.2 Critical products

In this chapter cotton and rice are presented exemplary in more detail since they play an important role as traded goods and also need a great amount of water for their cultivation.

Cotton – the white gold

With the import of raw cotton and cotton products, Germany leaves a water footprint of 5.46 km³ annually, which already account for nine percent of its external agricultural water footprint. Among the countries where Germany leaves its greatest water footprint through the import of cotton are India, Turkey, Pakistan, Uzbekistan, Bangladesh and China (table 4).

Cotton belongs to the most water intensive cultivated plants. On average, globally about 11,000 litres of water are necessary to produce one kilogram of cotton material. Only 45 percent of this water amount is actually taken up by the plants. An extreme 41 percent are losses because of irrigation water evaporating from the irrigation channels or from the fields. On average, 1,540 litres are grey water – that means they are theoretically necessary to dilute the wastewater polluted by pesticides, fertilizer or chemicals used in cotton processing.

Worldwide, each year about 256 km³ of water are used for cotton cultivation that split up into 42 percent of blue water, 30 percent of green water and 19 percent grey water. About 44 percent of these 256 km³ are used for the production of cotton destined for export. The EU 25 cover its cotton needs mainly (84 percent) outside of Europe, especially in India. Cotton cultivation uses already 3.5 percent of the water used for crop production. China, USA, India, Pakistan and Uzbekistan together supply already 70 percent of worldwide cotton production [9].

Turkey is the seventh biggest cotton growing country in the world with a production volume of 960,000 tons each year. In the last years production could be increased due to intensification of cultivation. The areas under cotton cultivation are mostly in the Aegean and in the south and southwest of Turkey. The biggest problems caused by cotton cultivation are water pollution by excessive use of pesticides and insecticides. Water consumption is also very high since the fields are mostly supplied by flood irrigation. Cultivation during the summer months especially puts a severe strain on the water resources in the cultivation areas.

Pakistan has in the Indus basin alone almost three million hectares under cotton cultivation that consume 51.43 km³ water each year. The irrigation technique used in Pakistan is very inefficient so that already 90 to 97 percent of the water amount taken from the Indus is destined for agriculture. But only on third of this water amount really reaches the fields, the rest evaporates on the way or seep away because of maroden irrigation channels. For cotton cultivation in Pakistan, also great amounts of pesticides and fertiliser are used, that severely strain water quality. Now already 31 percent of the water destined for the irrigation of cotton fields is taken from groundwater resources [9].

Uzbekistan is a good example to show how the extreme the consequences of cotton cultivation can be. There, each year 14.6 km³ of water are used for cotton cultivation, especially blue water. As a consequence of the over-abstraction of the Amu-Darja and the Syr-Darja, the two tributaries to the Aral Sea, almost no water reached the sea any more. Consequently, the Aral Sea decreased in the last 40 years about 85 percent, connected with salinisation and other ecologically harmful processes. Uzbekistan uses about 3 km³ of water for the production of cotton destined for the EU 25 each year. That means these countries carry arithmetically a responsibility of 20 percent on the drying up of the Aral Sea [9].

Table 4: The most important import countries for cotton

Country	**India**	**Turkey**	**Pakistan**	**Uzbekistan**	**Banglades h**	**China**
EWF (Mm³/year)	988	760	365	356	348	262

Abb. 5

Figure 5: Global map of the German water footprint for cotton production

More than a handful of rice

The import of rice to Germany equals one percent of the external agricultural water footprint of Germany, but this still is an import of 532 million m³ of virtual water. A look at the producing countries shows that they have significantly less water available and therefore strain their natural and water household by the rice cultivation.

In the Indus basin, each year up to 70 million m3 of water are used in rice cultivation. Worldwide, more than one fifth of the water quantities used for the cultivation for crop products are used for rice production.

Almost half of the world's population depends on rice cultivation for their food security and/or as an important cash crop. Over 90 percent of the annual rice production are produced and also consumed within Asia. Traditional cultivation techniques need between 3,000 and 5,000 litres in order to gain one kilogram of rice. Worldwide, rice is cultivated on about 154 million hectares. The most important exporting countries are Thailand, Vietnam, China, USA, Pakistan and India.

On all cultivation areas in Europe, Australia and the USA, rice is produced with the traditional methods, meaning that the fields are flooded. Therefore, the water need for the cultivation of rice is worldwide up to five times higher than that for maize and wheat, which are also very water intensive crops. Globally, rice cultivation consumes 85 percent of the water quantity applied for irrigation. With a share of 63 percent of artificially irrigated rice fields worldwide, rice cultivation already provides 37 percent of all irrigated area worldwide [10].

Two third of the rice produced in Europe are cultivated in Italy. Within the EU, Italy is therefore the most important production country. The areas under rice cultivation are mostly in the Po basin, the plain with the most intensive agricultural use in the country and therefore with vast ecological problems ranging from drought events to intrusion of marine water. Italy's rice exports make about five percent of the rice quantity traded worldwide [11].

Table 5: Countries where Germany leaves the biggest water footprint due to rice imports

Country	**Togo**	**Italy**	**USA**	**Spain**	**India**	**Pakistan**
EWF (Mm³/year)	151	120	79	47	46	28

Abb. 6

Figure 6: Global map of the German water footprint for the production of rice

The use of pesticides in rice cultivation has, based on insufficient knowledge and missing controls, especially outside of Europe very negative consequences. Of all pesticides used worldwide, 13 percent alone are applied in the Asian rice production.

Bild

Rice cultivation in China, Province of Jünnern © WWF

3.3. Global ways of the (virtual) water

Germany leaves its water footprint in over 200 countries of this world (figure 7), which differs in intensity according to the product and the climatic and natural conditions, but also the technological standards implemented in agriculture, respectively. These values again can have different impacts on the natural water and land resources, as well as the local and national economy, depending on the location and situation.

In the following, some countries are presented exemplary where exports of virtual water have negative consequences for the regions affected by the production of the traded goods. In the selected countries, WWF is also actively engaged in the protection of the natural ecosystems and resources and where he supports initiatives for a more sustainable development.

Abb. 7

Figure 7: Germany's external agricultural water footprint

3.3.1 Brazil

With a country area of over 8.5 million square kilometres, Brazil already makes 47.3 percent of the Latin-American continent. Brazil is a very water-rich country: the more than 6,400 kilometres long Amazon River alone contains one fifth of the global freshwater resources. In all, Brazil has 12 to 14 percent of the freshwater quantities worldwide. But as paradox as it may sound, the country experiences a water crisis. Main reason is the uncontrolled water pollution, so that a large portion of the population cannot be supplied with clean drinking water. This leads to a great number of illnesses caused by polluted water. Reasons for this pollution are for one the fast population growth and also wastewater from agriculture and fishery. Approximately one third of the drinking water is as well lost due to ailing pipe systems, which leads to supply bottlenecks especially in the cities [12].

Brazil is on top of the countries where Germany leaves its water footprint for agricultural goods (table 2). Annually, we import 5.73 km³ in form of agricultural products from Brazil. The most important products are coffee (2.65 km³), soy (1.93 km³) and livestock (0.39 km³).

Soy production and meat consumption

In 2005, about 23 million hectares of soy were cultivated in Brazil, which is therefore the second most important soy producer after the USA. Half of the soy production is destined for export, whereas the EU is with 40 percent the most important buyer. Because of the growing meat consumption, the production of soy as fodder has doubled worldwide in the last 20 years. The growing demand almost exclusively is at the expense of South America.

Soy production plays an important role in the destruction of the Amazon Rainforest. Since land prices are higher for soy cultivation areas than that of extensive grazing land, cattle breeders are driven from their pastures. But this forces them to slash and burn up to then untouched rainforest areas and to convert them to pasture, which again will be taken over by soy farmers after some time. Each year, about 1.4 million hectares of the Amazon are destroyed for pasture by this vicious circle [13].

To get one kilogram of soy, globally about 1,800 litres of water are invested for cultivation on average. Based on the importance of soy as fodder, it clearly influences the high virtual water content of livestock products, like the 15,500 litres of water in one kilogram beef explained in chapter 1.

Bild
Intensive cultivation of soybeans in Brazil © WWF

Brazilian coffee
With a market share of almost 30 percent, Brazil is internationally the most important producer of coffee beans. Depending on the climatic conditions, up to 1.8 million tons are exported annually, and another 600,000 tons are produced for the national consumption, which makes Brazil the country with the third largest coffee consumption [14].

On average, about 22,500 litres of water are needed globally to produce one kilogram of coffee beans. That makes 140 litres of water for 125 millilitres of coffee.

3.3.2 India
India's economy is very much depending on agriculture, which again increasingly favours irrigation. Although large rivers like Ganges, Indus or Brahmaputra supply the country and India has vast aquifers, the country already experiences water scarcity [15]. The Indian farmers extract about 250 km³ of water each year for irrigation, but only 150 km³ are replaced by precipitation [16]. One of the main problems of the future will therefore be to find enough water resources for irrigation after supplying the population with drinking water [15] and also leave enough water for ecological needs. At the moment, agricultural yields and efficiency of irrigation in India are fare behind the technical possibilities [17]. But for the Indian government, it is very important that India will remain food self-sufficient [18]. In view of the great strain of the resources and the need for the growing population, it is questionable whether this will be possible in the future. In all, India imports only 1.6 percent of its annually needed water amounts (figure 8), mostly as agricultural products.

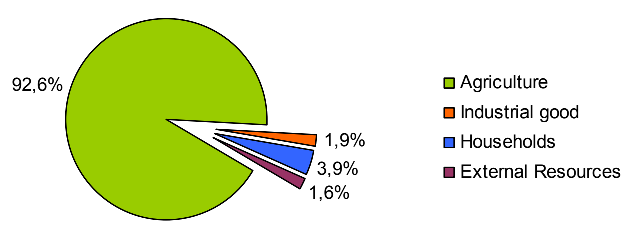

Figure 8: Share of water use in India [19]

Cotton as an important economic factor
Cotton is one of the most important economical products for India and is grown by almost four million farmers. Approximately 60 million Indians altogether depend on the cotton sector in one form. With about nine million hectares cultivation area (this is about one fourth of the area of Germany) India alone has 27 percent of the cotton cultivation areas in the world. At the same time, India also has the lowest yields worldwide. While in 2006 around 709

kilograms of cotton were produced on one hectare worldwide on average, it were only 400 kilograms in India [15]. Therefore, despite the largest areas under cotton cultivation, India only produces 14 percent of the cotton worldwide.

Up to now, nearly one third of India's cotton fields are irrigated. The irrigated areas are mostly in the northern part of the country in the catchment area of the Ganges. Cotton production in the central and southern regions on the other hand is mostly rain-fed [15]. There, cotton production stresses mostly the green water resources [9], whereas in northern India "blue" water from groundwater resources or rivers is used.

Bild

Wrongly planned irrigation channel in the Province Andhra Pradesh in India © WWF

Surface waters and aquifers are highly polluted by cotton production in India [9]. About 54 percent of pesticides are used in cotton production, although the cultivated areas only make up five percent of the arable land in India. The use of about one kilogram of pesticides per hectare and season stresses the water resources and also causes massive health problems for the farmers and the local population. The high chemical pollution also reduces the quality of the cotton, so that farmers sometimes have problems to sell it at the cotton mills [15].

WWF and the Better Cotton Initiative

To find practical possibilities to reduce the ecological impacts of cotton production worldwide and also minimize the use of water and pesticides, WWF co-funded the "Better Cotton Initiative" (BCI). In this initiative, non-governmental organisations work together with important companies like Adidas, IKEA, Gap and H&M in order to develop a standard after whose criteria cotton production can be implemented economically, ecologically and socially more sustainable.

WWF and IKEA therefore have for example started pilot projects in India, where it can be shown that with a change in cultivation techniques about three fourth of water and pesticides can be saved while at the same time the net profit of the farmers was up to 70 percent higher. One of these projects was started in 2006 in the province Andhra Pradesh with about 40 families. Now, it stretches over 18 villages with a total of about 600 cotton farmers.

In 2010, additional "Better Cotton" pilot projects will be started in India, but also in Pakistan, parts of Africa and Brazil. These projects should produce enough cotton after the "Better Cotton" standards to provide textile producers and buyers with larger amounts of sustainably produced cotton.

3.3.3 Kenya

Agriculture is in Kenya an important economic factor and the most important employee, which already provides 70 percent of the jobs and contributes already 16 percent to Kenya's GDP. With the export of agricultural goods Kenya gets 60 percent of its export earnings. The horticultural sector is especially important. Flowers make up more than half of the horticultural export products, followed by vegetables (35 percent) and fruits (12 percent). The EU is the most important buyer of these products. But altogether, only 10 percent of the total fruit and vegetable yields of Kenya are destined for export, mostly they are produced for the national market. Other important export products are tea and coffee [20] (table 6).

On country-level, irrigation plays up to now only a subordinate role. Only about 19 percent of the possible area is irrigated [21]. So the farmers are mainly depending on rainfall. Since climate change led to a great variability and unreliability in rainfall in the last years, the Kenyan government will increased support irrigation projects in the future to raise the productivity in agriculture and also make it independent of precipitation regimes. Irrigation also allows the cultivation of products with a higher profit margin, like for example French beans or snow peas [20]. If these plans were implemented, the already severe water situation will further aggravate.

Table 6: The most important products forming Germany's EWF in Kenya

Product	**WF (m^3/year)**
Coffee	488.440.449
Tea	4.609.881
Beans	2.122.940
Nuts	1.676.056
Flowers	1.447.985
Tobacco	1.295.634
Sunflowers	1.008.030
Cotton	194.446
Sugar (or Citrus fruits?)	104.685
Bovine	80.366
Bananas	79.569
Total	**502.133.072**

At the moment, the water need of Kenya is at 2.7 km^3 each year. But a doubling to 5.8 km^3 is expected until 2010. While in 1969, the Kenyan population had 1,853 m^3 of water at their availability every day, it was only 612 m^3 in 2004. Since Kenya has one of the highest population growth rates in the world, the available water amount therefore will still decrease in the coming years. It will likely fall to 235 m^3 per capita till 2025 [20]. According to WHO, only 61 percent of the Kenyan population hat access to save drinking water in 2004. But this was already an increase compared to 2000, where not even half of the population could be supplied with clean drinking water [21].

WWF for water protection in the Mara River catchment area

One of the biggest environmental problems in Kenya with the greatest impact on the available water resources is the degradation of the river catchment areas caused by land conversion and the growing population. At the beginning of this destructive chain are high deforestation rates that explain why only less than three percent of the 582,646 km^2 large country are still forest areas. This has serious consequences for the water household since precipitation has no storage capacity and has no chance to drain into the soil. Higher surface runoff means higher evaporation. This water amount is then missing in the aquifers and surface water bodies.

WWF addresses these core problems with his project work at the Mara River. Especially the headwater region of the Mara with its Mau rainforest is threatened by illegal logging. During the last 30 years, one quarter of this Mau forest was converted into agricultural area. This has dramatically changed the runoff as well as the water quality. The situation is worsened by large irrigated plantations in the Mara plains, where especially green beans are cultivated.

Thanks to the climatic conditions, two yields of green beans are possible each year; the first cultivation season is between March and June, the second between September and December

[21]. The cultivation area is between 500 and 700 hectares and produces beans destined only for export. For the production of one ton of Kenyan beans, altogether 4,614 m^3 of water are needed, thereof 3,320 m^3 blue water and 1,295 m^3 green water [23]. The first harvest is especially critical, since it begins during dry season or shortly before the beginning of the rainy season, when the water supply in the region is already low and critical. This is especially severe since the Mara is the only river in that region that still has water during dry season. This water not only has to supply the population in the Mara catchment area, but also two very important protected areas: the Serengeti National Park and the Masai Mara National Reserve. Moreover, this is the time of the greatest mammal migration in the world: more than one million wildebeest, 300,000 zebras and as much Thomson gazelles migrate to the northern part of the Serengeti National Park and the Masai Mara Reserve in order to survive the dry season there. This unique natural spectacle attracts numerous tourists each year, which are a further stress for the already short water resources of the region [22].

With the support of WWF, the foundation of a water users' organisation was formed that includes all communities, land users, tourism companies and organisations concerned. In the future, this organisation is supposed to regulate the management of the water resources. WWF also engages in reforestation and restoration of destructed forest areas as well as the protection of the remaining Mau forest. Another part of WWF's engagement are measures for the protection of springs, which are also the source of water supply for households and livestock of the local population.

Bild

Low water table in a tributary of the Mara River in the Mau Forest, Kenya © WWF, D. August

3.3.4 Spain

Spain is the most arid country in the EU [26]. Despite this unfavourable water situation, Spain cultivates a great part of the fruit and vegetable production for the European market. About 3.3 million hectares of the agricultural area of Spain are irrigated, which consumes around 24 km^3 of water each year. That's almost three quarters of the total water consumption of Spain. So the agricultural sector is by far the biggest water user. Although efficient and modern irrigation techniques like drip irrigation gain in importance, the water needs of agriculture still are clearly higher than the available water quantity. In the province of Andalusia alone each year a water deficit of 270 million m^3 occurs [25]. Countrywide, almost half (45.3 percent) of the agricultural area is still flood-irrigated. This wasteful use of water is favoured by extremely low, subsidised water prices which by far do not pass on the real costs to the farmers. But more severe is the number of illegal boreholes. According to information of the Spanish Environmental Ministry, there are about 500,000 illegal boreholes with an overall annual extraction of at least 3.6 km^3 of groundwater. The legal groundwater abstraction in comparison is 4.5 km^3. That means that at least 45 percent of the groundwater is illegally used. This water amount could supply 58 million people in Spain, but is instead used to irrigate about one sixth of the agricultural area as well as for the maintenance of numerous golf courts. Many water infrastructure projects like dams, channels or water transfer projects financed with public means help to mitigate the negative consequences of these illegal machinations. The Júcar-Vinalopó transfer with a budget of about 231.5 million Euros for example helps to refill an illegally overexploited aquifer. The Spanish water authorities have neither working instruments for water management nor a sufficiently strict law enforcement to effectively work against illegal actions.

The main reason for illegal water use lies in the huge profits that can be expected, especially in agriculture, tourism and urban development.
The illegal overexploitation of surface water bodies and aquifers does not only threaten the water supply of the population but has also severe consequences for nature. This is especially true for the south of Spain where most of the fruit and vegetable plantations can be found.

Andalusia under water stress
About 24 percent of the economy in the Andalusian region of Almeria is based on agriculture. This is extremely high compared to the national average of only 3.7 percent [28]. On an area of 50.000 hectares, 35.000 of it under plastic, each year about 2.7 million tons of fruits and vegetables are produced around Almeria. Almost half of this production is destined for export, especially within Europe, but also to Canada and the USA. About 400.000 tons alone get to the German market. Roughly half of the earnings are produced with intensive cultures like tomatoes and paprika [29]. The rising water need of the region leads to overexploitation of aquifers. This again leads to immense water deficits and the intrusion of saltwater into the aquifers [28]. Partly, four to five times more water is abstracted than can be replaced by rainfall.

Ecological consequences of strawberry production
Among the most important products of Andalusia are strawberries, which are mostly cultivated in the region Huelva. Here, more than 60 percent of the Spanish strawberries are cultivated on about 6,000 hectares. Huelva is the most important cultivation area for strawberries worldwide and produces almost one quarter of the European strawberries. Germany alone imported in 2008 about 57,600 tons of fresh and 5,500 tons of produced strawberries [30]. Of the cultivation costs of about 24,500 Euros per hectare strawberry plantation, only 3.42 percent are allotted to irrigation costs. Additionally to the low water prices, this is due to the high amount of illegally abstracted water. Official estimates talk about 1,000 illegal wells in the Huelva region. Each year, 20 million m³ of water are needed for strawberry cultivation alone. This is one third of the water resources available in the region.

Bild
Illegal water abstraction for strawberry production in a protected area in the province of Huelva © WWF, D. August

The negative impacts are especially severe in the National Park Coto de Doñana, a freshwater ecosystem of international importance that is also UNESCO World Heritage. Because of the high water abstraction from the aquifers as well as the surface water bodies, the water levels of the inflows in the Doñana area have fallen in the last years. The groundwater table also has fallen massively. The water amount of the Rocina River for example, one of the most important rivers supplying the Doñana, has halved within the last 30 years. As a consequence, lagoons, mires and other water-dependant ecosystems in the Doñana fall dry.

But not only a portion of the water is used illegally, the fields are also often used illegally for cultivation. More than 2,100 hectare of public or private forests were converted into strawberry plantations without permission, 450 hectares of them even in Natura 2000 Protected Areas. The fields and the construction of supply roads fragment the remaining areas and block natural corridors for migrating animal species, especially the endangered Iberian Lynx.

WWF's engagement for the protection of Doñana

Already since 1964, WWF is active for the protection of the Doñana. Thanks to its intense engagement, in 1969 at least a part of the wetlands was classified as National Park. In order to still be able to protect the Doñana against negative impacts of intensive agriculture in the future, WWF pursues different approaches. Against the background of the severe fragmentation of the areas, protection corridors were established for migrating animal species, and their establishment was pursued together with farmers and communities. In close cooperation with farmers in the region, water saving irrigation techniques and instruments are supported in the field. In another project, WWF has formed a cooperation with farmers and supermarkets. Since January 2008, WWF for example works together with the REWE Group. Goal of this cooperation is the exclusion of illegal water and land use and the implementation of more effective irrigation techniques at their strawberry suppliers in the Doñana region. Also, the cultivation on protected areas and established forest areas will be stopped. Based on this cooperation, also criteria for water and land use in fruit and vegetable production will be worked out who will be included in the Global GAP standard as obligatory criteria for the whole business sector.

3.3.5 Turkey

The agricultural sector is also a very important economic sector in Turkey. Of about 400,000 agricultural land, 59 percent are used for agriculture and 35 percent as pasture. Today, agriculture already uses more than half of the area, and will very possibly further increase in the coming years. About one tenth of the GDP is gained in agriculture. Almost three fourth of them by grain production, but fruit, vegetables and livestock are also important products. Another important product is cotton. Turkey was the sixth important cotton producer in 2007. On an area of 700,000 hectares, 2.3 million tons of cotton are produced annually, half of it alone in the region of Eastern Anatolia. For the cultivation, about 9,630 m³ of water per hectare are needed – that are 3,100 litres per kilogram of cotton.

Agriculture consumes already 71 percent of Turkey's water resources, mainly for irrigation. Here exists a huge saving potential, since irrigation is in 94 percent flood-irrigation, only on six percent of the area drip-irrigation or sprinklers are used [24].

Of roughly 4.9 million hectares of agricultural land suitable for irrigation in 2006, only 86 percent – that are 4.2 million hectares, could be irrigated because of a severe drought.

As a consequence of the high water need in agriculture, the groundwater resources are more and more overexploited. In all, Turkey has more than 14.000 km³ of groundwater available each year, but already 37 percent of this are already used by agriculture. Often, groundwater is extracted illegally. According to assumptions of the Turkish government, in 2008 there were 92,000 wells in the catchment area of the Konya River in Central Anatolia, one third (66,000) of them illegal. Additionally, precipitation clearly decreased in the last years, meaning that aquifers could not be refilled sufficiently. In 2007 alone, drought damages in agriculture amounted to 2.5 billion Euros [24].

The Turkish government sees dam building as the solution of these problems. Within the Southeast-Anatolia-Project (GAP) for example, a total of 22 large dams at Euphrat and Tigris are planned. The largest dam is the already working Atatürk dam that should secure irritation for 1.7 million hectares, among others for cotton cultivation. Since Turkey uses more cotton than it produces at the moment, the Turkish governments aims to increase cotton production significantly. Another 550 dams are said to follow in the coming years.

Beneath the overexploitation of water resources, the situation in Turkey is further worsened by a decreasing water quality. Municipal wastewaters reach the rivers and lakes untreated, and pesticide and fertilizer residues from agriculture further pollute the water resources.

The daily per capita water use in Turkey is at the moment at 111 litres, that are 40.5 m^3 a year. If the population will increase as expected up to 80 million in 2030, the annual water need could rise up to 1,100 m^3.

A part of the drinking water supply in Turkey is already privatized. Now the Turkish government plans also to sell rivers and lakes to private corporations. To make this possible, a change in the Constitution is necessary, since up to now private control of surface water bodies and coastal areas is limited and the public interest put in first place. The government hopes that these companies will invest in dam building projects and with that solve regional water problems. But small farmers and communities fear that they will loose their access to the water resources.

WWF in Turkey

With campaigns and pilot projects, WWF tries to build up an understanding for the necessity of a sustainable and controlled water management and also help formulate environmental-friendly water laws. In 2005, a WWF campaign on water use was reason for the Turkish government to support 18 pilot projects on the establishment of modern irrigation techniques and to teach 1,500 farmers in water saving methods [24]. WWF is also working to preserve the protection status of important ecosystems like the Gediz delta. Thanks to the work of WWF, in the last years two new Ramsar Sites in the Konya catchment area were established. In another 21 pilot projects in the Konya catchment area and at the Bafa Lake, farmers will be taught in the use of modern irrigation techniques, with which more than half of the water quantities usually needed for the cultivation of sugar cane, cotton and maize could be saved.

Bild

Illegal groundwater use for irrigation in the Konya area in Turkey © WWF

4. Environmental relevance of water resources protection

The calculation of the water footprint for the agricultural goods and the more precise contemplation of some agricultural products show that these results cannot be interpreted without a detailed analysis of additional factors. A respective valuation needs a climatic and geographic classification of the production area as well as information about the cultivation methods, the recent use by the population, the future water distribution and the connection to the respective water availability from groundwater and surface water resources.

Different climatic conditions define the water household and often seasonal differences in the water availability. Interventions in the natural household and changes due to intensive agricultural use could have critical impacts on quality and functionality of vegetation and biodiversity in the affected ecological and hydrological systems, as already can be seen in many regions.

Within the European Union, water legislation gives a good action and development framework. The implementation on the other hand shows in the countries most affected by water-climate restrictions like for example Greece the greatest deficits. On the international level, usually a binding legal basis, guidelines and indicators for the estimation and assessment of the water use are missing. In trade and business, especially in the more water-intensive sectors, often lack the will to implement a regular examination of the legal use of water and a water management in accordance with regulations. This tempts to overexploit the water resources leading to the turn over of the water balance.

Worldwide, around 80 percent of the agricultural areas are rain-fed, so that the yields are dependant on sufficient precipitation. Arid and semi-arid regions have at least in some phases of the year a negative water balance, when evaporation is higher than precipitation and thus soil moisture has the lowest values. This means a higher vulnerability of production, which is not restricted by temperature but by water availability. To ease this disadvantage, agricultural areas are more and more supplied with surface or groundwater by a variety of irrigation mechanisms. Around 18 percent of the global arable land is irrigated. This allows not only the cultivation and development in climatically relatively water-scarce regions, but also two to three times higher yields compared to rain-fed production.

Among the arid and semi-arid regions in the world most affected by this in the tropics and subtropics are for example the Mediterranean region, Australia and South America.

To further estimate the impacts of the external water footprint of Germany, the exporting countries with the highest water exports were further analysed. Negative consequences on the water resources were defined as “water stress” and the respective water stress indicator (WSI) was calculated (figure 9). By taking into account the environmental requirements of natural systems, water scarcity for human use was determined. Four groups of countries can be formed after this method in relation to the German water footprint. The definition of these groups is listed in table 7.

Table 7: Schematic of the impacts
Tabelle 7

Abb 9
Figure 9: Location of the agricultural water footprint of Germany and estimation of the water stress

The highest water stress occurs in group D because of high water abstraction per unit available and high volumes of the external water footprint (figure 9). In this group are for example Kenya, India, Spain and Turkey, but also China, Morocco, Pakistan, South Africa and Uzbekistan. But the consequences for the ecoregions and their biodiversity can not only be estimated based on the water quantity, but need further integration of ecological, hydrological, social and climatic information for ecological units, which rarely can be defined by national borders.

Stop negative impacts

For countries with high water abstraction for the production of agricultural goods, mostly groups C and D, there is a distinct spatial overlapping with the location of the 238 ecosystems WWF identified as most threatened because of their valuable biodiversity, called the Global 200.

But not only in those regions, intensive agriculture poses a threat for biodiversity and the natural resources that are already negatively impaired. Wetlands, floodplains and mires are still drained to be converted into agricultural areas or polluted by wastewaters. Despite changing water levels during the seasons, rivers are overexploited over the whole year by dam projects for irrigation schemes or water transfer projects in other regions and thereby destroyed as functional river catchment unit.

Due to the all year round cultivation under irrigation, huge amounts are constantly extracted from groundwater and surface waters that cannot even regenerate during rainy periods. The ratio between groundwater renewal and groundwater abstraction therefore has to be regarded very critically. Especially in regions where more than 50 percent of the newly generated resources are abstracted, the risk of water scarcity, droughts and water stress rises. This is at the moment the case in southern and northern Africa, Asia, parts of Europe and also in some regions of China, India, Pakistan and the USA, where more than 20 to 50 percent of the available water resources are used.

There is still unawareness regarding the long-term consequences of these management methods in different parts of the world, especially in developing countries. Also the understanding of changes in variability and how they influence water bodies is still insufficient. This is also true for the connection between deforestation and erosion processes on water quality and water availability. But it is already clear that many regions affected by climate change urgently have to implement measures to adapt to these changes, even if they have a good water management. A balanced water household is the basic prerequisite for this.

This trend of growing overexploitation of natural resources has to be stopped to avert the loss of ecosystems, species and livelihood, but also to allow a sustainable agricultural development. A look at the global map and the calculations of the regional distribution of the external water footprint of Germany shows that the biggest water footprint is left in Western Europe and North Africa, meaning the Mediterranean Region, followed by South America and Southeast Asia (table 8, figure 10). An in-depth interpretation of the consequences caused by the cultivation of certain agricultural products for the German market in the respective countries is only possible with restrictions, for once because of the scale, but also because of the missing context to distinct regions and river catchment areas (see also chapter 2). Nevertheless, these results still allow numerous starting points for the development and implementation of new guidelines and standards.

Table 8: External water footprint sorted by regions

Region	Sum EWF (km³/year)
Southern Africa	486
Oceania	1,082
FSU	1,343
Central America	2,076
Middle East	2,331
Central Africa	2,342
Central and South Asia	3,218
North America	3,265
Eastern Europe	3,461
South East Asia	4,935
North Africa	9,523
South America	10,167
Western Europe	16,086
Grand Total	**60,315**

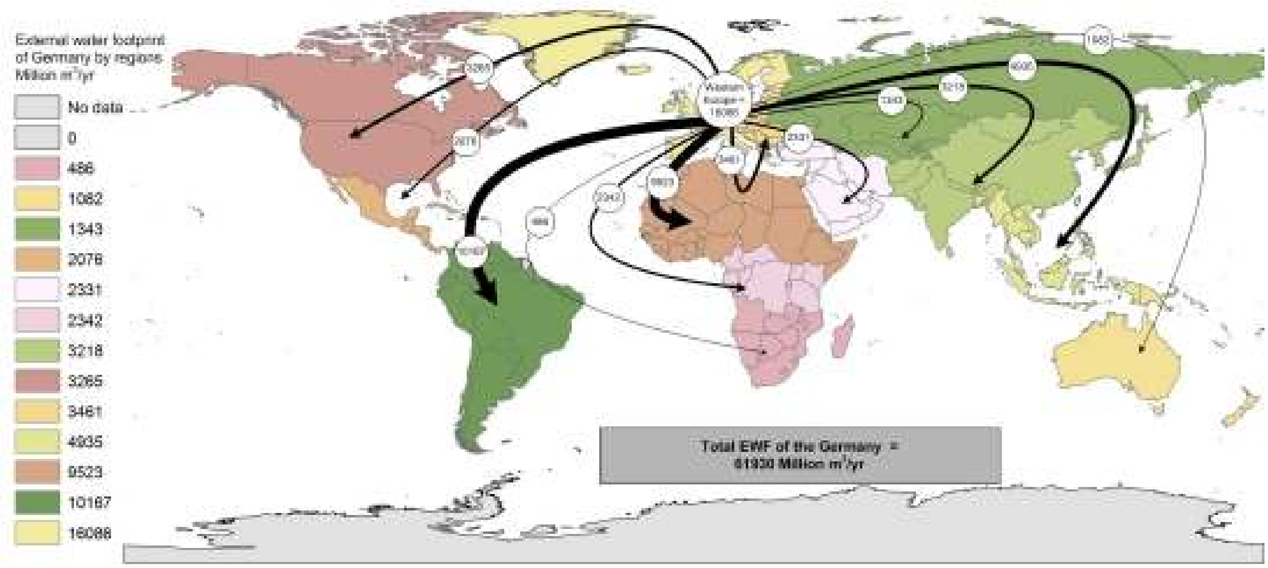

Figure 10: External water footprint of Germany after regions

5. Solutions and Recommendations

There are as yet only few countries that conducted such a detailed analysis based on the same in-depth methods and databases like this study. Already published is only a report in the UK, and studies for Belgium, Switzerland and Sweden will be published within 2009. But preliminary results from WWF Sweden are already available and could be used for comparison with the German results. Although the German external water footprint only makes up about half of the total water footprint while the British EWF is at 62 percent [32], it is with 79.5 km^3 in absolute terms roughly 25 percent higher than the British EWF.

The Swedish external water footprint is with 51 percent of the total WF comparable to the German one, but in absolute terms only 9.7 km^3 and therefore only a fraction of the German one [28]. Thus Germany has a special global responsibility which we have to live up to.

This is currently first and foremost the responsibility of governments and companies and only then that of consumers since up to now only little courses of action to reduce the personal water footprint by purposeful consumption.

5.1 Recommendations for governments

The recommendations for governmental institutions can be divided into three groups: a) the German government, b) the European Union and c) the governments of the production countries of our goods.

We are calling the **German Federal Government** to:

- Show a considerably higher engagement and higher investments within the frame of bilateral and multilateral development cooperation to establish the necessary basis for a sustainable management of water resources, especially of river catchment areas, but also from aquifers in such regions where water is getting scarcer and is at present also badly managed, as well as in countries where Germany does import its products from;
- Support applied research dealing with the water footprint of Germany, the EU and on a global scale and from which future trends, concrete recommendations and necessary implementation steps can be deduced, especially in relation to the food supply of a growing world population and the need for bio-energy. Based on these research results, strategies have to be developed in cooperation with companies on how we can counteract a global water crisis. Especially the methodology to analyse the water footprint of industrial products must be further developed to get the basis for a standardisation in this sector and to enable the survey of products with a uniform and accepted evaluation method;
- Use the Mediterranean Union considerably more intense as platform to broach the issue of the water footprint of Western European countries in southern Europe and also to jointly develop, finance and implement concrete measures for the Mediterranean countries and Northern Africa;
- Keener engage in the EU for a consequent implementation of the European Water Framework Directive, especially in the Mediterranean and also to demand this in the neighbouring countries in Europe as well as in the candidate and potential candidate countries like Turkey, and to support with Twinning projects or technological advice.

The **European Commission and the member states of the EU** should:

- At the European level insist on the consequent implementation of the Water Framework Directive for rivers and aquifers, especially in the Mediterranean countries

Spain, Italy and Greece, but also in the candidate country Turkey and other riparian states, and to impose severe retributions for member states for non-compliance;
- Actively provide the experiences from the implementation of the Water Framework Directive as a concrete example for a sustainable water management in other regions of the world;
- Pay subsidies only in cases of verifiably sustainable use of water resources, meaning to consequently couple subsidy payments on the compliance of environmental standards (cross-compliance);
- Immediately stop the high subsidies for irrigated cotton production in Greece, Spain and Portugal, since they are not only extremely water-intensive, but ruin small-scale farmers in West Africa by indirect price dumping;
- Support the development of water efficiency standards in cooperation with companies on an international level and carefully consider to which extend at least the legality of water supply in the non-European agriculture could be established as a minimum standard for the import of products into the EU. This is comparable to the compliance of minimum standards regarding the import of biofuels into the EU from 2010 on.

The **governments in the emerging and developing countries** we obtain our water imports from should:
- Legally establish and consequently implement a water policy that demands a sustainable management of water resources and a quantity allotment of water corresponding to the products under compliance of ecological discharges for groundwater and surface water bodies, but also to punish in the case of inadequate compliance;
- Assess if it would not be more sensible in the frame of their national development strategies for agricultural or industrial products to import products with a high virtual water content instead of produce those themselves or even to export them. Some countries like Morocco, Jordan, Israel and Egypt (all virtual water importers) already included the virtual water trade in their water policies and developed strategies to reduce the export of water intensive products, especially crops. But the inclusion of virtual water into policies requires the knowledge about consequences and interactions of virtual water trade with the local social, economical, ecological and cultural conditions [34].

5.2 Recommendations for companies

Companies should:
- Measure, document and better understand the water footprint of their products along the whole supply chain and the risks connected to this;
- Reduce the impacts especially in already or future water scarce regions by concrete specifications and cooperation with suppliers of the products or raw materials;
- Engage together with other companies on the political level in the respective water catchment areas and countries for a more efficient and more sustainable management of the water resources that also secures the access of the population as well as ecological discharge;
- Engage actively for the development, application and broad implementation of water standards and needed methodologies for products that allow the consumers to choose between products with a high or low footprint in critically water scarce regions.

Comparable initiatives for standard development already exist, like the Alliance for Water Stewardship or the CEO Water Mandate. But up to now, only few German companies actively engage in the processes. Global GAP, the standard for the certification of fruits and vegetables worldwide, is recently under revision. This is the chance to possibly include criteria for water, especially relating to the legality of water use for irrigation systems. Also the development, promotion and spreading of standards for a better cultivation of cotton, sugar cane or rice make important contributions for future water standards, and further engagement by German companies would be desirable.

Bild

WWF cooperation with communities for the promotion of water users associations in the Mara River catchment area, Kenia © WWF, K. Gichangi

5.3 Recommendations for Consumers

Consumers also have possibilities, although at the moment fewer than governments and companies, to reduce the virtual water use respectively to keep the consequences of their (water) consume on the environment as low as possible.

Consumers can:

- Primarily buy regional and seasonal vegetables and fruits, since especially the products imported from the Mediterranean, Northern Africa, Israel and Turkey do rarely meet the demands on an efficient irrigation or could guarantee a careful use of scarce water resources;
- Reduce their meat consumption. This is also the suggestion of Anthony Allen, the British "inventor" of the virtual water concept [35];
- Ask companies if they made an analysis of the water footprint of the goods produced or sold by them and if they adopted measures to reduce their impact;
- Call upon the Federal Government and the Parliament (for example via their respective member of the Bundestag) to work towards a more sustainable water management, especially on the European level, but also in the development cooperation.

But since no accepted and established standards on the water footprint of products and their consequences exist at the moment, it will still be difficult for consumers in the near future to work purposefully towards a reduction of the negative consequences of their consumed products additionally to the reduction of their virtual water use. Only when standards exist, companies inform direct and extensively about their water footprint and when these topics are displayed publicly and transparently, consumers are able to make informed decisions in the choice of products and consumer buying habits

5.4. Outlook

The water use and the demands we have on aquifers and river systems will dramatically increase in the near future. Fundamental factors are the growing world population and the securing of their nourishment as well as economic growth and a connected change in consumer buying habits. . In China, for example, more and more virtual water was invested for the nourishment of the population in the last 50 years, because with increasing wealth meat consumption also rose in the country [36]. All the more urgent governments, companies and consumers must face the responsibility today and must invest in a better and sustainable water management for the sake of the local population as well as water-dependant ecosystems and their future services, which are also valuable and important for the people.

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