UNESCO-IHE
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The water needed to have the Dutch drink tea

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Appendices

Summary

The objective of this study is to calculate the volumes of water required to drink tea in the Netherlands. The underlying aim is to contribute to the production of figures that can be used for raising awareness on the effects of our consumption pattern on the use of natural resources.

We have specifically looked at the sources of the Dutch tea, because the water requirements per kilogram of tea differ in the various tea-producing countries. The 'virtual water content' of tea has been defined as the total volume of water required for producing the tea. For calculating the crop water requirements of the tea plant we have used data and models of the Food and Agriculture Organization. Data on international tea trade have been taken from the United Nations Statistics Division.

We found that for drinking one standard cup of tea in the Netherlands we need about 34 litres of water. If we assume that a standard cup of tea is 250 ml, producing this cup of tea requires 136 equal-sized cups of water. Most tea is produced in rain-fed areas; only a minor fraction of the world tea production comes from areas with supplementary irrigation (a practice sometimes applied at lower altitudes). The water needs for post-harvest processing can be neglected if compared to the water needs for growing the tea plant. The virtual water content of tea thus mainly consists of rainwater. The figures calculated for the Dutch situation are quite representative as a global average.

Total tea consumption in the Netherlands requires a total of 90 million cubic metres of water per year, which is equal to 1.2% of the annual Meuse flow. The Dutch people account for 0.3% of the world tea consumption. All together, the world population requires about 30 billion cubic metres of water per year in order to be able to drink tea. This is equivalent to 4 times the annual Meuse runoff.

The water needed to drink tea in the Netherlands is actually not Dutch water, because the tea is produced in Indonesia, China, Sri Lanka, Argentina, India and a number of other far-off countries. By far the most important sources of the Dutch tea are Indonesia, China and Sri Lanka (the latter is in the tea world still known as Ceylon).

Although tea needs a lot of water, coffee needs even more. Drinking tea instead of coffee would save a lot of water. For a standard cup of coffee of 125 ml we require 140 litre of water. This means that (per unit of volume) coffee requires about eight times more water than tea.

1. Introduction

1.1. The 'virtual water' content of tea: How much water is needed to produce tea?

Tea is the dried leaf of the tea plant. The two main varieties of the tea plant are *Camellia Sinensis* and *Camellia Assamica*. Indigenous to both China and India, the plant is now grown in many countries around the world. Tea was first consumed as a beverage in China sometime between 2700 BC and 220 AD (L'Amyx, 2003). The now traditional styles of green, black and oolong teas first made an appearance in the Ming Dynasty in China (1368-1644 AD). Tea began to travel as a trade item as early as the fifth century with some sources indicating Turkish traders bartering for tea on the Mongolian and Tibetan borders. Tea made its way to Japan late in the sixth century, along with another famous Chinese export product - Buddhism. By the end of the seventh century, Buddhist monks were planting tea in Japan. Tea first arrived in the west via overland trade into Russia. Certainly Arab traders had dealt in tea prior to this time, but no Europeans had a hand in tea as a trade item until the Dutch began an active and lucrative trade early in the seventeenth century. Dutch and Portuguese traders were the first to introduce Chinese tea to Europe. The Portuguese shipped it from the Chinese coastal port of Macao; the Dutch brought it to Europe via Indonesia (Twinings, 2003a). From Holland, tea spread relatively quickly throughout Europe (L'Amyx, 2003). Although drunk in varying amounts and different forms, tea is the most consumed beverage in the world next to water (Sciona, 2003). Tea is grown in over 45 countries around the world, typically between the Tropics of Cancer and Capricorn (FAO, 2003c).

Growing environmental awareness has made people more and more often ask the question: what are the hidden natural resources in a product? Which and how many natural resources were needed in order to enable us to consume a certain product? This type of questions has been a driving force behind this study. Here, we have looked into the total volume of water needed to drink one cup of tea. This report has been preceded by a similar study into the water needs for drinking coffee (Chapagain and Hoekstra, 2003b).

The volume of water consumed during the production process of tea is the 'virtual water' content of tea. The idea of starting a discussion about the virtual water volumes 'hidden' in products comes from Allan, who was intrigued by the fact that still water-scarce countries export water-intensive products (Allan, 1993; 1994). In general terms, the virtual water content of a commodity or service is defined as the volume of water required to produce this commodity or service (Allan, 1998, 1999; Hoekstra, 1998). When tea is traded from one place to another there is a significant transfer of water in its virtual form. In this way water is flowing in its virtual form from the tea producing countries to the tea consuming countries. Import of virtual water into the consuming countries means that these countries indirectly employ the water in the producing countries.

1.2. Objectives of the study

Due to the fact that the production of tea for many people in the world – certainly for the Dutch people – is in a country far off, most people have little idea of the resources needed to enable them to consume. This study is

meant to assess the volume of water needed to have the Dutch drink tea, in order to have concrete figures for creating awareness. More specifically, the study has three objectives:

1. To estimate the virtual water content of tea imported into the Netherlands, distinguishing between the different sources of the tea.
2. To quantify the volumes of virtual water trade inflows into and outflows from the Netherlands in the period 1995-99 insofar as they are related to tea trade.
3. To assess the volume of water needed to drink one cup of tea in the Netherlands.

The study is limited to tea made from the real tea plant, of which the two main varieties are *Camellia Sinensis* and *Camellia Assamica*. This excludes other sorts of 'tea', made from other plants, such as 'rooibos tea' (from a reddish plant grown in South Africa), 'honeybush tea' (related to rooibos tea and also grown in South Africa), 'yerba mate' (from a shrub grown in some Latin American countries), and 'herbal tea' (a catch-all term for drinks made from leaves or flowers from various plants infused in hot water).

2. Method

2.1. Stages in tea production

After plantation it takes a few years before the tea plants give yield. A tea bush may happily produce good tea for 50 to 70 years, but after 50 years the yields will reduce. At this time the older bushes will be considered for replacement by younger plants grown on nursery.

Tea is like wine. The flavour of wine comes from the local conditions of the area where the grapes are grown. It is the same for tea. The soil, altitude, and the prevailing weather conditions affect the flavour of the tea that is produced. The region where it is grown is therefore of great importance to the tea. Also the process after harvesting is determining the quality of the end product. As with the grapes, from which one can make red, white or rose wine, fresh tealeaves can be processed into different products. One can make black tea (like red wine, fuller and stronger flavours), green tea (like white wine, lighter and more delicate flavours), or oolong or red tea (like rose wine) (Twinings, 2003b). There is another, less popular variety of tea known as 'white tea'. It is produced only in China, primarily in Fujian province. White tea is made entirely from leaf buds that are covered with whitish hairs. The new buds are plucked before they open in early spring, then steamed and dried. Unlike other tea processing methods, the leaf buds are not rolled or oxidized. The result of this processing is a tea with a delicate, fresh flavour and natural sweetness (The Fragrant Leaf, 2003b).

The share to the global tea production is: black tea 78%, green tea 20% and oolong tea 2% (Sciona, 2003). The major tea-producing countries in the world are: India, China, Sri Lanka, Kenya, Indonesia, and Turkey (FAO, 2003c). The annual production of tea per country during the period 1995-99 is presented in Appendix I.

Before the leaves of the tea plant result in a cup of tea, there are a number of steps. First, the tealeaves are harvested. The leaves are plucked as the new tea shoots (or 'flush') emerge. In hotter climates, the plants have several flushes and can be picked year-round. In cooler conditions at higher elevations, there is a distinct harvesting season. Leaves from the earlier flushes, usually in the spring, give the finest quality teas (The Fragrant Leaf, 2003b). Most harvesting is still done by hand which is very labour-intensive (see Figure 2.1).

The first step after harvesting is withering the tea leaves, aimed at reducing the moisture content in the tealeaves by up to 70 per cent, which varies from region to region. The leaves are simply spread out in the open (preferably in the shade) until they wither and become limp. Alternatively, the leaves are brought to a tea factory, where the plucked leaves are spread on vast trays or racks, normally placed at the top of the factory, and are left to *wither* in warm air. The moisture in the leaves evaporates in the warm air leaving the leaves flaccid. This process can take between 10 to 16 hours, depending on the wetness of the leaves.

The withered leaves can be further processed along either the *orthodox method* or the so-called *CTC-method*. Depending on the precise process steps applied, the orthodox method results in either black, green or oolong tea. The CTC-method is particularly designed to produce black tea for packing into teabags.

Figure 2.1. Tea harvesting in Indonesia (photo: Hoekstra).

After *withering*, the basic steps in the orthodox production of black tea are *rolling, oxidation*, and *firing* (Figure 2.2). Rolling is rarely done by hand anymore; it is more often done by machine. Rolling helps mix together a variety of chemicals found naturally within the leaves, enhancing oxidation. After rolling, the clumped leaves are broken up and set to oxidize. Oxidation, which starts during rolling, is allowed to proceed for an amount of time that depends on the variety of leaf. Longer oxidation usually produces a less flavourful but more pungent tea. Many texts refer to the oxidation process by the misleading term 'fermentation'. Oxidation of tealeaves is a purely chemical process and has nothing to do with the yeast-based fermentation that produces bread or beer. Finally, the leaves are heated, or 'fired', to end the oxidation process and dehydrate them so that they can be stored. Oolong tea is produced just like black tea, except that the leaves are oxidized during a shorter period. It is gently rolled after picking allowing the essential oils to react with the air and slowly oxidize. This process turns the leaf darker with time and produces distinctive fragrances. When the leaf has reached the desired oxidation the leaf is heated, in a process called 'panning', to stop the process. It is then rolled to form the tea into its final shape. The resulting tea can be anywhere between green and black, depending on the processing method. Green tea is not oxidized at all. Some varieties are not even withered, but are simply harvested, fired, and shipped out.

The *CTC-method* is used primarily for lower-quality leaves. This method was invented during the Second World War to increase the weight of tea that can be packed in a sack or chest. The CTC-method replaces the step of rolling in the orthodox method by a mechanical process in which the leaves are passed through a series of

cylindrical rollers with small sharp 'teeth' that cut, tear and curl (CTC). The CTC machines rapidly compress withered tealeaves, forcing out most of their sap; they then tear the leaves and curl them tightly into balls that look something like instant tea crystals. The leaves are then oxidised and fired as in the orthodox method.

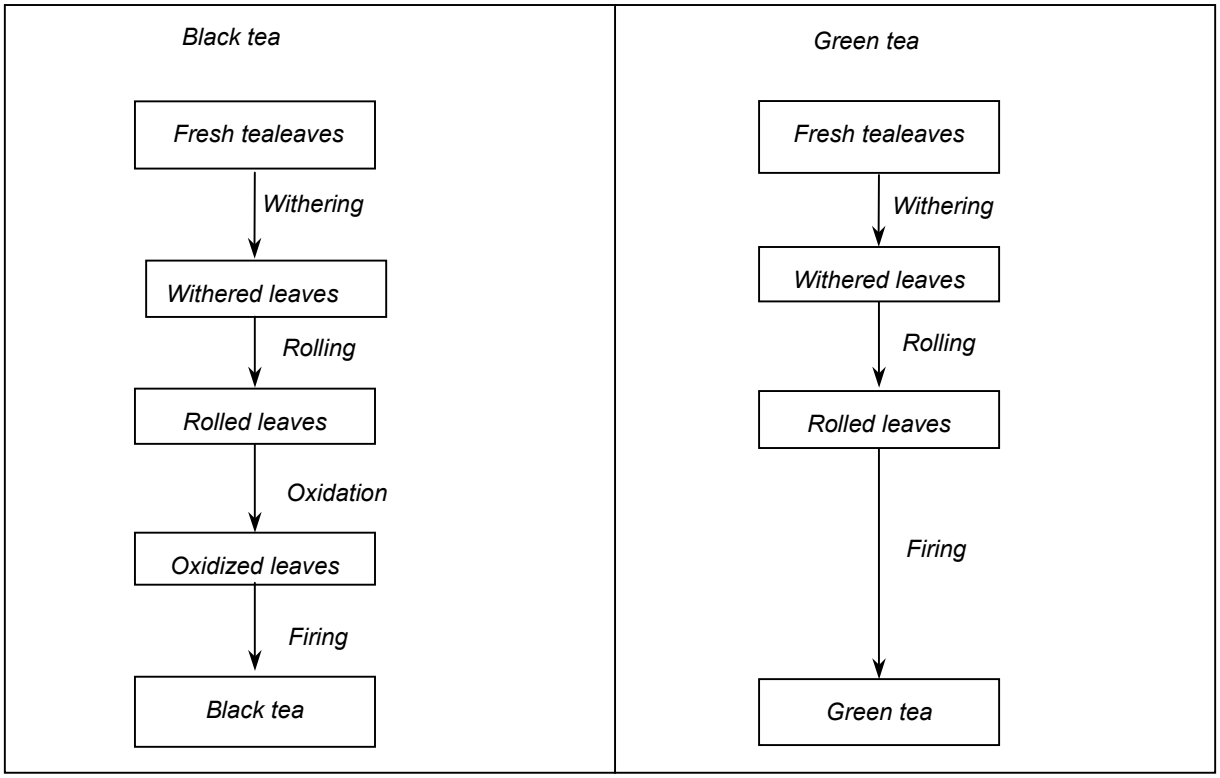

Figure 2.2. Post-harvesting steps within the orthodox method. Green tea production differs from black tea production by the fact that the step of oxidation is left out. If the oxidization step is limited, one gets semi-oxidized tea, known as oolong tea.

2.2. Calculating the water required in the different production stages of tea

The virtual water content of tea is the volume of water required to produce one unit of tea, generally expressed as cubic metre of water per ton of tea. This is different at the different stages of tea processing. First, the virtual water content of fresh leaves is calculated based on the crop water requirement of the tea plant (in m^3/ha) and the yield of fresh leaves (in ton/ha). After each processing step, the weight of the remaining product is smaller than the original weight. Following the methodology proposed by Chapagain and Hoekstra (2003a) we define the 'product fraction' (*pf*) in a certain processing step as the ratio of the weight of the resulting product to the weight of the original product. The virtual water content of the resulting product (expressed in m^3/ton) is larger than the virtual water content of the original product. It can be found by dividing the virtual water content of the original product by the product fraction.

Figure 2.3 shows how the virtual water content of tea is calculated in its subsequent production stages in the case of the orthodox production of black tea. To illustrate the calculation process, Table 2.2 shows an example for India. Appendix II includes the calculations for all tea producing countries that export tea to the Netherlands.

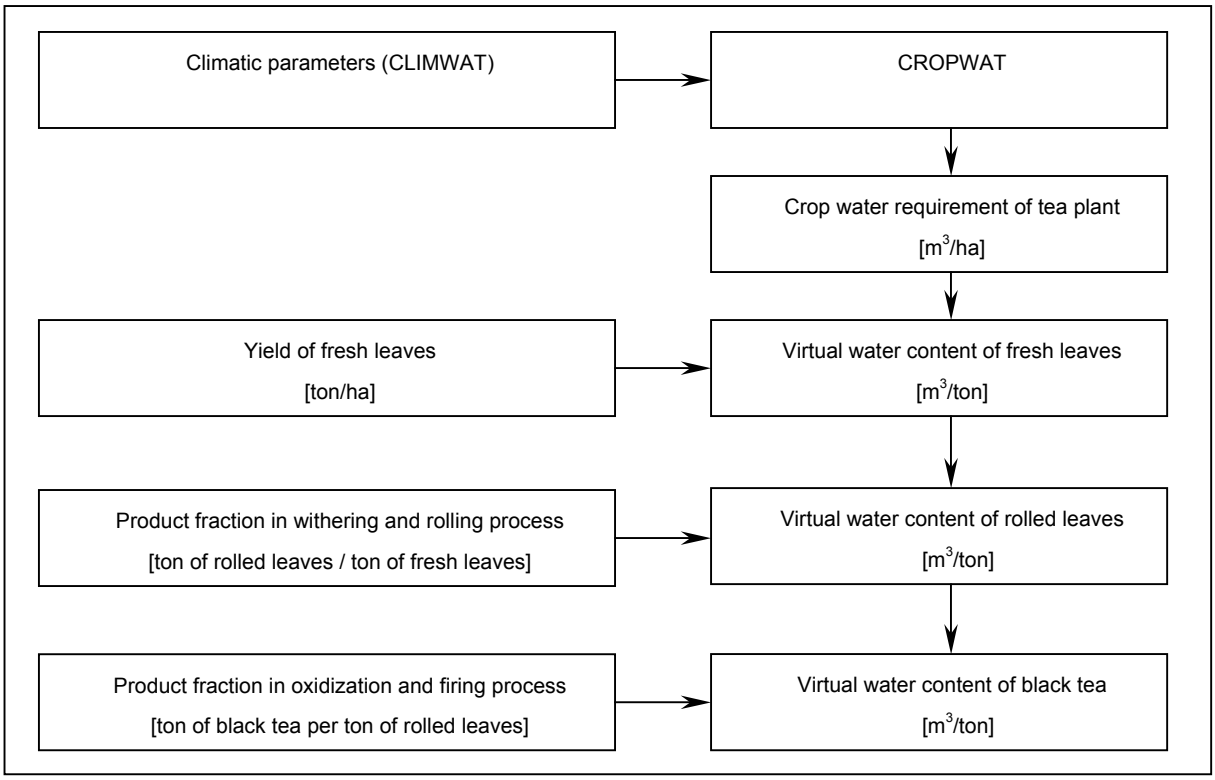

Figure 2.3. Steps in the calculation of the virtual water content of black tea produced along the orthodox method.

Table 2.1. Calculation of the virtual water content of black tea produced in India along the orthodox method.

	Variable	Value	Unit	Source
A	Crop water requirement	917	mm	FAO (2003a)
B	Yield of fresh leaves	7.10	ton/ha	Calculated from yield of made tea given by FAO (2003c) B= C/(E×G)
C	Yield of made tea	1.84	ton/ha	FAO (2003c)
D	**Virtual water content of fresh leaves**	**1290**	m^3/ton	D=10×A/B
E	Remaining fraction after withering and rolling	0.36	ton/ton	Twinings (2003c) and Harvest Fields (2003)
F	Virtual water content of withered and rolled leaves	3584	m^3/ton	F= D/E
G	Remaining fraction after oxidization and firing	0.72	ton/ton	Twinings (2003c)
H	**Virtual water content of black tea**	**4978**	m^3/ton	H = F/G

2.3. Calculating import and export of virtual water into and from the Netherlands as a result of tea trade

The volume of virtual water imported into the Netherlands (in m^3/yr) as a result of tea import can be found by multiplying the amount of tea imported (in ton/yr) by the virtual water content of the tea (in m^3/ton), which depends upon the origin of the tea. The origin of the tea is important because water consumed in growing tea plants and yield of leaves are different in different countries.

The volume of virtual water exported from the Netherlands is calculated by multiplying the export quantity by the average virtual water content of tea in the Netherlands. The latter is taken as the average virtual water content of the tea imported into the Netherlands.

The difference between the total virtual water import and the total virtual water export is the net virtual water import to the Netherlands, an indicator of the total amount of water needed to have the Dutch drink tea.

3. Data sources

3.1. Climate data and crop parameters

The annual crop water requirement of a tea plant is calculated per country using the CROPWAT model developed by the Food and Agriculture Organization (FAO, 2003a). The crop coefficients for tea have been taken from Allen *et al.* (1998, Table 12). The climate data required as input into the CROPWAT model have been taken from the CLIMWAT database (FAO, 2003b). In the cases where this database contains data for a number of climate stations within a country, we have taken the data from the station in the capital. We admit that this is a crude assumption, because the climate near the capital is not necessarily representative for the climate in the areas in the country where tea is grown, but global data on exact locations of tea plantations are not easily obtainable.

3.2. Tea yields

Country-specific data on tea production per unit of land (ton/ha) have been obtained from the FAOSTAT database (FAO, 2003c). The figures provided in the database refer to yields in terms of 'made tea', that is processed tea ready for use, e.g. black tea, green tea or oolong tea. Yields in terms of fresh leaves have been calculated based on the ratio of made tea weight to fresh leaves weight (using the production factors as explained in Section 2.2).

3.3. Tea trade

Data on tea trade have been taken from the Personal Computer Trade Analysis System (PC-TAS), a cd-rom produced by the United Nations Statistics Division (UNSD) in New York in collaboration with the International Trade Centre (ITC) in Geneva. These data are based on the Commodity Trade Statistics Data Base (COMTRADE) of the UNSD. Individual countries supply the UNSD with their annual international trade statistics, detailed by commodity and partner country. We have used the data available for the period 1995-99. The UNSD uses the wrong terminology of 'fermented' and 'not fermented' tea. As has been explained in Section 2.1 one should actually speak about oxidised (black) and non-oxidised (green) tea respectively.

The total volume of tea imported into the Netherlands and the total volume of tea exported are presented in Table 3.1. The trade position of the Netherlands is clearly shown by the fact that more than half of the tea import is exported again. Appendix III includes a list of all countries exporting tea to the Netherlands. Please note that some of the countries exporting tea to the Netherlands do not grow tea themselves. These countries import the tea from elsewhere in order to further trade it. Appendix IV includes a list of all countries that import tea from the Netherlands.

Table 3.1. Tea import into and export from the Netherlands by product type during the period 1995-99.

Product code in PC-TAS	Product	Import (ton/yr)	Export (ton/yr)
090210	Green tea (not fermented) in packages not exceeding 3 kg	225	51
090220	Green tea (not fermented) in packages exceeding 3 kg	936	17
090230	Black tea (fermented) & partly fermented tea in packages not exceeding 3 kg	2580	1346
090240	Black tea (fermented) & partly fermented tea in packages exceeding 3 kg	13485	7977
090300	Mate	18	15
Total		17244	9406

3.4. Production factors

According to Harvest Fields (2003), 10 kg of green shoots (containing 75-80% water) produce about 2.5 kg of dried tea. The overall remaining fraction after processing fresh tealeaves into made tea is thus 0.25. The weight reduction occurs in two steps. Withering reduces moisture content up to 70% and drying further reduces it down to about 3% (Twinings, 2003c). There is no reduction of weight in the rolling and oxidation processes. Due to the higher firing temperatures, oolong teas contain less moisture and have a longer shelf life than green teas (The Fragrant Leaf, 2003b). In our calculations we have taken a remaining fraction after withering of 0.72 (ton of withered tea per ton of fresh leaves) and a remaining fraction after firing of 0.36 (ton of black tea per ton of rolled leaves). The different methods of processing fresh tealeaves into black, green or oolong tea are more or less equal if it comes to the remaining fraction after all (ton of made tea per ton of fresh tealeaves). For that reason, we have not distinguished between different production methods when calculating the virtual water content of tea in the different tea-producing countries (Chapter 4). We have just made the calculations for black tea and taken them as representative for green tea and oolong tea as well.

4. Virtual water content of tea per producing country

The global average virtual water content of fresh tealeaves is 2.7 m^3/kg. The average virtual water content of made tea is 10.4 m^3/kg. The latter figure has been based on a calculation for black tea, but there would be hardly any difference for green tea or oolong tea, because the overall weight reduction in the case of green tea or oolong tea is similar to the weight reduction when producing black tea (see Section 3.4). Besides, it is good to note here that black tea takes the largest share in the global production of tea (78%). The calculations of the virtual water content of tea per tea-producing country are given in Appendix II. The results are summarised in Table 4.1. The appendix and table only show the tea-producing countries that export tea to the Netherlands. These countries together are responsible for 81 per cent of the global tea production. The data on yields and production are averages for the period 1995-99 and have been taken from Appendix I.

Table 4.1. Virtual water content of tea per tea-producing country.

Countries	Virtual water content of fresh leaves	Virtual water content of withered and rolled leaves	Virtual water content of made tea	Production	Weight
	m^3/ton	m^3/ton	m^3/ton	ton/yr	
India	1290	3584	4978	794180	0.349
China	4304	11955	16604	649489	0.286
Sri Lanka	3174	8817	12247	269013	0.118
Indonesia	3213	8924	12395	160334	0.070
Turkey	1828	5078	7053	146756	0.065
Japan	1802	5004	6950	87140	0.038
Argentina	2387	6630	9208	53124	0.023
Bangladesh	3383	9397	13052	51912	0.023
Tanzania	3467	9632	13377	24140	0.011
Uganda	4046	11239	15610	20365	0.009
South Africa	2842	7894	10965	10866	0.005
Brazil	2180	6055	8410	6753	0.003
Mauritius	1864	5178	7191	2206	0.001
Total production in the countries listed [1]				2276278	
Total production in the world [2]				2820719	
Average virtual water content [3]	**2694**	**7483**	**10394**		

[1] The table includes only countries exporting tea to the Netherlands.

[2] See Appendix I.

[3] Country figures have been weighted based on the share of each country in the total tea production.

5. The total volume of water needed to have the Dutch drink tea

5.1. Virtual water import related to tea import

The virtual water import to the Netherlands as a result of tea import in the period 1995-99 has been 197 Mm^3/yr in average. For comparison: this is equal to about 3 percent of the annual Meuse river runoff. Indonesia is the largest source (contributing 35% of the total import into the Netherlands). Other sources are China (21%), Sri Lanka (14%) Argentina (6%), India (5%), Turkey (3%) and Bangladesh (1%). There is also some import from within Europe: Germany (6%), Switzerland (4%), United Kingdom (2%) and Belgium-Luxemburg (2%). It is difficult to trace back the original source of the tea imported from these countries, which do not produce tea themselves. For the tea imported from these countries, we have taken the global average virtual water content of tea.

The background calculations are given in Appendix III. The total import of tea over the period 1995-99 amounts to 17×10^3 ton/yr. The average virtual water content of tea imported into the Netherlands is 11.4 m^3 per kg of made tea. This figure is very close to the global average virtual water content of made tea, which is 10.4 m^3 per kg (see Table 4.1).

5.2. Virtual water export related to tea export

As the Netherlands does not grow tea itself, the virtual water content of the tea exported from the Netherlands is taken as equal to the average virtual water content of the tea imported into the Netherlands. The total virtual water export from the Netherlands as a result of tea export is 107 Mm^3/yr. The largest importers of virtual water from the Netherlands are: Germany (21%), United Kingdom (17%), the Russian Federation (15%), Switzerland (8%), USA (6%), Italy (4%), France (4%), and Belgium-Luxemburg (3%). The detailed calculations of virtual water export from the Netherlands in relation to tea export are given in Appendix IV.

5.3. Net virtual water import related to tea trade

The virtual water balance of the Netherlands related to tea trade is presented in Table 5.1 along with the virtual water balances related to the trade in coffee, crops and livestock products. The figures show that tea trade accounts for only 0.33 per cent of the total net virtual water import into the Netherlands (looking at virtual water import related to trade in agricultural products only). The table shows that the virtual water import into the Netherlands in relation to net tea import is much less than the virtual water import related to net coffee import. This can be explained by the fact that the Dutch consume much more coffee than tea plus the fact that tea has much lower virtual water content than coffee.

Table 5.1. Virtual water imports into and exports from the Netherlands related to trade in tea, coffee, crops and livestock products in the period 1995-99.

	Gross import of virtual water (Mm^3/yr)	Gross export of virtual water (Mm^3/yr)	Net import of virtual water (Mm^3/yr)
Related to tea trade	197	107	90
Related to coffee trade[1]	2953	314	2639
Related to crop trade [2]	35002	5462	29540
Related to trade in livestock and livestock products [3]	8527	13344	-4817
Total	**46679**	**19227**	**27452**

[1] *Chapagain and Hoekstra (2003b).*

[2] *Hoekstra and Hung (2002, 2003).*

[3] *Chapagain and Hoekstra (2003a).*

6. The water needed to drink one cup of tea

A cup of tea is normally 250 ml and one tea bag typically includes 1.5 to 3 grams of processed tea (The Fragrant Leaf, 2003a). For simplicity we assume here 3 grams of processed tea (either black, green or oolong tea) for a cup of normal or 'strong' tea and 1.5 gram for 'weak' tea. Based on a water need of 11.4 m^3 per kilogram of processed tea, this means that one cup of normal tea requires 34 litres of water and a cup of weak tea half of that amount.

It is interesting to compare one cup of tea with one cup of coffee. The water needs for coffee have been calculated in another study (Chapagain and Hoekstra, 2003b). Table 6.1 shows that one consumes about 4 times more water if the choice is made for a cup of coffee instead of a cup of tea.

The figures presented for the Netherlands here are quite representative for the global average, so the figures can be cited in more general terms as well.

Table 6.1. Virtual water content of a cup of tea or coffee.

		Virtual water content of the dry ingredient	One cup of tea or coffee		
			Dry product content	Real water content	Virtual water content
		m^3/kg	gram/cup	litre/cup	litre/cup
Tea	Standard cup of tea	11.4	3	0.25	34
	Weak tea	11.4	1.5	0.25	17
Coffee	Standard cup of coffee	20.4	7	0.125	140
	Weak coffee	20.4	5	0.125	100
	Strong coffee	20.4	10	0.125	200
	Instant coffee	39.4	2	0.125	80

7. Conclusion

The Dutch people account for 0.28% (7.8×10^3 ton/yr) of the world tea consumption (2.82 million ton/yr). In order to drink one standard cup of tea in the Netherlands we need about 34 litres of water. If we compare this figure with the water requirement for one cup of coffee, we can conclude that drinking tea puts less pressure on available water resources than drinking coffee. With a standard cup of tea of 250 ml, we need about 136 drops of water for producing one drop of tea (compare: we need 1100 drops of water to produce one drop of coffee).

The total tea consumption in the Netherlands requires a total volume of water of 90 million cubic metres of water per year, which is equal to 1.2% of the annual Meuse flow. All together, the world population requires about 30 billion cubic metres of water per year in order to be able to drink tea. This is equivalent to 4 times the annual Meuse runoff.

The water needed to drink tea in the Netherlands is actually not Dutch water, because the tea is produced in South East Asia (Indonesia, China, Sri Lanka, India, and Bangladesh) and some other countries in different parts of the world (Argentina, Turkey, Brazil, Tanzania, and South Africa). There is also tea import from some countries that do not produce tea themselves, such as Germany, Switzerland, the United Kingdom, and Belgium-Luxemburg. They are merely intermediate countries, where tea is just transited or upgraded (e.g. through blending or making brand names to gain higher economic returns).

The water needed to make tea depends particularly on the water productivity at the point of plant growth. Normally tea plants are grown with rainfall, with some supplementary irrigation in exceptional cases (at the lower altitudes). Considering the overall water requirements for tea, one can say that it is mainly a rainwater product; it hardly includes irrigation water or process water.

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Appendix I. Tea production by country during the period 1995-99. Source: FAO (2003c).

Country	Tea production (ton/yr)						Tea yield (ton/ha)					
	1995	1996	1997	1998	1999	Average	1995	1996	1997	1998	1999	Average
India	753900	756000	780000	811000	870000	794180	1.76	1.77	1.81	1.87	2.00	1.84
China	609392	616517	636871	687675	696990	649489	0.69	0.69	0.72	0.78	0.75	0.73
Sri Lanka	245961	258427	276861	280056	283760	269013	1.30	1.38	1.45	1.48	1.45	1.41
Kenya	244530	257160	220722	294165	248700	253055	2.20	2.26	1.94	2.47	2.16	2.21
Indonesia	154013	166256	153600	166800	161000	160334	1.36	1.45	1.34	1.52	1.46	1.43
Turkey	102713	114540	139523	177850	199155	146756	1.34	1.49	1.82	2.32	2.59	1.91
Japan	84800	88600	91200	82600	88500	87140	1.58	1.68	1.76	1.61	1.75	1.68
Iran	54352	62100	68600	60100	80000	65030	1.58	1.79	1.98	1.74	2.37	1.89
Viet Nam	40200	46800	52200	56600	70300	53220	0.57	0.66	0.82	0.85	1.01	0.78
Argentina	51481	47064	54125	57148	55800	53124	1.38	1.25	1.44	1.51	1.41	1.40
Bangladesh	52000	47675	53310	50575	56000	51912	1.09	0.99	1.10	1.04	1.15	1.08
Malawi	34182	37232	44080	40362	48159	40803	1.82	1.98	2.34	2.15	2.23	2.10
Georgia	38500	34000	33200	47234	200	30627	0.84	0.74	1.05	1.70	2.00	1.27
Tanzania	24300	24000	25500	21900	25000	24140	1.31	1.30	1.34	1.18	1.32	1.29
Uganda	12692	17418	21075	25901	24739	20365	0.79	0.97	1.03	1.18	1.63	1.12
Myanmar	15900	16000	17700	20364	18424	17678	0.27	0.27	0.29	0.30	0.29	0.28
Zimbabwe	15000	16822	17098	17500	18530	16990	3.19	3.30	3.29	3.24	3.31	3.27
Rwanda	5414	9057	13239	14875	12959	11109	0.60	0.82	1.10	1.22	1.29	1.01
South Africa	11975	9062	8207	13010	12077	10866	1.90	1.43	1.23	1.94	1.80	1.66
Brazil	8607	6181	6150	5807	7020	6753	1.90	1.87	1.87	1.78	1.79	1.84
Papua New Guinea	4699	5113	5156	7260	10000	6446	1.04	1.11	1.72	2.27	2.27	1.68
Burundi	6985	5648	4169	6669	6865	6067	0.98	0.75	0.56	0.89	0.92	0.82
Malaysia	6000	6000	6000	6000	5000	5800	2.04	2.03	2.00	1.94	1.61	1.92

Country	Tea production (ton/yr)						Tea yield (ton/ha)					
	1995	1996	1997	1998	1999	Average	1995	1996	1997	1998	1999	Average
Thailand	5100	5100	5300	5300	5500	5260	0.30	0.30	0.29	0.29	0.30	0.30
Russian Federation	7210	4722	4060	3700	2000	4338	4.51	2.95	2.54	2.47	1.33	2.76
Peru	1378	2351	2608	7397	6964	4140	0.61	1.01	1.11	2.93	4.57	2.05
Cameroon	3873	3581	4190	3944	4597	4037	2.56	2.37	2.77	2.61	2.97	2.66
Bolivia	2975	3050	3150	3150	3468	3159	8.50	7.63	8.29	7.88	8.50	8.16
Congo, Dem Republic of	3418	3431	3433	3328	2183	3159	0.67	0.67	0.69	0.69	0.61	0.67
Nepal	2457	2721	2906	3020	4493	3119	2.73	3.52	3.73	3.78	0.56	2.86
Ecuador	1836	5673	1866	1572	1572	2504	2.30	6.10	3.11	1.71	1.71	2.98
Azerbaijan	3000	3034	1634	863	2730	2252	0.33	0.39	0.23	0.13	0.51	0.32
Mauritius	3785	2497	1787	1488	1473	2206	1.82	2.25	2.33	2.16	2.20	2.15
Mozambique	976	1670	1500	1500	1600	1449	0.49	0.84	0.75	0.75	0.80	0.72
Korea, Republic of	699	947	1000	1470	1109	1045	0.98	1.14	1.11	1.30	0.78	1.06
Ethiopia	700	700	700	700	700	700	0.26	0.26	0.26	0.26	0.26	0.26
Guatemala	450	450	450	450	460	452	1.00	1.00	1.00	1.00	1.00	1.00
Zambia	450	500	450	400	450	450	1.13	1.14	1.13	1.05	1.13	1.11
Réunion	370	370	370	370	370	370	1.28	1.28	1.28	1.28	1.28	1.28
Madagascar	300	300	320	312	400	326	1.76	1.76	1.78	1.73	1.82	1.77
Laos	764	101	110	260	350	317	1.33	0.26	0.28	0.29	0.38	0.51
Seychelles	226	223	270	250	236	241	0.51	0.51	0.57	0.56	0.54	0.54
Panama	188	161	158	160	160	165	0.99	1.00	1.00	1.00	1.00	1.00
Mali	202	69	50	60	60	88	0.67	0.69	0.56	0.67	0.67	0.65
Portugal	82	63	25	24	27	44	0.66	0.66	0.61	0.59	0.68	0.64
Total						2820719						

Appendix II. Virtual water content of tea by country.

Countries	Crop water requirement of tea plant	Yield of made tea[1]	Yield of fresh tealeaves[2]	Virtual water content of fresh tealeaves	Virtual water content of withered and rolled leaves	Virtual water content of made tea	Production
	mm/yr	ton/ha/yr	ton/ha/yr	m^3/ton	m^3/ton	m^3/ton	ton/yr
Argentina	1286	1.40	5.39	2387	6630	9208	53124
Bangladesh	1404	1.08	4.15	3383	9397	13052	51912
Brazil	1550	1.84	7.11	2180	6055	8410	6753
China	1205	0.73	2.80	4304	11955	16604	649489
India	917	1.84	7.10	1290	3584	4978	794180
Indonesia	1769	1.43	5.51	3213	8924	12395	160334
Japan	1165	1.68	6.47	1802	5004	6950	87140
Mauritius	1548	2.15	8.31	1864	5178	7191	2206
South Africa	1822	1.66	6.41	2842	7894	10965	10866
Sri Lanka	1731	1.41	5.45	3174	8817	12247	269013
Tanzania	1726	1.29	4.98	3467	9632	13377	24140
Turkey	1349	1.91	7.38	1828	5078	7053	146756
Uganda	1746	1.12	4.32	4046	11239	15610	20365
Total production							2276278
Weighted mean of virtual water content (m^3/ton)				**2694**	**7483**	**10394**	

1 Source: FAO (2003c).

2 Back calculated from product fractions and yield of made tea (column 3).

Appendix III. Average annual virtual water import to the Netherlands related to tea import in the period 1995-99.

Origin	Import of tea (ton/yr)					Virtual water content* (m^3/ton)	Virtual water import (10^6 m^3/yr)	Share of total import volume (%)
	090210	090220	090230	090240	090300			
	Green tea		Black tea		Mate			
Indonesia	24	38	29	5489		12395	69	35
China	130	834	203	1315		16604	41	21
Sri Lanka	9		711	1584		12247	28	14
Argentina				1300		9208	12	6
Germany	10	16	848	231		10394	11	6
India		17	188	1521		4978	9	5
Switzerland-Liecht				696		10394	7	4
Turkey			127	735		7053	6	3
United Kingdom	2		95	238		10394	3	2
Belgium-Luxemburg	39		266	5		10394	3	2
Bangladesh			28	119		13052	2	1
Brazil				90	18	8410	1	0.5
Tanzania				72		13377	1	0.5
South Africa			4	50		10965	1	0.5
Hungary			38			10394	0.4	0.2
France	2	20	13	1		10394	0.4	0.2
Mauritius			24	12		7191	0.3	0.15
Czech Republic				28		10394	0.3	0.15
Japan	9	11				6950	0.1	0.05
Denmark			4			10394	0.05	0.03
Singapore			2			10394	0.02	0.01
Uganda				1		15610	0.01	0.01
Total	225	936	2580	13485	18		**197**	**100**
Weighted average						**11398**		

* The virtual water content of tea imported into the Netherlands is dependent on the origin of the tea. For the tea-producing countries, the virtual water content of tea is taken from Appendix II. For the other countries, which are intermediate trade countries, the virtual water content of tea has been assumed to equal the average virtual water content of tea in all tea producing countries together (see also Appendix II).

Appendix IV. Average annual virtual water export from the Netherlands related to tea export in the period 1995-99.

Destination	Export of tea (ton/yr)					Virtual water content* (m^3/ton)	Virtual water export (10^6 m^3/yr)	Share of total export volume (%)
	090210	090220	090230	090240	090300			
	Green tea		Black tea		Mate			
Germany	15		226	1692	15	11398	22.2	21
United Kingdom			26	1602		11398	18.6	17
Russian Fed			245	1202		11398	16.5	15
Switzerland-Liecht				715		11398	8.1	8
USA			14	568		11398	6.6	6
Italy			20	372		11398	4.5	4
France			34	343		11398	4.3	4
Belgium-Luxemburg	24	6	183	23		11398	2.7	3
Saudi Arabia				213		11398	2.4	2
Denmark			196			11398	2.2	2
Canada			46	91		11398	1.6	1.50
Austria			4	125		11398	1.5	1.40
Finland			5	121		11398	1.4	1.31
Malta				124		11398	1.4	1.31
Ukraine			37	76		11398	1.3	1.21
Slovakia				101		11398	1.2	1.12
Belarus			18	75		11398	1.1	1.03
Nigeria				91		11398	1.0	0.93
Japan	5	8	39	29		11398	0.9	0.84
Spain			17	59		11398	0.9	0.84
Azerbaijan			67			11398	0.8	0.75
Cyprus				61		11398	0.7	0.65
Czech Republic			13	45		11398	0.7	0.65
Poland			3	39		11398	0.5	0.47
Lithuania			8	33		11398	0.5	0.47
Latvia			8	30		11398	0.4	0.37
Hungary			9	24		11398	0.4	0.37
Kazakstan			27			11398	0.3	0.28
India				26		11398	0.3	0.28
Panama				24		11398	0.3	0.28
Suriname			13	8		11398	0.2	0.19
Turkey		1	5	13		11398	0.2	0.19
Egypt				18		11398	0.2	0.19
Sweden			7	9		11398	0.2	0.19

Destination	Export of tea (ton/yr)					Virtual water content* (m^3/ton)	Virtual water export (10^6 m^3/yr)	Share of total export volume (%)
	090210	090220	090230	090240	090300			
	Green tea		Black tea		Mate			
Morocco				16		11398	0.2	0.19
Norway	2		9			11398	0.1	0.09
Afghanistan				11		11398	0.1	0.09
Australia			9			11398	0.1	0.09
Netherlands Antilles			8			11398	0.1	0.09
Romania			8			11398	0.1	0.09
Yugoslavia			7			11398	0.1	0.09
Greece			7			11398	0.1	0.09
Aruba		3	3			11398	0.1	0.09
Bulgaria			6			11398	0.1	0.09
Iceland	5					11398	0.1	0.09
Argentina			4			11398	0.04	0.04
Ireland			3			11398	0.03	0.03
Uzbekistan			2			11398	0.03	0.03
Moldova			2			11398	0.03	0.03
Slovenia			2			11398	0.02	0.02
Brazil			1			11398	0.02	0.02
El Salvador			1			11398	0.02	0.02
Estonia			1			11398	0.02	0.02
Uruguay			1			11398	0.01	0.01
Malaysia			1			11398	0.01	0.01
Total	51	17	1346	7977	15		**107**	100

* The virtual water content of tea exported from the Netherlands is assumed to be equal to the average virtual water content of the tea imported to the Netherlands (see last row of Appendix III).

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