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The water needed to have the Dutch drink coffee

A.K. Chapagain

A.Y. Hoekstra

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P.O. Box 3015
2601 DA Delft
The Netherlands

Contact author:
Arjen Hoekstra
Phone +31 15 215 18 28
E-mail arjen@ihe.nl

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Summary

Coffee is, in dollar terms, the most important agricultural product traded in the world. Producing coffee requires a lot of water, but at the start of this study no specific studies were available. The objective of this study is to calculate the volumes of water required to drink coffee in the Netherlands, with the underlying aim to contribute to 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 coffee, because the water requirements per kilogram of coffee differ in the various coffee-producing countries. The 'virtual water content' of coffee has been defined as the total volume of water required for producing the coffee. In order to calculate the total virtual water content of roasted coffee we have looked into the water requirements in each production stage. We have calculated the water requirements in both the wet and the dry production method. For calculating the crop water requirements of the coffee plant we have used data and models of the Food and Agriculture Organization. Data for the different stages of the post-harvesting production process have been taken from various sources. Data on international coffee trade have been taken from the United Nations Statistics Division.

We found that for drinking one standard cup of coffee in the Netherlands we need about 140 litres of water, by far the largest part for growing the coffee plant. A standard cup of coffee is 125 ml, which means that we need more than 1100 drops of water for producing one drop of coffee. This figure calculated for the Dutch situation happens to be quite representative as a global average. Total coffee consumption in the Netherlands requires a total of 2.6 billion cubic metres of water per year, which is equal to 36% of the annual Meuse flow. The Dutch people account for 2.4% of the world coffee consumption. All together, the world population requires about 110 billion cubic metres of water per year in order to be able to drink coffee. This is equivalent to 15 times the annual Meuse runoff, or 1.5 times the annual Rhine runoff.

The water needed to drink coffee in the Netherlands is actually not Dutch water, because the coffee is produced in Latin America, Africa and Asia. The most important sources are Brazil and Colombia. There is also a large amount of coffee imported from transit-countries, particularly Belgium and Germany.

The water needed to make coffee depends on the climate at the place of production and the yields per hectare that are obtained. For the overall water need, it makes hardly any difference whether the dry or wet production process is applied, because the water used in the wet production process is a very small fraction (0.34%) of the water used to grow the coffee plant. However, this relatively small amount of water is often a problem, because this is water to be obtained from surface water, which is sometimes scarcely available. Besides, the wastewater from the coffee factories is often heavily polluted. The large volume of water to grow the coffee plant comes from rainwater, a source with less competition between alternative uses than in the case of surface water.

Drinking tea instead of coffee would save a lot of water. For a standard cup of tea of 250 ml we require 34 litre of water. This means that tea requires about eight times less water than coffee.

1. Introduction

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

The roots of coffee consumption are probably in Ethiopia. The coffee tree is said to originate in the province of Kaffa (ICO, 2003). Coffee spread to the different parts of the world in the 17th and 18th century, the period of colonisation. Early 18th century the Dutch colonies had become the main suppliers of coffee to Europe. Today people drink coffee all over the world. The importance of coffee to people cannot easily be overestimated. Coffee is of great economic importance to the producing, mostly developing countries and of considerable social importance to the consuming countries. Coffee is, in dollar terms, the most important agricultural product traded in the world (Dubois, 2001).

Coffee consumption is possible through the use of natural and human resources in the producing countries. One of the natural resources required to make coffee is water. There is a particular water need for growing the coffee plant, but there is also a need for water to process coffee cherries into the final product.

For expressing the total volume of water needed to produce a good, Allan has proposed the concept of 'virtual water' (Allan, 1993; 1994). 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 there is a transfer of a product from one place to another, there is little direct physical transfer of water (apart from the water content of the product, which is quite insignificant in terms of volume). There is however a significant transfer of virtual water. In this way the coffee producing countries export immense volumes of 'virtual water' to the large coffee consuming countries. Import of virtual water into the consuming countries means that these countries indirectly employ the water in the producing countries. Due to the fact that the production of coffee 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 coffee, in order to have concrete figures for creating awareness.

1.2. Objectives of the study

This study has three specific objectives:

1. To estimate the virtual water content of coffee imported to the Netherlands, distinguishing between the different sources of the coffee.
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 coffee trade.
3. To assess the volume of water needed to drink one cup of coffee in the Netherlands.

2. Method

2.1. Stages in coffee production

After plantation it takes about 3 to 5 years before the coffee plants give yield. The plant reaches its optimum yield between the sixth and tenth year of life and then gradually diminishes until its fifteenth year, stopping altogether after 40 years (CPC, 2003).

There are two major varieties of coffee: Arabica and Robusta (ICO, 2003). The Arabica plant, *Coffea Arabica*, is a plant growing at high altitudes, between 800 and 2000 metres, and supplies about 75 per cent of the world coffee. Arabica coffee is grown throughout Latin America, in Central and East Africa, in India and to some extent in Indonesia. The Arabica plant is generally a large bush with dark-green oval leaves. The fruits are oval and mature in 7 to 9 months. The fruits usually contain two seeds, the coffee beans, but sometimes there is just one seed.

Robusta coffee comes from the *Coffea Canephora*, a plant cultivated from sea level up to 600 metres, mainly in West and Central Africa, throughout South-East Asia and to some extent in Brazil. Robusta coffee accounts for about 25 per cent of the world coffee production. The Robusta plant is a robust shrub or small tree growing up to 10 metres in height, but with a shallow root system. The fruits are rounded and take up to 11 months to mature; the seeds are oval in shape, brownish-yellow in appearance and smaller than those of *Coffea Arabica*. If compared with Arabica coffee, Robusta coffee is generally considered of inferior quality.

Figure 2.1 shows the major areas of coffee production in the world. The annual production of coffee per country during the period 1995-99 is presented in Appendix I.

Figure 2.1. Coffee production in the world (source: FNC, 1996).

The coffee bean is the seed of the coffee tree. The fruits of the coffee tree, with the beans inside, are green at first and become red orange at maturity. The fruits are called cherries due to their colour, shape and size. As shown in schematised form in Figure 2.2, the coffee seeds are inside the cherry in the form of two beans coupled at their flat surface. The beans are covered by a thin membrane or coat. This membrane or seed skin (spermoderm), is referred to in the coffee trade as the 'silver skin'. Each of these coated beans is surrounded by a kind of parchment layer (endocarp or *pergamino*), very resistant, and golden yellow. The beans with parchment layer are embedded in a layer of sugary mucilaginous fleshy pulp (mesocarp). The outer layer of a cherry is formed by a thin film, the skin (epicarp or *esocarpo*).

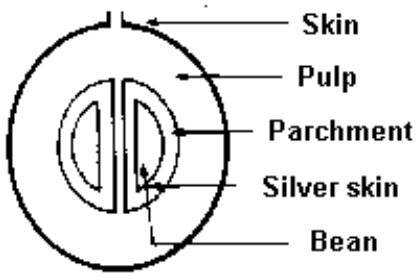

Figure 2.2. The components of a coffee cherry.

Before the seeds of the coffee plant result in a cup of coffee, there are a number of steps. First, the coffee cherries are harvested. Second, the cherries are processed into so-called 'green coffee'. There are basically two processes to process fresh cherries into green coffee: the dry and the wet method, which will be discussed below. The green coffee is processed into roasted coffee through roasting, a heat treatment process to transform the green beans into the aromatic brown coffee we all know. The roasted coffee is the ingredient for making a cup of coffee. Both green coffee and roasted coffee are internationally traded. The different stages in post-harvest processing of coffee beans are shown in Figure 2.3.

The dry method, also called the natural method, is the simplest, cheapest and most traditional method of processing coffee. The first step of processing is to dry the cherries, normally in direct sunlight to reduce the moisture content to the optimum of 12.5 per cent. The second step is hulling of the dried cherries, which means that the whole of the dried outer coverings of the original cherries (including the pulp and the parchment layer) are removed, leaving the coffee beans with some silver skin remainders. During the next step, any silver skin that remains on the beans after hulling is removed in a polishing machine. Polishing beans is an optional process that is not always done. Although coffee beans are of a fairly uniform size and proportion, they are graded first by size and then by density. Unhulled beans are removed. The product after polishing, grading and sorting is called 'green coffee'. The green coffee obtained through the dry method is sometimes referred to as 'unwashed coffee' or 'natural coffee'. The dry method is used for about 95% of the Arabica coffee produced in Brazil, most of the coffees produced in Ethiopia, Haiti and Paraguay, as well as for some Arabicas produced in India and Ecuador. Almost all Robustas are processed through this method (ICO, 2003).

The essential difference between the wet and the dry method is that in the wet method the pulp of the fruit is separated from the beans before the drying stage. The first step in the wet method is washing the cherries to remove waste and then pulping the cherries (removing the pulp) in a dépulpeuse machine, leaving two beans surrounded with their parchment. The pulping generally leaves some residual flesh to the beans as well as the sticky mucilage adhering to the parchment surrounding the beans. In order to be able to remove residual pulp and mucilage, the beans are put in fermentation tanks, accelerating the process of destruction of the residual pulp and mucilage. After fermentation, the beans are washed, leaving so-called 'wet parchment coffee'. After drying this product one has 'dry parchment coffee'. [If people briefly speak of 'parchment coffee' they generally refer to dry parchment coffee.] Hulling is done to remove the dried parchment layer immediately surrounding the beans. The beans are then sieved, polished and sorted out before being put in bags. The coffee at this stage is 'green coffee', in the case of the wet production process also called 'washed coffee'. The wet method is generally used for all the Arabica coffees, with the exception of those produced in Brazil and the Arabica-producing countries mentioned above as users of the dry method. It is rarely used for Robustas.

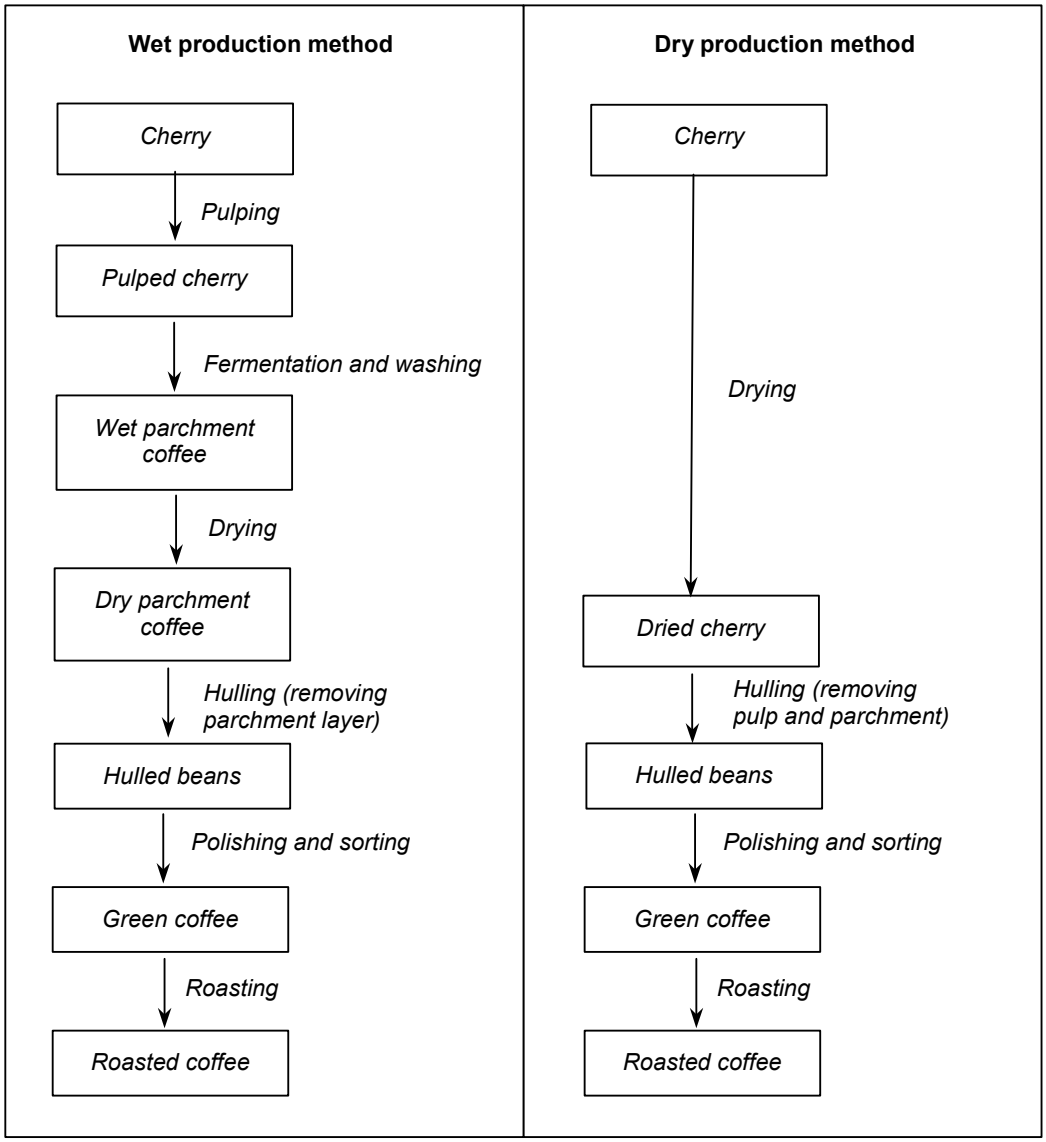

Figure 2.3. Post-harvesting steps of coffee production: the dry and the wet method.

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

The virtual water content of coffee is the volume of water required to produce one unit of coffee, generally expressed as cubic metre of water per ton of coffee. This is different at the different stages of coffee processing. First, the virtual water content of fresh cherries is calculated based on the crop water requirement of the coffee plant (in m^3/ha) and the yield of fresh cherries (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. If a particular processing step requires water (viz. the processes of pulping, fermentation and washing in the wet production method), the water needed (in m^3 per ton of original product) is added to the initial virtual water content of the original product before translating it into a value for the virtual water content of the resulting product. Figure 2.4 shows how the virtual water content of coffee is calculated in its subsequent production stages in the case of the wet production method. As an illustration of the calculation process, Tables 2.1 and 2.2 show examples for Brazil for the wet and the dry production method respectively. Appendices II and III include the calculations for all coffee producing countries from which the Netherlands imports coffee.

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

The volume of virtual water imported into the Netherlands (in m^3/yr) as a result of coffee import can be found by multiplying the amount of coffee imported (in ton/yr) by the virtual water content of the coffee (in m^3/ton). The latter depends on the form of the imported coffee (green or roasted coffee) and the origin of the coffee. The origin of the coffee is important because coffee production takes more water in some countries if compared to other countries.

The volume of virtual water exported from the Netherlands is calculated by multiplying the export quantity by the average virtual water content of coffee in the Netherlands. The latter is taken as the average virtual water content of the coffee 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 for the total amount of water needed to have the Dutch drink coffee.

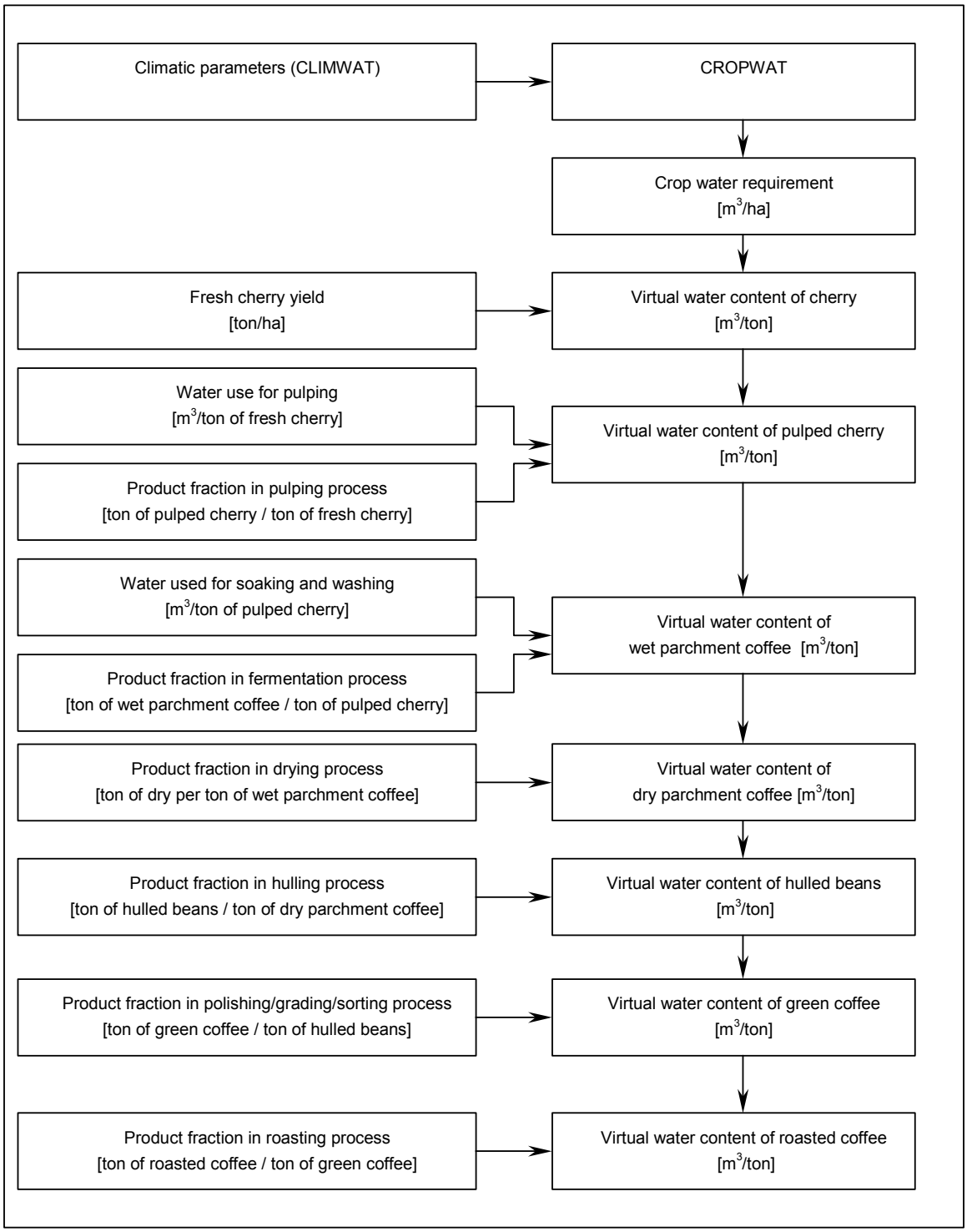

Figure 2.4. Steps in the calculation of the virtual water content of coffee under the wet production process.

Table 2.1. Calculation of the virtual water content of coffee produced in Brazil with the wet production method.

	Variable	Value	Unit	Source
A	Crop water requirement	1277	mm	CROPWAT
B	Yield of fresh cherry	4.22	ton/ha	Calculated from yield of green coffee given by FAO (2003c)
C	**Virtual water content of fresh cherries**	**3028**	m^3/ton	C=10×A/B
C1	Water use for pulping	7.5	m^3/ton of fresh cherries	Assumption, based on GTZ (2002b)
D	Remaining fraction after pulping	0.44	ton/ton	Bressani (2003), GTZ (2002a)
E	Virtual water content of pulped cherries	6899	m^3/ton	E=(C+C1)/D
E1	Water use for soaking and washing	5	m^3/ton of pulped cherries	The Roast and Post Coffee Company (2003), GTZ (2002b)
F	Remaining fraction after fermentation and washing	0.9	ton/ton	Bressani (2003)
G	Virtual water content of wet parchment coffee	7671	m^3/ton	G = (E+E1)/F
H	Remaining fraction after drying	0.506	ton/ton	GTZ (2002c)
I	**Virtual water content dry parchment coffee**	**15159**	m^3/ton	I=G/H
J	Remaining fraction after hulling (removing the parchment layer)	0.9	ton/ton	GTZ (2002a)
K	Virtual water content of hulled beans	16844	m^3/ton	K=I/J
L	Remaining fraction after polishing, grading and sorting	0.89	ton/ton	GTZ (2002a)
N	**Virtual water content of green coffee**	**18925**	m^3/ton	N=K/L
O	Remaining fraction after roasting	0.84	ton/ton	GTZ (2002a), Hicks (2001), ICO (2003), Sovrana(2003)
P	**Virtual water content of roasted coffee**	**22530**	m^3/ton	P=N/O

Table 2.2. Calculation of the virtual water content of coffee produced in Brazil with the dry production method.

	Variable	Value	Unit	Source
A	Crop water requirement	1277	mm	CROPWAT
B	Yield of fresh cherry	4.22	ton/ha	From Table 2.1
C	**Virtual water content of fresh cherries**	**3028**	m^3/ton	C=10×A/B
D	Remaining fraction after drying	0.36	ton/ton	Hicks (2001)
E	Virtual water content of dried cherries	8395	m^3/ton	E=C/D
F	Remaining fraction after hulling (removing pulp and parchment)	0.5	ton/ton	Hicks (2001)
G	Virtual water content of hulled beans	16790	m^3/ton	G=E/F
H	Remaining fraction after polishing, grading and sorting	0.89	ton/ton	GTZ (2002a)
I	**Virtual water content of green coffee**	**18865**	m^3/ton	I=G/H
J	Remaining fraction after roasting	0.84	ton/ton	GTZ (2002a), Hicks (2001), ICO (2003), Sovrana(2003)
K	**Virtual water content of roasted coffee**	**22458**	m^3/ton	K=I/J

3. Data sources

3.1. Climate data and crop parameters

The annual crop water requirement of a coffee plant is calculated per country using the CROPWAT model developed by the Food and Agriculture Organization (FAO, 2003a). The crop coefficients for coffee 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 coffee is grown, but global data on exact locations of coffee plantations are not easily obtainable.

3.2. Coffee yields

Country-specific data on coffee 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 green coffee. Yields in terms of fresh cherries can be calculated based on the ratio of green coffee weight to fresh cherry weight (using the production factors as explained in Section 2.2).

3.3. Coffee trade

Data on coffee 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 total volume of coffee imported into the Netherlands and the total volume of coffee exported are presented in Table 3.1. The data are given for four different coffee products: non-decaffeinated non-roasted coffee, decaffeinated non-roasted coffee, non-decaffeinated roasted coffee and decaffeinated roasted coffee. The term ‘non-roasted coffee’ in PC-TAS refers to what is generally called ‘green coffee’. The list of countries exporting coffee to the Netherlands is presented in Appendix IV. Please note that some of the countries exporting coffee to the Netherlands do not grow coffee themselves. These countries import the coffee from elsewhere in order to further trade it. The list of countries importing coffee from the Netherlands is presented in Appendix V.

Table 3.1. Coffee 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)
090111	Coffee, not roasted, not decaffeinated	135381	7252
090112	Coffee, not roasted, decaffeinated	5331	731
090121	Coffee, roasted, not decaffeinated	22020	7229
090122	Coffee, roasted, decaffeinated	3887	1444
Total		166620	16656

3.4. Production factors

From fresh cherries to green coffee the weight is reduced to about 16 per cent of the original weight, due to removing pulp and parchment, reduction in moisture content and sorting out of low-quality beans (GTZ, 2002a).

The weight reduction occurs in steps. In the wet production method, only 44% of the fresh cherry remains after pulping (Bressani, 2003), 90% of the pulped cherry remains after fermentation and washing (Bressani, 2003), 51% of the wet parchment coffee remains after drying (GTZ, 2002c) and 80% of the dry parchment coffee remains after hulling, polishing and sorting (GTZ, 2002a). In the dry production method, about 36% of the fresh cherry remains after drying (Hicks, 2001), 50% of the dried cherry remains after hulling (Hicks, 2001) and 89% of the hulled beans remains after polishing and sorting.

From green coffee to roasted coffee there is another weight reduction, due to reduction in moisture content. The remaining fraction after roasting is generally reported to be 84% of the original green coffee (GTZ, 2002a; ICO, 2003; Hicks, 2001; Sovrana, 2003).

3.5. Water requirements in the wet production method

The wet production method requires water both for the pulping process and the fermentation and washing process. The total amount of water needed ranges between 1 and 15 m^3 per ton of cherry (GTZ, 2002b). In this study we crudely assume that 7.5 m^3 of water per ton of fresh cherry is needed in the pulping process and that 5 m^3 of water per ton of pulped cherry is needed in the fermentation and washing process (The Roast and Post Coffee Company, 2003). If we bring these two numbers into one denominator, this is equivalent to about 10 m^3 of water per ton of cherry. We will see later that the overall result of the study, the estimated total water needs for making coffee, are not sensitive to the assumptions made here.

4. Virtual water content of coffee per producing country

Detailed calculations of the virtual water content of green coffee and roasted coffee are given in Appendix II for the wet production method and in Appendix III for the dry production method. The differences between the two production methods in terms of *total* water needs are very small. The virtual water content of green coffee is 17.63 m^3/kg for the wet production method, whereas it is 17.57 m^3/kg for the dry production method (global averages). The water needs for roasted coffee are 20.98 and 20.92 m^3/kg respectively. Most water is needed for growing the coffee plant. In the wet production method, only 0.34% of the total water need refers to process water. The results are summarised in Table 4.1. The table only shows the coffee-producing countries that export coffee to the Netherlands. These countries together are responsible for 84 per cent of the global coffee production. The data on yields and production are averages for period 1995-99 and have been taken from Appendix I. For the data on virtual water content we have taken the wet-production data, because the wet production method is most frequently applied and the differences with the dry-production data are small.

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

Countries	Crop water requirement	Yield of green coffee	Virtual water content of green coffee	Virtual water content of roasted coffee	Average production (1995-99)	Relative weight in production
	mm	ton/ha	m^3/ton	m^3/ton	ton/yr	
Brazil	1277	0.68	18925	22530	1370232	0.262
Colombia	893	0.74	12139	14451	689688	0.132
Indonesia	1455	0.55	26650	31727	466214	0.089
Vietnam	938	1.87	5086	6054	384220	0.073
Mexico	1122	0.46	24347	28985	329297	0.063
Guatemala	1338	0.90	14940	17786	240222	0.046
Uganda	1440	0.84	17139	20404	229190	0.044
Ethiopia	1151	0.91	12749	15177	227078	0.043
India	754	0.81	9312	11086	220200	0.042
Costa Rica	1227	1.47	8424	10028	157188	0.030
Honduras	1483	0.78	19028	22652	154814	0.030
El Salvador	1417	0.85	16789	19987	138121	0.026
Ecuador	1033	0.32	32616	38828	121476	0.023
Peru	994	0.61	16335	19446	116177	0.022
Thailand	1556	1.12	13993	16658	75814	0.015
Venezuela	1261	0.35	35923	42766	67802	0.013
Nicaragua	1661	0.73	22797	27139	65373	0.013
Madagascar	1164	0.33	35521	42287	63200	0.012
Tanzania	1422	0.38	37219	44308	44540	0.009
Bolivia	1093	0.94	11733	13968	22613	0.004
Togo	1409	0.34	41447	49341	14416	0.003

Countries	Crop water requirement	Yield of green coffee	Virtual water content of green coffee	Virtual water content of roasted coffee	Average production (1995-99)	Relative weight in production
	mm	ton/ha	m^3/ton	m^3/ton	ton/yr	
Sri Lanka	1426	0.68	21115	25137	11133	0.002
Panama	1294	0.41	31634	37660	10726	0.002
Ghana	1381	0.35	39946	47554	4909	0.001
USA	938	1.24	7611	9061	2924	0.001
Total production in the countries listed [1]					5227567	
Total production in the world [2]					6201976	
Average virtual water content [3]			**17629**	**20987**		

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

[2] See Appendix I.

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

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

5.1. Virtual water import related to coffee import

The virtual water import to the Netherlands as a result of coffee import amounts to 2953 Mm^3/yr, which is about 4 percent of the annual Rhine river runoff or 40 percent of the annual runoff of the Meuse! Brazil and Colombia together are responsible for 25 percent of this import. Other important sources are Guatemala (5%), El Salvador (5%) and Indonesia (4%). A large part of the coffee import comes from the non-coffee-producing countries Belgium and Germany (34% in total). It is difficult to trace the original source of this Belgian and German coffee. For the coffee imported from countries that do not produce coffee themselves, we have taken the global average virtual water content of coffee as given in Table 4.1.

Detailed calculations of virtual water import into the Netherlands as a result of coffee import can be found in Appendix IV. The total import of green coffee over the period 1995-99 amounts to 141×10^3 ton/yr. The import of roasted coffee is 26×10^3 ton/yr. The average virtual water content of coffee imported into the Netherlands is 17.1 m^3 per kg of green coffee and 20.4 m^3 per kg of roasted coffee. These figures are very close to the average global virtual water content of green and roasted coffee respectively.

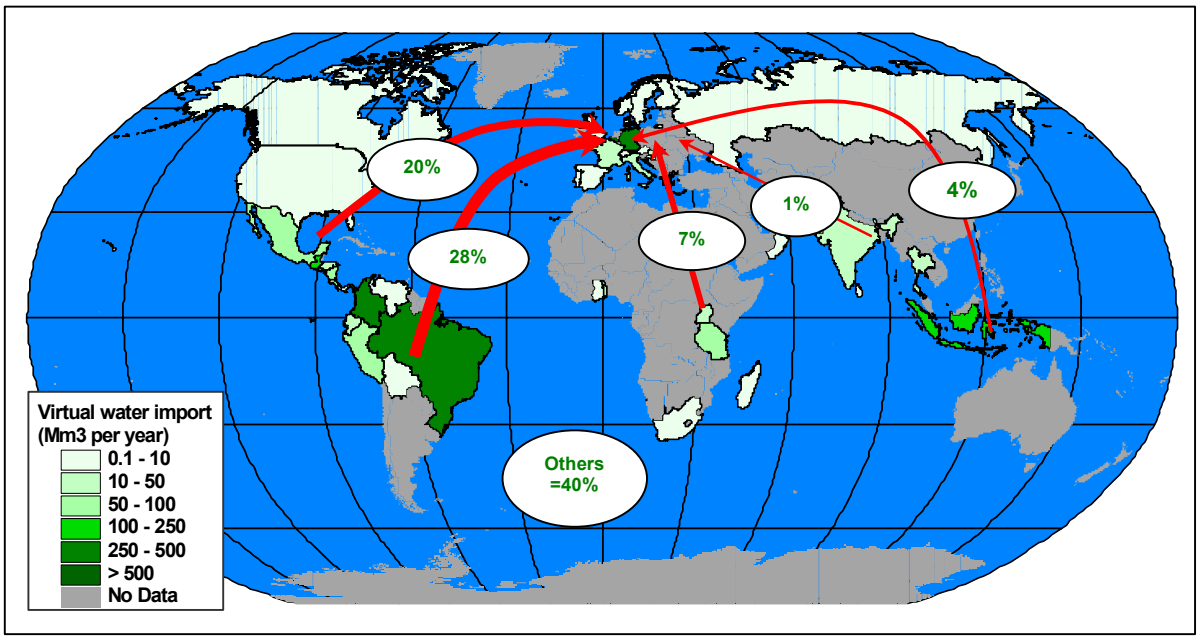

Figure 5.1. Virtual water import to the Netherlands related to coffee imports. The greener the area the more the import to the Netherlands.

5.2. Virtual water export related to coffee export

As the Netherlands does not grow coffee itself, the virtual water content of the coffee exported from the Netherlands is taken as equal to the average virtual water content of the coffee imported into the Netherlands. The total virtual water export from the Netherlands as a result of coffee export is 314 Mm^3/yr. The largest

importers of virtual water from the Netherlands are: Belgium-Luxemburg (23%), United Kingdom (20%), Germany (18%), and France (12%). The detailed calculations of virtual water export from the Netherlands in relation to coffee export are given in Appendix V.

5.3. Net virtual water import related to coffee trade

The virtual water balance of the Netherlands related to coffee trade is presented in Table 5.1 along with the virtual water balances related to the trade in crops and livestock products. The figures show that coffee trade alone is responsible for nearly 10 per cent of the net virtual water import into the Netherlands related to the trade in agricultural products.

Table 5.1. Virtual water imports into and exports from the Netherlands related to trade in 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 coffee trade	2953	314	2639
Related to crop trade [1]	35002	5462	29540
Related to trade in livestock and livestock products [2]	8527	13344	-4817
Total	**46482**	**19120**	**27362**

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

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

6. The water needed to drink one cup of coffee

The quantity of roasted coffee per cup of coffee is not a fixed figure. It is differs among people. The Speciality Coffee Association of America (SCAA) suggests 10 gram per cup as the proper measure for brewed coffee if using the American standards. If using Euro standards the measure is 7 gram per cup (Coffeefaq, 2003). Van Wieringen, (2001) suggests 5 grams of coffee per cup. The standard volume of a cup of coffee is 125 ml.

For the calculation of the virtual water content of a standard cup of coffee, we have taken 7 gram of roasted coffee for a cup of 125 ml. Based on an average virtual water content in roasted coffee of 20.4 m^3/kg, this means that producing one cup of coffee requires about 140 litres of water in total. This is of course more or less depending on the strength of the coffee preferred. The results are presented in Table 6.1.

For making one kilogram of soluble coffee powder, one needs 2.3 kg of green coffee (Rosenblatt *et al*., 2003). That means that the virtual water content of instant coffee is about 39400 m^3/ton. This is much higher than in the case of roasted coffee, but for making one cup of instant coffee one needs a relatively small weight of coffee powder (about 2 gram). Surprisingly, the virtual water content of a cup of instant coffee is thus lower than the virtual water content of a cup of normal coffee.

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. The virtual water content of one cup of coffee in the Netherlands.

	Virtual water content		One cup of coffee (125 ml)		
	Roasted coffee	Soluble coffee powder	Coffee content	Real water content	Virtual water content
	m^3/ton	m^3/ton	gram/cup	litre/cup	litre/cup
Standard cup of coffee	20400		7	0.125	140
Weak coffee	20400		5	0.125	100
Strong coffee	20400		10	0.125	200
Instant coffee		39400	2	0.125	80

7. Conclusion

In order to drink one standard cup of coffee in the Netherlands we need about 140 litres of water, by far the largest part for growing the coffee plant. This means that we need about 14 buckets of water for one cup of coffee. A standard cup of coffee is 125 ml, which means that we need more than 1100 drops of water for producing one drop of coffee.

The total coffee consumption in the Netherlands requires 2.6 billion cubic metres of water per year, which is equal to 36% of the annual Meuse flow. The Dutch people account for 2.4% of the world coffee consumption. All together, the world population requires about 110 billion cubic metres of water per year in order to be able to drink coffee. This is equivalent to 15 times the annual Meuse runoff, or 1.5 times the annual Rhine runoff.

The water needed to drink coffee in the Netherlands is actually not Dutch water, because the coffee is produced in Latin America (Brazil, Colombia, Guatemala, El Salvador, Mexico, Costa Rica, Nicaragua, Peru, Honduras, etc.), Africa (Togo, Tanzania, Uganda) and Asia (Indonesia, India). The most important sources are Brazil and Colombia. There is also a large amount of coffee imported from Belgium and Germany, but these countries do not produce the coffee themselves and are merely intermediate countries, where coffee is just transited or upgraded from green to roasted coffee.

The water needed to make coffee depends particularly on the climate at the place of production and the yields per hectare that are obtained. The latter partly depends on the climatic conditions, but also on soil conditions and management practice. For the overall water needs, it makes hardly any difference whether the dry or the wet production process is applied, because the water used in the wet production process is only a very small fraction (0.34%) of the water used to grow the coffee plant. However, this relatively small amount of water can be and actually often is a problem, because this is water to be obtained from surface or groundwater, which is sometimes scarcely available. Besides, the wastewater from the coffee factories is often heavily polluted (GTZ, 2002b). The large volume of water to grow the coffee plant comes from rainwater, which is another source, where there is less competition between alternative uses than in the case of surface or groundwater.

Drinking tea instead of coffee would save a lot of water. In another study we have estimated that for a standard cup of tea of 250 ml we require 34 litre of water (Chapagain and Hoekstra, 2003b). This means that for a certain volume of tea we need eight times less water than for the same volume of coffee.

References

Allan, J.A. (1993) 'Fortunately there are substitutes for water otherwise our hydro-political futures would be impossible' In: *Priorities for water resources allocation and management*, ODA, London, pp. 13-26.

Allan, J.A. (1994) 'Overall perspectives on countries and regions' In: Rogers, P. and Lydon, P. *Water in the Arab World: perspectives and prognoses*, Harvard University Press, Cambridge, Massachusetts, pp. 65-100.

Allan, J.A. (1998) 'Global soil water: A long term solution for water-short Middle Eastern Economies', Proceeding of water workshop: Averting a water crisis in the Middle East - make water a medium of cooperation rather than conflict, Green Cross International, March 1998, Geneva. http://www.greencrossinternational.net/greencrossprograms/waterres/middleeast/allan.html

Allan, J.A. (1999) 'Water stress and global mitigation: water food and trade' *Arid Lands Newsletter* No.45. http://ag.arizona.edu/OALS/ALN/aln45/allan.html

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith (1998) 'Crop evapotranspiration: Guidelines for computing crop water requirements', FAO Irrigation and Drainage Paper 56, FAO, Rome, Italy.

Bressani, R. (2003) 'Coffea arabica: Coffee, coffee pulp' Website: http://www.fao.org/ag/aga/agap/frg/afris/Data/540.htm

Chapagain, A.K. and Hoekstra, A.Y (2003a) 'Virtual water flows between nations in relation to trade in livestock and livestock products', Value of Water Research Report Series No. 13, UNESCO-IHE, Delft, the Netherlands. http://www.ihe.nl/vmp/articles/Projects/PRO-Virtual_Water_Trade.html

Chapagain, A.K. and Hoekstra, A.Y (2003b) 'The water needed to have the Dutch drink tea', Value of Water Research Report Series No. 15, UNESCO-IHE, Delft, the Netherlands.

Chapman, K. and Subhadrabandhu, S. (eds.) (2001) The First Asian Regional Round-Table on Sustainable, Organic and Speciality Coffee Production, Processing and Marketing, 26-28 February 2001, Chiang Mai, Thailand. http://www.fao.org/docrep/003/x6938e/x6938e00.htm

Coffeefaq (2003) Website on frequently asked questions about coffee: http://coffeefaq.com/coffaq1.htm

CPC (2003) Website of the Consorzio Promozione Caffè: http://www.decoffea.it/ind_ing.htm

Dubois, P. (2001) International cooperation for the development of a sustainable coffee economy, In: Chapman, K. and Subhadrabandhu, S. (eds.) The First Asian Regional Round-Table on Sustainable, Organic and Speciality Coffee Production, Processing and Marketing, 26-28 February 2001, Chiang Mai, Thailand.

FAO (2003a) CROPWAT model. Website: http://www.fao.org/ag/AGL/aglw/cropwat.htm

FAO (2003b) CLIMWAT database. Website: http://www.fao.org/ag/AGL/aglw/climwat.stm

FAO (2003c) FAOSTAT database. Website: http://apps.fao.org

FNC (1996) Website of the Colombian Coffee Federation: http://www.juanvaldez.com

GTZ (2002a) Post harvesting processing: Facts and figures, PPP Project, May 2002. http://www.venden.de/postharvestprocessing.htm

GTZ (2002b) Post harvesting processing: Coffee waste water, PPP Project, May 2002. http://www.venden.de/postharvestprocessing.htm

GTZ (2002c) Post harvesting processing: Coffee drying, PPP Project, May 2002. http://www.venden.de/postharvestprocessing.htm

Hicks, P.A. (2001) Postharvest processing and quality assurance for speciality / organic coffee products. In: Chapman, K. and Subhadrabandhu, S. (eds.) The First Asian Regional Round-Table on Sustainable, Organic and Speciality Coffee Production, Processing and Marketing, 26-28 February 2001, Chiang Mai, Thailand.

Hoekstra, A.Y. (1998) *Perspectives on water: An integrated model-based exploration of the future*, International Books, Utrecht, the Netherlands.

Hoekstra, A.Y. (ed.) (2003) 'Virtual water trade: Proceedings of the international expert meeting on virtual water trade, Delft, the Netherlands, 12-13 December 2002', Value of Water Research Report Series No. 12, UNESCO-IHE, Delft, the Netherlands. http://www.ihe.nl/vmp/articles/Projects/PRO-Virtual_Water_Trade.html

Hoekstra, A.Y. and Hung, P.Q. (2002) 'Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade', Value of Water Research Report Series No. 11, UNESCO-IHE, Delft, the Netherlands. http://www.ihe.nl/vmp/articles/Projects/PRO-Virtual_Water_Trade.html

ICO (2003) Website of the International Coffee Organisation: http://www.ico.org

Rosenblatt, L., Meyer, J. and Beckmann, E. (2003) *Koffie: Geschiedenis, teelt, veredeling, met 60 heerlijke koffierecepten*, Fontaine Uitgevers, Abcoude, The Netherlands.

Sovrana (2003) Website of the Sovrana Trading Corporation: http://sovrana.com/roasting.htm

The Roast and Post Coffee Company (2003) Website: http://www.realcoffee.co.uk/Article.asp?Cat=TreeToCup&Page=3

Van Wieringen, S. (2001) *Alles over koffie*, Fair Trade, Culemborg, The Netherlands.

Appendix I. Green coffee production by country (1995-99). Source: FAO (2003c).

	Country	Production (ton/yr)					Average annual production (ton/yr)	Yield (ton/ha)					Average yield (ton/ha)
		1995	1996	1997	1998	1999		1995	1996	1997	1998	1999	
1	Brazil	930135	1369196	1228513	1689366	1633950	1370232	0.50	0.71	0.62	0.82	0.74	0.68
2	Colombia	821820	671401	642239	766980	546000	689688	0.82	0.67	0.64	0.95	0.63	0.74
3	Indonesia	450369	462300	426800	498200	493400	466214	0.53	0.55	0.51	0.59	0.55	0.55
4	Viet Nam	218000	320100	420500	409300	553200	384220	1.41	1.55	2.41	1.91	2.05	1.87
5	Mexico	324526	374153	368315	277372	302119	329297	0.45	0.50	0.53	0.41	0.42	0.46
6	Côte d'Ivoire	194968	167786	279219	341000	307331	258061	0.21	0.21	0.34	0.39	0.38	0.31
7	Guatemala	210920	213188	248460	235020	293520	240222	0.79	0.80	0.92	0.90	1.08	0.90
8	Uganda	181465	287925	219624	205056	251881	229190	0.69	1.03	0.81	0.77	0.92	0.84
9	Ethiopia	229980	229980	228000	229980	217450	227078	0.92	0.92	0.91	0.92	0.87	0.91
10	India	180000	223000	205000	228000	265000	220200	0.65	0.81	0.85	0.81	0.95	0.81
11	Costa Rica	150061	154131	146825	171000	163925	157188	1.39	1.43	1.36	1.61	1.55	1.47
12	Honduras	132400	148830	162658	172772	157409	154814	0.72	0.71	0.84	0.87	0.77	0.78
13	El Salvador	139513	148859	124239	117214	160782	138121	0.86	0.91	0.76	0.72	0.99	0.85
14	Philippines	133922	118992	130000	122200	117361	124495	0.93	0.79	0.87	0.82	0.78	0.84
15	Ecuador	148205	190696	87350	48190	132939	121476	0.39	0.50	0.23	0.12	0.35	0.32
16	Peru	96697	106520	112890	119905	144872	116177	0.59	0.60	0.61	0.64	0.61	0.61
17	Cameroon	74000	104121	55261	112532	98000	88783	0.30	0.39	0.18	0.38	0.33	0.31
18	Kenya	95400	97976	68642	53715	70900	77327	0.59	0.55	0.39	0.30	0.40	0.45
19	Thailand	86233	75856	83897	78214	54871	75814	1.21	1.09	1.24	1.20	0.84	1.12
20	Papua New Guinea	59589	65091	64524	80940	83040	70637	1.19	1.12	0.74	0.93	0.95	0.99
21	Venezuela	65088	69422	57804	66840	79854	67802	0.36	0.38	0.32	0.33	0.36	0.35
22	Congo, Dem Republic of	84714	73975	70299	57446	48712	67029	0.37	0.32	0.37	0.37	0.32	0.35
23	Nicaragua	54587	49900	65169	65420	91791	65373	0.65	0.59	0.70	0.70	1.01	0.73
24	Madagascar	68000	68000	55000	60000	65000	63200	0.35	0.35	0.29	0.31	0.34	0.33
25	Tanzania	41971	52490	43568	38002	46670	44540	0.35	0.42	0.40	0.35	0.40	0.38
26	Dominican Republic	44877	41641	41682	56943	34609	43950	0.29	0.33	0.33	0.41	0.25	0.32

Country		Production (ton/yr)					Average annual production (ton/yr)	Yield (ton/ha)					Average yield (ton/ha)
		1995	1996	1997	1998	1999		1995	1996	1997	1998	1999	
27	Haiti	29000	27000	27000	27239	28000	27648	0.50	0.50	0.50	0.50	0.52	0.50
28	Sierra Leone	25025	25000	30700	26000	15350	24415	1.79	1.79	2.19	1.86	1.10	1.74
29	Burundi	25516	26875	20195	17035	30000	23924	0.73	0.79	0.70	0.61	0.94	0.75
30	Bolivia	20309	22035	23420	24333	22968	22613	0.86	0.93	0.98	0.98	0.93	0.94
31	Guinea	28000	22750	20000	20888	20888	22505	0.51	0.41	0.40	0.42	0.42	0.43
32	Cuba	17100	16680	19980	13500	22020	17856	0.20	0.20	0.24	0.19	0.26	0.22
33	Rwanda	21952	15285	14830	14268	18800	17027	1.10	0.76	0.74	0.57	0.70	0.78
34	Togo	12080	22400	10600	20000	7000	14416	0.25	0.46	0.22	0.41	0.35	0.34
35	Laos	8576	10020	12300	16999	17530	13085	0.43	0.43	0.53	0.59	0.60	0.52
36	Central African Republic	9000	18000	15000	12037	11260	13059	0.47	0.72	0.60	0.48	0.45	0.54
37	Puerto Rico	12701	12175	11567	13393	12800	12527	0.39	0.38	0.35	0.44	0.42	0.40
38	Malaysia	11300	11500	11700	12000	13000	11900	0.76	0.77	0.78	0.77	0.79	0.77
39	Sri Lanka	11481	11760	11348	10498	10580	11133	0.69	0.71	0.69	0.65	0.65	0.68
40	Panama	11067	10478	9893	10800	11390	10726	0.44	0.43	0.38	0.45	0.35	0.41
41	Yemen	8993	10600	10325	11283	11182	10477	0.33	0.36	0.33	0.35	0.34	0.34
42	Zimbabwe	7860	11500	9300	10000	10000	9732	1.57	1.77	1.43	1.47	1.47	1.54
43	Paraguay	4008	4024	4823	4750	7885	5098	0.67	0.67	0.80	0.79	0.79	0.75
44	Ghana	3000	6330	2880	8370	3965	4909	0.30	0.42	0.40	0.40	0.21	0.35
45	China	3196	3023	3573	6237	7000	4606	0.53	0.55	0.48	1.42	1.40	0.88
46	Malawi	5460	4797	4552	3840	3540	4438	1.37	1.23	1.23	1.20	1.18	1.24
47	Nigeria	3900	4100	4000	4000	4000	4000	0.50	0.50	0.50	0.50	0.50	0.50
48	Equatorial Guinea	4500	4000	3400	3300	3500	3740	0.37	0.36	0.36	0.36	0.37	0.36
49	Angola	3300	2820	3840	5100	3300	3672	0.04	0.03	0.03	0.04	0.04	0.04
50	Liberia	3000	3000	3000	3000	3000	3000	0.20	0.20	0.20	0.20	0.20	0.20
51	United States of America	1960	2320	3260	3450	3630	2924	0.90	1.08	1.44	1.40	1.40	1.24
52	Zambia	1620	2100	2400	3660	2940	2544	0.90	1.05	1.09	1.22	1.05	1.06
53	Jamaica	2580	2580	2887	1740	2400	2437	0.47	0.46	0.51	0.44	0.48	0.47
54	Myanmar	1550	1550	1696	1913	1714	1685	0.42	0.42	0.41	0.47	0.41	0.43

	Country	Production (ton/yr)					Average annual production (ton/yr)	Yield (ton/ha)					Average yield (ton/ha)
		1995	1996	1997	1998	1999		1995	1996	1997	1998	1999	
55	Congo, Republic of	1606	1600	1338	850	1490	1377	0.46	0.47	0.42	0.27	0.30	0.38
56	Mozambique	900	950	1000	1000	1000	970	0.69	0.70	0.71	0.71	0.71	0.71
57	Trinidad and Tobago	831	352	1102	367	343	599	0.14	0.14	0.18	0.13	0.12	0.14
58	Dominica	350	360	360	360	370	360	0.86	0.88	0.88	0.88	0.89	0.88
59	Cambodia	200	250	280	290	300	264	0.78	0.83	0.80	0.81	0.82	0.81
60	Guyana	300	285	261	136	140	224	0.60	0.57	0.50	0.39	0.40	0.49
61	Benin	200	200	200	200	200	200	0.20	0.20	0.20	0.20	0.20	0.20
62	Saint Vincent/Grenadines	160	160	160	160	170	162	0.38	0.38	0.38	0.38	0.40	0.38
63	Gabon	159	219	154	120	120	154	0.27	0.37	0.26	0.24	0.24	0.27
64	Comoros	92	94	94	96	96	94	0.15	0.15	0.15	0.15	0.15	0.15
65	Belize				93	70	54				3.88	1.75	1.13
66	Vanuatu	30	40	40	50	50	42	0.75	0.80	0.80	0.83	0.83	0.80
67	Sao Tome and Principe	17	21	45	50	58	38	0.08	0.08	0.14	0.13	0.13	0.11
68	Martinique	35	35	40	40	40	38	2.50	2.50	2.50	2.50	2.50	2.50
69	New Caledonia	44	37	25	43	39	38	0.13	0.13	0.13	0.13	0.13	0.13
70	Nepal	20	29	37	56	45	37	0.10	0.13	0.14	0.21	0.16	0.15
71	Suriname	50	45	33	11	10	30	0.26	0.20	0.14	0.05	0.05	0.14
72	Guadeloupe	23	23	23	23	23	23	0.23	0.23	0.23	0.23	0.23	0.23
73	Cook Islands	15	20	15	10	5	13	0.75	1.33	1.00	0.67	0.33	0.82
74	French Polynesia	10	10	11	16	18	13	0.20	0.20	0.22	0.20	0.20	0.20
75	Samoa	13	12	11	10	9	11	0.19	0.20	0.22	0.25	0.27	0.23
76	Fiji Islands	10	10	10	10	10	10	0.50	0.50	0.50	0.50	0.50	0.50
	Total						6201976						

Appendix II. Virtual water content of coffee produced with the wet production method by country of origin.

Countries	Crop water require-ment	Yield of fresh cherry	Virtual water content of cherry	pf	Virtual water content of pulped cherry	Water used for pulping, soaking & washing	pf	Virtual water content of wet parchment coffee	pf	Virtual water content of dry parchment coffee	pf	Virtual water content of hulled beans	pf	Yield of green coffee	Virtual water content of green coffee	pf	Virtual water content of roasted coffee	Product-ion
	mm	ton/ha	m^3/ton	ton/ton	m^3/ton	m^3/ton	ton/ton	m^3/ton	ton/ton	m^3/ton	ton/tn	m^3/ton	ton/ton	ton/ha	m^3/ton	ton/tn	m^3/ton	ton/yr
	A	B	C	D	E	E1	F	G	H	I	J	K	L	M	N	O	P	Q
Brazil	1277	4.22	3028	0.44	6882	22	0.90	7671	0.506	15159	0.90	16844	0.89	0.677	18925	0.84	22530	1370232
Colombia	893	4.61	1939	0.44	4406	22	0.90	4920	0.506	9723	0.90	10803	0.89	0.74	12139	0.84	14451	689688
Indonesia	1455	3.41	4268	0.44	9699	22	0.90	10802	0.506	21347	0.90	23719	0.89	0.55	26650	0.84	31727	466214
Vietnam	938	11.63	807	0.44	1833	22	0.90	2061	0.506	4074	0.90	4526	0.89	1.87	5086	0.84	6054	384220
Mexico	1122	2.88	3898	0.44	8859	22	0.90	9868	0.506	19502	0.90	21669	0.89	0.46	24347	0.84	28985	329297
Guatamala	1338	5.60	2388	0.44	5428	22	0.90	6055	0.506	11967	0.90	13296	0.89	0.90	14940	0.84	17786	240222
Uganda	1440	5.25	2741	0.44	6230	22	0.90	6947	0.506	13729	0.90	15254	0.89	0.84	17139	0.84	20404	229190
Ethiopia	1151	5.65	2036	0.44	4628	22	0.90	5167	0.506	10212	0.90	11346	0.89	0.91	12749	0.84	15177	227078
India	754	5.08	1485	0.44	3375	22	0.90	3774	0.506	7459	0.90	8288	0.89	0.81	9312	0.84	11086	220200
Costarica	1227	9.14	1342	0.44	3051	22	0.90	3414	0.506	6748	0.90	7497	0.89	1.47	8424	0.84	10028	157188
Hondurus	1483	4.87	3044	0.44	6919	22	0.90	7712	0.506	15241	0.90	16935	0.89	0.78	19028	0.84	22652	154814
El Salvador	1417	5.28	2685	0.44	6102	22	0.90	6805	0.506	13448	0.90	14942	0.89	0.85	16789	0.84	19987	138121
Ecuador	1033	1.98	5225	0.44	11875	22	0.90	13219	0.506	26125	0.90	29028	0.89	0.32	32616	0.84	38828	121476
Peru	994	3.80	2612	0.44	5937	22	0.90	6621	0.506	13084	0.90	14538	0.89	0.61	16335	0.84	19446	116177
Thailand	1556	6.96	2236	0.44	5082	22	0.90	5671	0.506	11208	0.90	12453	0.89	1.12	13993	0.84	16658	75814
Venezuala	1261	2.19	5756	0.44	13082	22	0.90	14560	0.506	28775	0.90	31972	0.89	0.35	35923	0.84	42766	67802
Nicaraguwa	1661	4.55	3649	0.44	8294	22	0.90	9240	0.506	18260	0.90	20289	0.89	0.73	22797	0.84	27139	65373
Madagascar	1164	2.04	5692	0.44	12935	22	0.90	14397	0.506	28453	0.90	31614	0.89	0.33	35521	0.84	42287	63200
Tanzania	1422	2.38	5964	0.44	13555	22	0.90	15085	0.506	29812	0.90	33125	0.89	0.38	37219	0.84	44308	44540
Bolivia	1093	5.84	1874	0.44	4258	22	0.90	4756	0.506	9398	0.90	10443	0.89	0.94	11733	0.84	13968	22613
Togo	1409	2.12	6643	0.44	15097	22	0.90	16799	0.506	33199	0.90	36887	0.89	0.34	41447	0.84	49341	14416
Sri Lanka	1426	4.22	3379	0.44	7680	22	0.90	8558	0.506	16913	0.90	18793	0.89	0.68	21115	0.84	25137	11133
Panama	1294	2.55	5068	0.44	11517	22	0.90	12822	0.506	25339	0.90	28155	0.89	0.41	31634	0.84	37660	10726
Ghana	1381	2.16	6402	0.44	14549	22	0.90	16190	0.506	31996	0.90	35552	0.89	0.35	39946	0.84	47554	4909
USA	938	7.74	1212	0.44	2754	22	0.90	3085	0.506	6097	0.90	6774	0.89	1.24	7611	0.84	9061	2924
Average*	1195	4.53	2820		6409			7145		14121		15690		0.798	17629		20987	
*Country data have been weighted on the basis of their total green coffee production																Total production:		5227567

See notes to the table on the next page.

Notes to the table on the previous page.

	Parameter:	Source:
A	Crop water requirement (mm)	FAO (2003a)
B	Yield of fresh cherry (ton/ha)	Back calculated from yield of green coffee (M)
C	Virtual water content of cherry (m^3/ton)	C=10xA/B
D	Product fraction (ton of pulped cherry per ton of fresh cherry).	Bressani (2003). See also GTZ (2002a): 400 kg wet parchment coffee per 1000 kg of fresh cherry.
E	Virtual water content of pulped cherry (m^3/ton).	E=C/D
E1	Water use for pulping, soaking and washing (m^3 per ton of pulped cherry).	The Roast and Post Coffee Company (2003): 10 m^3 of water for soaking and washing per ton of (dry parchment) coffee, which is equivalent to 4.6 m^3 of water per ton of pulped cherry. Further we assume a need of 7.5 m^3 of water for pulping per ton of fresh cherry - based on GTZ (2002b) - which is equivalent to 17 m^3 of water per ton of pulped cherry.
F	Product fraction (ton of wet parchment coffee per ton of pulped cherry).	Bressani (2003)
G	Virtual water content of wet parchment coffee (m^3/ton).	G=(E+E1)/F
H	Product fraction (ton of dry parchment coffee per ton of wet parchment coffee).	GTZ (2002c): wet parchment coffee with a moisture content of about 55% is processed into dry parchment coffee with a moisture content of about 11%. [This means: dry parchment coffee = 45% / 89% of wet parchment coffee.]
I	Virtual water content of dry parchment coffee (m^3/ton).	I=G/H
J	Product fraction (ton of hulled beans per ton of dry parchment coffee).	GTZ (2002a): 1000 kg of dry parchment coffee gives 750-800 kg of exportable green beans; we assume 10% weight reduction due to hulling.
K	Virtual water content of hulled beans (m^3/ton).	K=I/J
L	Product fraction (ton of green coffee per ton of hulled beans).	GTZ (2002a): 1000 kg of dry parchment coffee gives 750-800 kg of exportable green beans; we assume 11% weight reduction due to sorting.
M	Yield of green coffee (ton/ha).	FAO (2003c)
N	Virtual water content of green coffee (m^3/ton).	N=K/L or N=10xA/M
O	Product fraction (ton of roasted coffee per ton of green coffee).	GTZ (2002a): 1000 kg of green beans gives 840 kg of roasted coffee. ICO (2003) & Hicks (2001): roasting causes on average a 16% loss in weight. Sovrana (2003): with roasting the weight of green coffee drops by about 18-20%.
P	Virtual water content of roasted coffee, expressed in cubic metre per ton.	P=N/O

Appendix III. Virtual water content of coffee produced with the dry production method by country of origin.

Countries	Crop water requirement	Yield of fresh cherry	Virtual water content of cherry	*pf*	Virtual water content of dried cherry	*pf*	Virtual water content of hulled beans	*pf*	Virtual water content of green coffee	*pf*	Virtual water content of roasted coffee	Production
	mm	ton/ha	m^3/ton	ton/ton	m^3/ton	ton/ton	m^3/ton	ton/ton	m^3/ton	ton/ton	m^3/ton	ton/yr
	A	B	C	D	E	F	G	H	I	J	K	L
Brazil	1277	4.22	3028	0.361	8395	0.50	16790	0.89	18865	0.84	22458	1370232
Colombia	893	4.61	1939	0.361	5375	0.50	10750	0.89	12078	0.84	14379	689688
Indonesia	1455	3.41	4268	0.361	11833	0.50	23665	0.89	26590	0.84	31655	466214
Vietnam	938	11.63	807	0.361	2236	0.50	4472	0.89	5025	0.84	5982	384220
Mexico	1122	2.88	3898	0.361	10808	0.50	21615	0.89	24287	0.84	28913	329297
Guatemala	1338	5.60	2388	0.361	6621	0.50	13243	0.89	14880	0.84	17714	240222
Uganda	1440	5.25	2741	0.361	7600	0.50	15200	0.89	17079	0.84	20332	229190
Ethiopia	1151	5.65	2036	0.361	5646	0.50	11293	0.89	12688	0.84	15105	227078
India	754	5.08	1485	0.361	4117	0.50	8234	0.89	9252	0.84	11014	220200
Costa Rica	1227	9.14	1342	0.361	3722	0.50	7444	0.89	8364	0.84	9957	157188
Hondurus	1483	4.87	3044	0.361	8441	0.50	16881	0.89	18968	0.84	22581	154814
El Salvador	1417	5.28	2685	0.361	7444	0.50	14888	0.89	16729	0.84	19915	138121
Ecuador	1033	1.98	5225	0.361	14487	0.50	28974	0.89	32555	0.84	38756	121476
Peru	994	3.80	2612	0.361	7242	0.50	14484	0.89	16275	0.84	19374	116177
Thailand	1556	6.96	2236	0.361	6200	0.50	12400	0.89	13932	0.84	16586	75814
Venezuala	1261	2.19	5756	0.361	15959	0.50	31918	0.89	35863	0.84	42694	67802
Nicaragua	1661	4.55	3649	0.361	10118	0.50	20235	0.89	22736	0.84	27067	65373
Madagascar	1164	2.04	5692	0.361	15780	0.50	31560	0.89	35461	0.84	42216	63200
Tanzania	1422	2.38	5964	0.361	16536	0.50	33071	0.89	37159	0.84	44236	44540
Bolivia	1093	5.84	1874	0.361	5195	0.50	10389	0.89	11673	0.84	13897	22613
Togo	1409	2.12	6643	0.361	18417	0.50	36834	0.89	41386	0.84	49269	14416
Sri Lanka	1426	4.22	3379	0.361	9369	0.50	18739	0.89	21055	0.84	25066	11133
Panama	1294	2.55	5068	0.361	14050	0.50	28101	0.89	31574	0.84	37588	10726
Ghana	1381	2.16	6402	0.361	17749	0.50	35498	0.89	39885	0.84	47483	4909
USA	938	7.74	1212	0.361	3360	0.50	6720	0.89	7551	0.84	8989	2924
Average*	1195	4.53	2820		7818		15636		17569		20915	
* Country data have been weighted on the basis of their total green coffee production.										Total production:		5227567

See notes to the table on the next page.

Notes to the table on the previous page.

	Parameter:	Source:
A	Crop water requirement (mm)	FAO (2003a)
B	Yield of fresh cherry (ton/ha)	See column B in Appendix II.
C	Virtual water content of cherry (m^3/ton).	C=10xA/B
D	Product fraction (ton of dried cherry per ton of fresh cherry).	Hicks (2001)
E	Virtual water content of dried cherry (m^3/ton).	E=C/D
F	Product fraction (ton of hulled beans per ton of dried cherry).	Hicks (2001)
G	Virtual water content of hulled beans (m^3/ton).	G=E/F
H	Product fraction (ton of green coffee per ton of hulled beans).	See column L in Appendix II.
I	Virtual water content of green coffee (m^3/ton).	I=G/H
J	Product fraction (ton of roasted coffee per ton of green coffee).	GTZ (2002a): 1000 kg of green beans gives 840 kg of roasted coffee. ICO (2003) & Hicks (2001): roasting causes on average a 16% loss in weight. Sovrana (2003): with roasting the weight of green coffee drops by about 18-20%.
K	Virtual water content of roasted coffee (m^3/ton).	K=I/J

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

Origin	Import of coffee (ton/yr)				Virtual water content* (m^3/ton)		Virtual water import (10^6 m^3/yr)	Share of total import volume (%)
	090111	090112	090121	090122				
	Green coffee		Roasted coffee		Green coffee	Roasted coffee		
Belgium-Luxemburg	23632	711	7506	1184	17629	20987	612	21
Brazil	22492				18925	22530	426	14
Germany	285	2694	13047	2560	17629	20987	380	13
Colombia	26691				12139	14451	324	11
Guatemala	10612				14940	17786	159	5
El Salvador	9202				16789	19987	154	5
Indonesia	4742	20	2		26650	31727	127	4
Togo	2386				41447	49341	99	3
Tanzania	2475				37219	44308	92	3
Mexico	3485		16		24347	28985	85	3
Costa Rica	8949				8424	10028	75	3
Nicaragua	3212				22797	27139	73	2
Peru	4366		26		16335	19446	72	2
Honduras	2539				19028	22652	48	2
India	3698	40		86	9312	11086	36	1.2
France	75	1787	62	10	17629	20987	34	1.2
Uganda	1851	24			17139	20404	32	1.1
Italy	23		837	37	17629	20987	19	0.6
Ecuador	577				32616	38828	19	0.6
Singapore	1014				17629	20987	18	0.6
Hungary	709		13		17629	20987	13	0.4
Thailand	860				13993	16658	12	0.4
Bolivia	662		4		11733	13968	8	0.3
Madagascar	223				35521	42287	8	0.3
Venezuela	192				35923	42766	7	0.2
Ghana	136				39946	47554	5	0.2
Austria	5		135		17629	20987	3	0.1
Spain	38		97		17629	20987	3	0.1
Switzerland-Liecht.	15		59	7	17629	20987	2	0.06
USA		47	46	3	7611	9061	1	0.03
South Africa	69				17629	20987	1	0.04
Greece			46		17629	20987	1	0.03
Denmark		9	35		17629	20987	1	0.03
Panama	40				31634	37660	1	0.04

Origin	Import of coffee (ton/yr)				Virtual water content* (m^3/ton)		Virtual water import (10^6 m^3/yr)	Share of total import volume (%)
	090111	090112	090121	090122				
	Green coffee		Roasted coffee		Green coffee	Roasted coffee		
Sri Lanka	38				21115	25137	1	0.03
Russian Federation	36				17629	20987	1	0.02
United Kingdom	21		15		17629	20987	1	0.02
Croatia			28		17629	20987	1	0.02
Norway			23		17629	20987	0.5	0.02
Sweden	12		11		17629	20987	0.4	0.02
Canada	12				17629	20987	0.2	0.01
Portugal			10		17629	20987	0.2	0.01
Finland	4				17629	20987	0.1	0.002
Oman	4				17629	20987	0.1	0.002
Total	135381	5331	22020	3887			**2953**	100
				Weighted average	**17135**	**20399**		

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

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

Destination	Export of coffee (ton/yr)				Virtual water content* (m^3/ton)		Virtual water export (10^6 m^3/yr)	Share of total export volume (%)
	090111	090112	090121	090122				
	Green coffee		Roasted coffee		Green coffee	Roasted coffee		
Belgium-Luxemburg	1057	357	1361	1053	17135	20399	73.5	23.4
United Kingdom	1212	53	1832	102	17135	20399	61.1	19.5
Germany	1861	81	987	103	17135	20399	55.5	17.7
France	1600	90	459	19	17135	20399	38.7	12.3
Sweden	2		806	13	17135	20399	16.8	5.3
Spain	552	5	15	53	17135	20399	10.9	3.5
Denmark	183	9	287	36	17135	20399	9.9	3.1
USA	367	35	23	13	17135	20399	7.6	2.4
Russian Federation	28		314		17135	20399	6.9	2.2
Italy	117		105	5	17135	20399	4.3	1.4
Norway			199	2	17135	20399	4.1	1.3
Finland	5		135		17135	20399	2.9	0.9
Netherlands Antilles		20	75	7	17135	20399	2.0	0.6
Austria	70		18		17135	20399	1.6	0.5
Lithuania	42	10	24		17135	20399	1.4	0.4
Czech Republic	73				17135	20399	1.2	0.4
Greece			71		17135	20399	1.5	0.5
Aruba			70		17135	20399	1.4	0.5
Portugal	5		59		17135	20399	1.3	0.4
Turkey	8		42		17135	20399	1.0	0.3
Estonia			47		17135	20399	1.0	0.3
Ireland	5		14	26	17135	20399	0.9	0.3
Oman		32	6		17135	20399	0.7	0.2
Switzerland-Liecht.	11	20	5		17135	20399	0.7	0.2
South Africa	15		21		17135	20399	0.7	0.2
Hungary			26	9	17135	20399	0.7	0.2
Croatia	9		21		17135	20399	0.6	0.2
Romania	9		19		17135	20399	0.5	0.2
Ukraine			24		17135	20399	0.5	0.2
Israel	10		13		17135	20399	0.4	0.14
Australia		18			17135	20399	0.3	0.10
Brunei			18		17135	20399	0.4	0.12
Saudi Arabia	7		7		17135	20399	0.3	0.09
Singapore			14		17135	20399	0.3	0.09

Destination	Export of coffee (ton/yr)				Virtual water content* (m^3/ton)		Virtual water export (10^6 m^3/yr)	Share of total export volume (%)
	090111	090112	090121	090122				
	Green coffee		Roasted coffee		Green coffee	Roasted coffee		
Latvia			13		17135	20399	0.3	0.08
Cyprus			10		17135	20399	0.21	0.07
Japan			10		17135	20399	0.20	0.06
Sri Lanka			10		17135	20399	0.20	0.06
Hong Kong			9		17135	20399	0.18	0.06
Taiwan			9		17135	20399	0.18	0.06
Belarus			8		17135	20399	0.16	0.05
Bulgaria			7		17135	20399	0.13	0.04
Egypt			6		17135	20399	0.12	0.04
Kazakhstan			6		17135	20399	0.11	0.04
Tunisia			5		17135	20399	0.10	0.03
Angola			5		17135	20399	0.09	0.03
United Arab Emirates			5		17135	20399	0.09	0.03
Cape Verde	4				17135	20399	0.07	0.02
Libya			3		17135	20399	0.07	0.02
Canada			2		17135	20399	0.04	0.01
South Korea				1	17135	20399	0.03	0.01
Uzbekistan				1	17135	20399	0.02	0.01
Area, not else specified			5		17135	20399	0.11	0.04
Total	7252	731	7229	1444	17135	20399	**314**	100

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