Assessing the Water Footprint of Tofu Produced from Organically Cultivated Crops

Ilyass Usman

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Author: Ilyass Usman

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ABSTRACT

This study employs a comprehensive approach in analysing products' water footprint. Today, millions of people around the globe are without adequate and safe freshwater supply, which is rightly captured in the Millennium Development Goals. This phenomenon can be attributed to myriads of factors including pollution from point and diffuse sources, inadequate sanitation systems as well as climate variability. Addressing these impediments requires a holistic approach that involves not only direct water pollution of any activity or products but also the use of freshwater from the root of a product.

Semi-structured interviews, questionnaires and a number of scientific papers and reports were used to collate information. The data includes countries of origin of primary crops, soy sauce, conditions of primary crop cultivation (irrigation vs. rain-fed) as well as OY Soya AB's own production processes.

The study investigates the volume of freshwater needed to produce 270 g of tofu using organically cultivated crops. The investigations revealed, inter alia, that the indirect water footprint associated with the production of tofu contributed approx. 90 % of OY Soya AB's annual freshwater use. Averagely, 250 litres of freshwater (0.25 m³) is needed to produce a packaged tofu (270 g).

Keywords: water footprint, water users, millennium development goals, indirect water footprint, direct water footprint, sustainable development.

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GLOSSARY AND ABBREVIATIONS

3Rs	Reduce, Recycle, Reuse
CFCs	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon dioxide
CSR	Corporate Social Responsibility
CWR	Crop Water Requirement
CWU	Crop Water Use
EAP	Ecological Agricultural Project
EF	Ecological Footprint
ESD	Education for Sustainable Development
EU	European Union
FAO	Food and Agricultural Organization
g	Gram
GHG	Greenhouse gas
ha.	Hectare
HFCs	Hydrofluorocarbons
JOAA	Japan Organic Agricultural Association
Kg	Kilogram
KWH	Kilowatt-hour
l	Litre
LDCs	Least Developed Countries
lgp	Length of Growing Period
m^3	Cubic metres
MDG	Millennium Development Goals
mm	millimetre
MWH	Megawatt-hour
N_2O	Nitrous Oxide
PAS2050	Publicly Available Specification 2050
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride
t	Ton
UN	United Nations

UNEP	United Nations Environment Program
WF	Water Footprint
yr	Year.

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1 INTRODUCTION

1.1 Background

It is an undeniable fact that the earth is endowed with abundant water. Nevertheless, about 97.5 % of global water distributions consist of saltwater mostly found in the oceans. Freshwater, which is found in the ground, rivers and lakes, and in the permafrost of the polar caps or glaciers, represent only 2.5% of the total water on earth (Lundin, Hultman, & Eriksson, 2009). Interestingly, 69.4% of the total freshwater exists in the form of ice, and as such it is not directly accessible for the use of humanity (Lundin et. al., 2009). Meanwhile, about 99% of the remaining fresh water exists in the ground water aquifers, which indicates that the total amount of surface freshwater on earth is less than 1%. (Lundin et. al., 2009). Water distribution in the hydrosphere has been presented in **Appendix I**.

In terms of per capita, the Finnish consumer has one of the largest water footprints in Scandinavia. The water footprint of the average Finn is 1 727 m³/capita/yr, while the global average amounts to 1 243m³/capita/yr (Hoekstra & Chapagain, 2008). The average water footprint for Swedish consumers amounts to 1 621 m³/capita/yr, Norwegian 1 467 m³/capita/yr, Danish 1 440 m³/capita/yr and Icelandic ones 1 327 m³/capita/yr (Hoekstra & Chapagain, 2008)

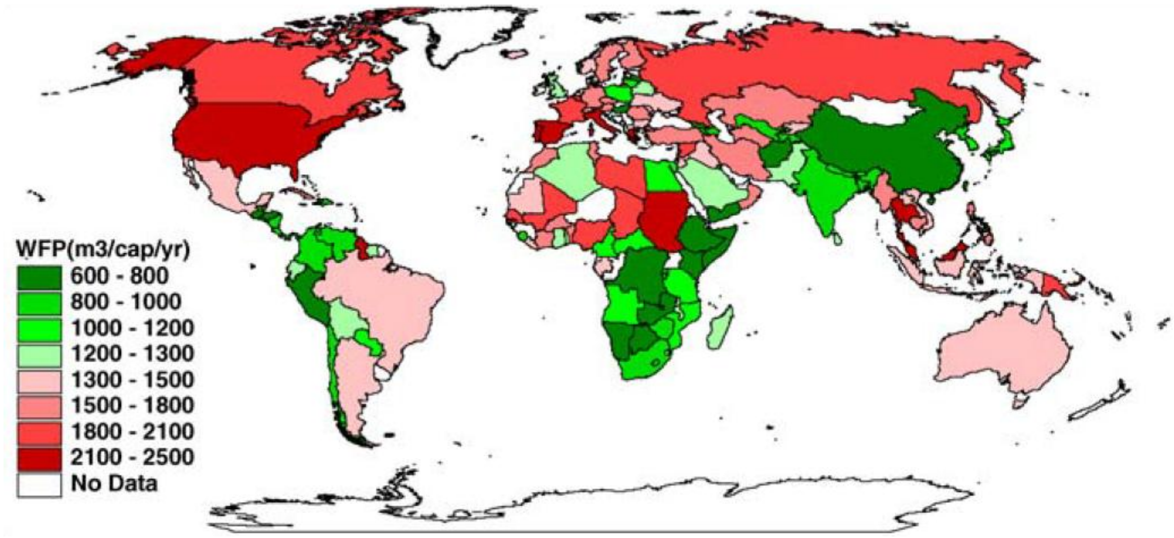


Figure 1 *Nations' water footprint per capita (m³/capita/year).Green indicates nations with per capita water footprint below global average; while countries in red have per capita water footprint greater than global average (Hoekstra & Chapagain, 2006).*

Undoubtedly, the most common, but essential aspect of life is water. It is life, a source of poverty alleviation, development and a major tool for global peace and security. We live in an era when the global community is faced with enormous challenges to ensure adequate supply and better access to safe drinking water as well as sanitation services to billions of people. Hence, the UN's declaration of 2005-2015 "*water for life*" decade ;(Annan, 2005). This has been rightly captured in the Millennium Development Goals (MDGs) and several other treaties and resolutions at global, regional and local levels such as EU Water Framework Directive, UN Convention on the Non-Navigational Uses of International Watercourses, and Nile Basin Initiative. It has been predicted that with adequate improvement in the water quality, ensuring efficiency and equitable distribution of the resource will go a long way in helping individual nations achieve their developmental targets. This will indeed lead to improving the standard of living thereby ensuring poverty alleviation. However, for better management and improved access to safe drinking water, there are myriads of tools and instruments needed by the water manager (Taylor, Gabbrielli & Holmberg, 2008).

It is equally important to understand that freshwater withdrawals have increased more than twice faster than population growth, and currently, ⅓ of the global population live in countries that experience medium to high water stress especially in Least Developed Countries (LDCs) (Taylor et al. 2008). Pollution is further exacerbating the problem of freshwater scarcity, reducing water usability downstream. The concerns about climate change and climate variability require punitive measures and improved management systems of water resources in order for humanity to adapt and cope with more intense droughts and floods.

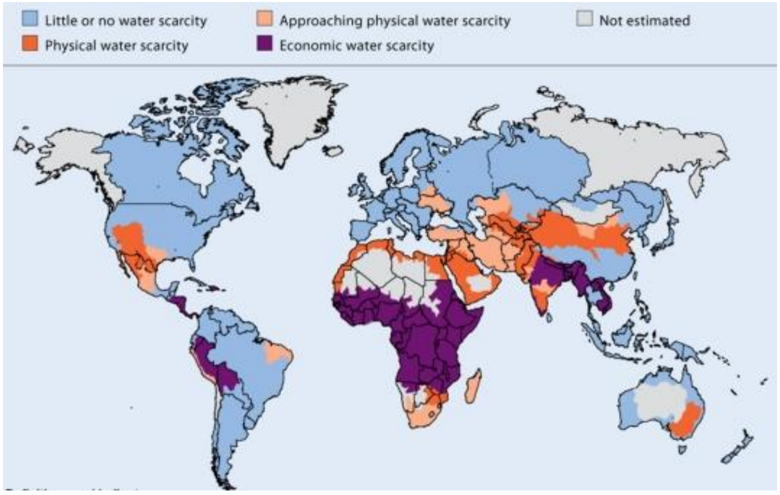


Figure 1.1 *Areas with physical and economic water scarcity. Source: UNEP, 2007.*

- ***Little or no water scarcity**: indicates areas with abundant water resources relative to use – less than 25% of water is withdrawn for human use.*
- ***Physical water scarcity**: more than 75% of freshwater is withdrawn for agriculture, industry and domestic purposes.*
- ***Approaching physical water scarcity**: more than 60% river flows are withdrawn. Areas experiencing this phenomenon will witness water scarcity in the near future.*
- ***Economic water scarcity**: this is associated with inadequate human, institutional and financial capital. These factors limit access to water despite the availability of the resource locally to meet human demand. Less than 25% of the water from rivers is withdrawn (UNEP, 2007).*

From a layman's perspective, however, water scarcity is directly associated with lack of drinking water (Savenije, 1998). This misconception is based on the man-freshwater relationship; as such, the reasons are not farfetched. Drinking water in terms of quantity is relatively very small. The notion which most people, including media and socio-political commentators create as the major reason for freshwater need is that of thirst. We read in the newspapers, on the internet and watch images on televisions, showing long queues of people to collect a gallon of water, or people walking long distances in search of drinking water. Of 1 243 m^3/capita/year of global average, about 1 % of the total is used as drinking water; the remaining 99 % is used in the production of consumer goods and services (Chapagain & Hoekstra, 2010). Water consumption and pollution can be associated with specific activities, such as irrigation, bathing, washing, cleaning, cooling and processing (Hoekstra, Chapagain, Aldaya & Mekonnen 2009).

1.2 The concept of water footprint

In 2002, Arjen Y. Hoekstra et. al., introduced the concept of water footprint, indicating the process of understanding and measuring freshwater use along the full supply chain. This idea gained widespread recognition for individuals and cooperate entities in their quest for freshwater appropriation. It is worth noting that understanding the total volume of fresh water needed to produce a given consumer goods or services is the only way forward through which efficiency and the resource appropriation can be assured. Water footprint of a product is therefore defined as the total volume of fresh water needed to produce the product throughout the entire production chain (Hoekstra et. al., 2009).

It is imperative to note that problems associated with freshwater pollutions are not independent from activities of humankind such as agriculture, industries and households. Conventionally, government agencies and ministries responsible for water management have directed all their efforts and policies towards what could be termed as 'water users' (households' and businesses' own use of freshwater). This approach has been the tradition over the years. Invariably, the approach has limitations (Hoekstra & Chapagain, 2007, 2008). The targeted scope is indeed narrow, neglecting major players of freshwater users including all business activities, retailers, traders and final consumers in the supply and production chain. This means that goods such as cotton, meat, wheat, cheese, leather, pulp, coffee, etc., which contribute significantly to water use and pollution, have been ignored in the governments' management policies. Meanwhile, global water resource use is directly linked to consumption of goods and services. In this regard, there is therefore the need for a concerted effort to integrate all stakeholders in the mitigation processes with the aim of understanding and/or identifying especially water-intensive consumer goods and services.

In view of a holistic approach towards sustainable use and management of freshwater, the 'water footprint' concept has been identified as a parameter that does not only look at the use of water from a narrow perspective but also from the point of view of the entire production chain of both direct and indirect use of freshwater (Hoekstra, 2003). In this regard, the water footprint of a country, community, organization, project or an individual is defined as the total amount of freshwater that is used to produce the goods and services consumed by the country, community, individual or produced by a business (Hoekstra et. al., 2009).

Global freshwater distribution has both a spatial and a temporal dimension; thus, freshwater availability is directly dependent on time and place. The distribution is accessed and measured in terms of space (place or geographic location) and time (the period of access and measurement) (Hoekstra et. al., 2009). In this sense, the measurement of water footprint is expressed in terms of freshwater volumes consumed (evaporated) and/or polluted per unit of time. This means that the water footprint does not only show the volume of freshwater used or polluted, but also includes the locations where the water was extracted from. This process can be used to calculate water footprint for any well-defined group of producers (e.g. public organization, private enterprise or economic sector) or consumers (e.g. an individual, family, village, city, province, nation or state). The water footprint of a product is therefore defined as the total volume of fresh water used to produce the product, measured at a place where the product is actually produced and including the whole production chain (Hoekstra & Chapagain, 2009).

1.3 Components of water footprint

Unlike ecological footprint (Box 1) which has six components (built up lands, grazing land, forest land, fishing grounds, crop land, and carbon sinks) and carbon footprint (Box 2) which also has six components, otherwise known as 'Kyoto basket of six' (carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6), water footprint can only boast of three components; thus, blue, green and grey water footprints (Wackernagel, 2010, GHG Protocol, 2011 & Hoekstra, 2009).

Box 1 *Components of Ecological Footprint*

Ecological Footprint (EF) analysis is a method of calculating society's use of nature's assets (Wackernagel, 2010). It compares humanity's EF (the demand our consumption of consumer goods and services places on the biosphere) with biocapacity (the biospheres ability to respond and meet these demands), this analysis in a way provides a kind of statement of account for the planet (Wackernagel, 2010). EF encompasses six components: 1- Built-up land; 2- Carbon uptake land; 3- Cropland; 4- Grazing land; 5- Forest; 6- Fishing ground (Global footprint Network, 2009). It is indeed disturbing to understand that, today, less than 20% of global population live in the countries whose ecosystems can absorb their emissions greenhouse gases comparative to 1960s (Wackernagel, 2010). Statistics show that, humanity is using resources and turning them into wastes faster than the earth's living systems can absorb. The results of 2006 of global EF show that, our footprint now overshoots biocapacity by 41% (Wackernagel, 2010). This indicate, inter alia, that the planet living systems need to grow for about a year and five months to meet the demand we are placing on then in a single year (Wackernagel, 2010). In ***Herman Daly's*** words "we are going to have to think of ourselves as a subsystem, part of the natural world and that we depend upon it in two ways: we'll have to take from the natural world resources at a rate at which the natural world can regenerate and we'll have to throw back the wastes from using those natural resources at a rate the natural world can assimilate".

1.3.1 Blue water footprint

The blue water footprint refers to the volume of groundwater or fresh surface water consumed per unit of time or per product unit (Hoekstra, 2009). The process of water footprint is usually expressed in water volume per unit of time. However, when it is divided by the quantity of products that resulted from the process, it is then expressed as water volume per product unit. The most common term in blue water footprint is 'consumptive water use' which refers to one of the following:

- Water evaporates or transpires through plants' stomata;
- Water is embedded or incorporated in the product (virtual water);
- Water does not return to the same catchment area from where it has been extracted, but seldom it returns to a different catchment area or sea;
- Water does not return in the same period as it was extracted, for instance, it is withdrawn in dry season and returned in rain or wet season (Hoekstra, 2009).

Of all the four components of blue water stated above, the first, evaporation is by far the most significant in a water footprint of a product. Hence, the common use of the term 'consumptive water use' in relation to blue water footprint. Nevertheless, the remaining three components should be given much attention when dealing with specific cases such as water footprint of a nation or water footprint of national consumption. These two cases require adequate consideration of spatiotemporal explication of water footprint analysis. For instance, assessing water footprint for Ghana during the rainy season will differ significantly from the assessment conducted in dry season. It is important to understand that 'consumptive water use' does not necessarily mean that the water has disappeared in the system; it is always returned into the hydrological system in one form or another. Even the water we drink returns into the system in a different form. However, the question of its returning into the system at the same period and/or to the same area from where it has been withdrawn is what we need to find out.

It is equally necessary to understand that the amount of water that recharges groundwater aquifers and fresh water that flows through a river is not equally available at all times. These waters are used in agricultural activities for irrigation, households and industrial purposes. Water is indeed a renewable resource. However, its availability is limited (Hoekstra et al., 2009). In dry periods for example, one cannot consume more water than is available (Hoekstra, 2009). Therefore, the blue water footprint measures the amount of available water in a certain period that is used or consumed (i.e. not immediately returned within the same catchment area). By this process, it provides the total amount of water consumed by humankind. The unused groundwater and fresh surface water flows are therefore left to sustain ecosystems.

The blue water footprint in the process step is calculated as:

$$WF_{proc,\,blue} = BlueWaterEvaporation + BlueWaterIncorporation + LostReturnflow$$

1.3.2 Green water footprint

Green water refers to part of the precipitation (rain) that does not run off or recharge groundwater but stays in soil or vegetation (Hoekstra, 2009). Subsequently, this part of precipitation evaporates or transpires through plants' stomata. It is important to note that, not all precipitation is absorbed by plants, but a significant amount of the total precipitation returns into the hydrological system, and there will always be evaporation from the soil. Furthermore, crop water needs are not the same in all periods of the year (Hoekstra, 2009).

The green water footprint can, therefore, be defined as the total volume of rain water consumed during the production process. This is primarily relevant in agriculture and forestry-based products (thus, products based on crops or wood) (Hoekstra, 2009). The green water footprint is actually the total rain water evapotranspiration (from fields and plantations) plus water embedded into the harvested crop or wood (Hoekstra, 2009). Therefore, the green water footprint in the process step is illustrated as:

$$WF_{proc,\,green} = GreenWaterEvaporation + GreenWaterIncorporation$$

It is important to acknowledge that, there is a significant difference between blue and green water footprints as far as their economic and social impacts are concerned. The social and economic impacts of rain water on vegetation differ significantly from the impacts of irrigation using surface water nearby, especially in dry seasons (Hoekstra & Chapagain, 2008). It is important to understand that for instance, for a community in northern Ghana whose livelihood depends on a nearby river or stream, it will be a catastrophic move for a farmer or group of farmers to go into massive irrigational agriculture during the dry season. However, socioeconomic impacts on the said community cannot be the same if the activity takes place in the rainy season. Indeed, there will be supplementary green water for the crops as well as enough flow of the surface water (river). In the measurement of green water consumption, a set of empirical formulae or crop models are used to estimate the evapotranspiration based on climate, soil and crop characteristics data (Hoekstra, 2009).

1.3.3 Grey water footprint

The final component of water footprint is associated with what is commonly known as grey water footprint. The process step of this component indicates the degree of freshwater pollution that is associated with the production process of consumer goods and services stemming from the production chain. It is defined as the volume of freshwater that is required to assimilate the load of pollutants based on the existing ambient water quality standards (Hoekstra, 2009).

It is important to note that, once a pollutant gets into a freshwater body (either groundwater or surface freshwater); it is difficult, if not impossible, to extract or remove the pollutant. For instance, we can assume without admitting that if 50 000 kg of nitrate enters River Volta in Ghana, West Africa, due to massive application of nitrogen-based fertilizers within the catchment areas, it will be practically impossible to remove this pollutant (nitrate) from the river. What is required is extra freshwater from the main source of River Volta or from various tributaries or even precipitation to dilute the pollutants in the river. The grey water footprint is then calculated as the volume of fresh water that is required to dilute pollutants to such an extent that the quality of the ambient water remains above agreed water quality standards (Hoekstra, 2009). The grey water footprint can therefore be said to indicate the requirement of dilution water. It is an indicator of pollution; therefore, to have very low, if not nil of grey water footprint, it is important to drastically if not totally eradicate pollutants in water bodies.

The grey water footprint is calculated by dividing the total load of pollutant (L, in mass/time) by the difference between the ambient water quality standard for that pollutant (the maximum acceptable concentration C_{max}, in mass/volume) and its natural concentration in the receiving water body (C_{nat}, in mass/volume) (Hoekstra, 2009). This is illustrated as:

$$WF_{proc,\,grey} = \frac{L}{C_{max} - C_{nat}}$$

However, it is imperative to note that when chemicals are directly discharged into a surface water body, the total amount of load applied can be directly quantified. For instance, if 50 kg of a nitrogen-based fertilizer is applied on an agricultural field, it is then known that 50 kg of fertilizer has been applied. However, it is not all the 50 kg of the fertilizer that will pollute the surface fresh water through run-off, or ground water through leaching. It has been estimated that only 10 % of an applied unit of a nitrogen-based fertilizer pollutes the blue water (Aldaya & Hoekstra, 2010). In this case, the pollutant load is the fraction of the total amount of chemicals applied that reaches the ground or surface water (Hoekstra et al., 2009).

In the formula above, the natural concentration (C_{nat}) in receiving water body represents the concentration that would occur in the absence of human interference in a given catchment area (Hoekstra et al., 2009). In Sweden for instance, the maximum acceptable nitrate concentration (C_{max}) in freshwater is 50 mg/litre (Lundin et. al., 2009). However, it is possible to have an ambient water quality (C_{nat}) higher than the maximum allowable concentration set by policy-makers to for instance 35 mg/litre. It is, therefore, paramount to make reference to the natural concentration in the fact that the grey water footprint is an indicator of appropriate assimilation or dilution capacity. This assimilation capacity of a receiving water body depends on the difference between the maximum allowable and the natural concentration of a substance (Hoekstra et al., 2009). It is also important to consider the fact that pollution and concentration in a receiving water body is not constant over time as such, it changes with the change in magnitude of chemical application. Predictably, one can expect that massive application of nitrogen-based fertilizer will invariably result in high concentration of nitrate in water bodies nearby. However, the question that arises will be whether the assimilation capacity could cope with a period of higher concentration which is obviously changing all the time.

The critical load (L_{crit}, in mass/time) is the load of pollutants that will fully overwhelm the assimilation capacity of the receiving water body (Hoekstra et al., 2009). It can be calculated by multiplying the runoff of the water body (R, in volume/time) by the difference between the maximum acceptable and natural concentrations (Hoekstra et al., 2009). This can be illustrated as follows:

$$L_{crit} = R \times (C_{max} - C_{nat})$$

The two equations above have one thing in common; both assume that, the decay of a pollutant or substance is negligible in a short of period. This indicates that a load given at a certain point in time will invariably and immediately result in raising the concentrations in a receiving water body. When the load into a flowing water body reaches the critical load, the grey water footprint will be equal to the runoff, which also indicates that a full runoff is needed for the assimilation of pollutants (Hoekstra et al., 2009).

In the likely event that pollutants are an integral part of an effluent discharge into a freshwater body, the pollutant load can be calculated as the effluent volume (E_{ffl}, in volume/time) multiplied by the difference between the concentration of the pollutant in the effluent (C_{effl}, in mass/volume) and its natural concentration in the receiving water body (C_{nat}, in mass/volume) (Hoekstra et al., 2009). The grey water footprint can be calculated as follows:

$$WF_{proc,\,grey} = \frac{L}{C_{max} - C_{nat}} = \frac{E_{ffl} \times (C_{effl} - C_{nat})}{C_{max} - C_{nat}}$$

where L represent load of pollutants in a given water body.

1.4 The scope of water footprint

Both carbon footprint and water footprint are complementary tools needed to ensure sustainability in natural resource use (Hoekstra, 2009). However, while carbon footprint accounting involves flexibility with regard to the scope (scopes 1 & 2 are mandatory; scope 3 is voluntary), a general recommendation concerning water footprint is to include both scopes (direct and indirect) in a given water footprint measurement (Hoekstra et al., 2009). By calculating only their direct water footprint, consumers will invariably neglect the fact that the largest proportion of part of their water use is associated with products they buy, not the products they process by themselves at home (Hoekstra et al., 2009)

Box 2 *The scopes of corporate carbon footprint.*

A carbon footprint is the total emissions of carbon dioxide and its equivalents of other green house gases (GHGs) for a defined system or activity (Adam, 2008). In corporate carbon footprint measurements, three 'scopes' have been defined (PAS 2050, 2008). Scope 1 refers to the accounting of 'direct' GHG emissions which occur from sources that are owned or controlled by the company. Example: owned combustion sources, site own vehicles, on-site electrical generation, Chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs) loses from owned refrigeration equipments, emissions from chemical production in owned or controlled process equipment etc. Scope 2 refers to measurements of 'indirect' GHG emissions from the generation of purchased electricity consumed by the company; it could be steamed or high temperature hot water, it could be negative (e.g. electricity from landfill gas). Scope 3 refers to other indirect GHG emissions which are as a result of activities of the company, but occur from outside the control and not owned by the company. Example: transportation of purchased material or goods, employee business travel, employee commuting impacts, outsourced work, transportation of waste, vegetation and trees, transportation of purchased fuel, use of sold products and services, etc. Whereas in carbon footprint 'scope 3' is not mandatory in corporate accounting, water footprint of a consumer or producer incorporate both direct and indirect water use. This means that, without specification, the term water footprint refers to the sum of direct and indirect water use. It is important to note that the distinction between scopes 2 and 3 in carbon footprint accounting is not useful in the case of water footprint analysis (Hoekstra et al., 2009). Thus, in water footprint, there are only two 'scopes': 'direct' and 'indirect' water footprints.

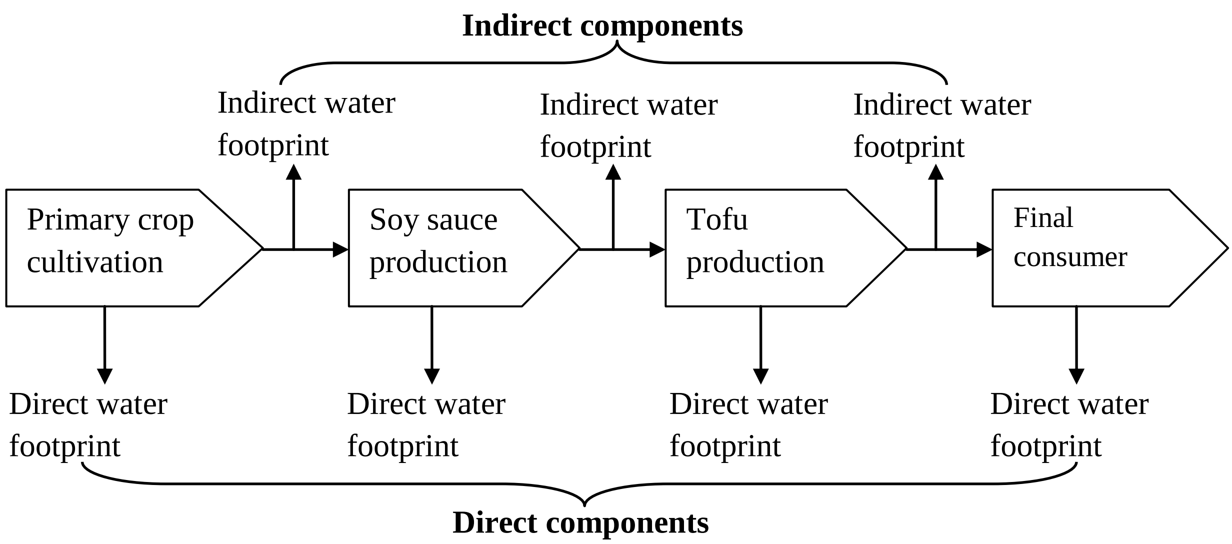


Figure 1.2 *Direct and indirect water footprint in the production chain of tofu (*Hoekstra et al., 2009*)*

Analysis has shown that, for most businesses, the water footprint in the supply chain is much bigger than the water footprint of their own operations. Therefore, strategic measures to ensure improvements in the efficient and prudent operational water use will be more cost-effective in the whole production chain (direct and indirect water footprints) than in their own operations only (direct water footprint) (Hoekstra et al., 2009).

1.5 WF of a nation vs. WF of national consumption

To better understand the importance of encompassing both direct and indirect water footprint of a given product or process, it is important to briefly discuss the water footprint of a nation, and water footprint of national consumption. These are two different but identical scenarios necessary to ensure water dependency and sustainability of imports and exports of consumer goods and services.

The 'water footprint within a nation' refers to the total freshwater volume consumed or polluted within the territory of a nation (Hoekstra et al., 2009). It does not only include water used for making products consumed domestically, but also export products. This, however, differs significantly from 'water footprint of national consumption', which refers to the total amount of water that is used to produce the goods and services consumed by the inhabitants of the nation (Hoekstra et al., 2009). It refers to both water used to domestically produced consumer goods and services, and water used to produce imported consumer goods and services in other countries (outside the territory of the nation) (Hoekstra et al., 2009). The water footprint of national consumption thus includes both internal and external components. This holistic analysis of water footprint is very vital in the presentation of national consumption of consumer goods and services to the effect that, in considering water management strategies, efficiency and sustainability, one will not only consider the water use within the nation (direct) but also take into account the water use outside the territory of the nation (indirect). Considering the water footprint within the nation is sufficient when the interest lies with the use of domestic water resources only (Hoekstra et al., 2009).

2 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to quantify freshwater used to produce 270 g of *tofu* from both direct and indirect use of freshwater in the production chain of a given product. This is in line with the OY Soya AB's 'Corporate Social Responsibility' through the following objectives:

- elaborate the general concept of water footprint
- quantify total fresh water used in the cultivation of primary crops
- estimate amount of fresh water (in m^3) used to produce 8000 litres of soy sauce
- quantify how much water is used in the processing of primary crops and

- to quantify the average water footprint per package tofu (270 g).

2.1 The system boundary

In defining the scope of this study, all raw materials as well as activities that might contribute significantly (more than one per cent) were integrated in the overall water footprint of tofu. On the basis of this, the analysis focuses on all primary crops and their corresponding water requirements as well as tofu production process.

It is important to note that the water footprint concept is still evolving as such, information on water use for some consumer goods and services such as energy were very limited at the time of this study. This problem could further be exacerbated when the energy used in the production process comes from different sources (e.g. Combined Heat and Power, Geothermal, Hydroelectricity, Coal, Peat, Boilers etc.). The flowchart below illustrates schematically the system boundary:

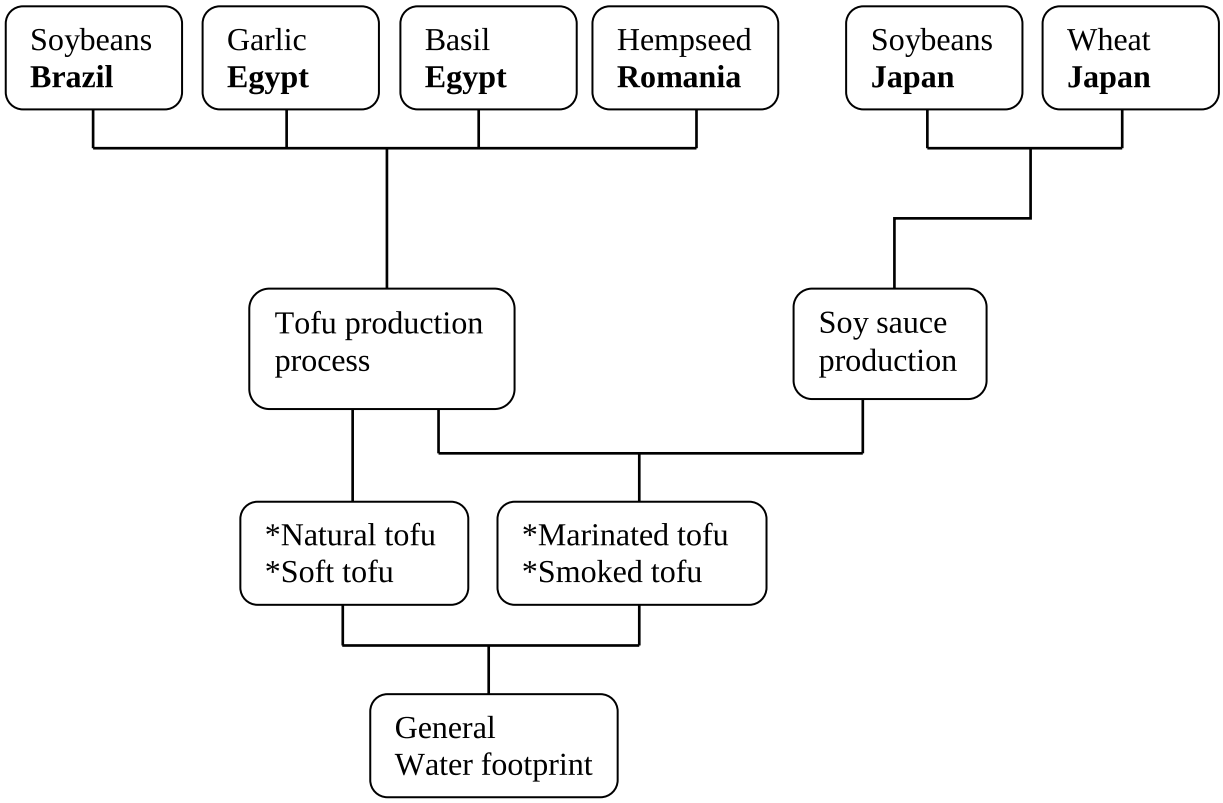


Figure 2.1 *Info graph of the system boundary.*

3 MATERIAL AND METHOD

Semi-structured face-to-face interview was used to sample information from the management of OY Soya AB. These include sources of primary crops, soy sauce and the company's own production processes. A questionnaire was also sent to some of the producers of primary crops to ascertain under which conditions (irrigation/rain fed) the products were produced. A series of scientific papers and reports were also used in this study. The questionnaire to the management of OY Soya AB can be found under **Appendix II**.

To facilitate easy quantification and water footprint analysis of the products, the study focused on 2009 data of the company. This includes total purchase of all ingredients, number of production days, types of production lines, number of packages produced per day, average weight per package as well as information regarding production process.

3.1 About OY Soya AB

OY Soya AB is relatively small company with 11 employees. It is located in the south-western part of Finland, about 6 km from the town of Ekenäs (Tammisaari in Finnish). The company was established in 1989 with the primary aim of producing *tofu* from organically cultivated crops. The module operandi of the company, producing a high quality product without compromising the environmental quality, placed them on a solid foundation at a time when certifications of fair trade have not been consulted. The study is considering activities of the company based on 2009 data. This is to establish a benchmark regarding the water footprint of the product upon which improvement strategies could be introduced.

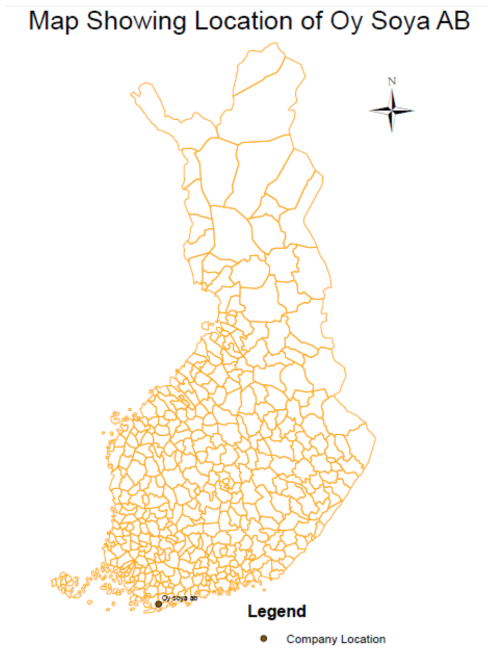


Figure 3.1 (a): *Picture of Oy Soya Ab. Photo: Ilyass Usman (2010)* *(b): Location*

Detail studies have been conducted on the water footprint of different products, including bio-ethanol, biodiesel, pasta and pizza, rice, coffee, tea (Chapagain & Hoekstra, 2010). However, this study addresses specific products not studied before; *tofu*. The study focuses on Brazil, Japan, Romania and Egypt, where the primary products are imported from, as well as Finland where processing and consumption takes place.

Table 3.1 *Total purchase of primary crops and soy sauce in 2009*

Primary crop/product	**Country of origin**	**Quantity purchased (t/year)**	**Source of information**
Soybeans	Brazil	132	Atte Lönn of marketing department of Oy Soya Ab.
Garlic	Egypt	0.36	Atte Lönn of marketing department of Oy Soya Ab.
Basil	Egypt	0.18	Atte Lönn of marketing department of Oy Soya Ab.
Hempseeds	Romania	2.1	Atte Lönn of marketing department of Oy Soya Ab.
Soy sauce	Japan	8000 (litres)	Atte Lönn of marketing department of Oy Soya Ab.

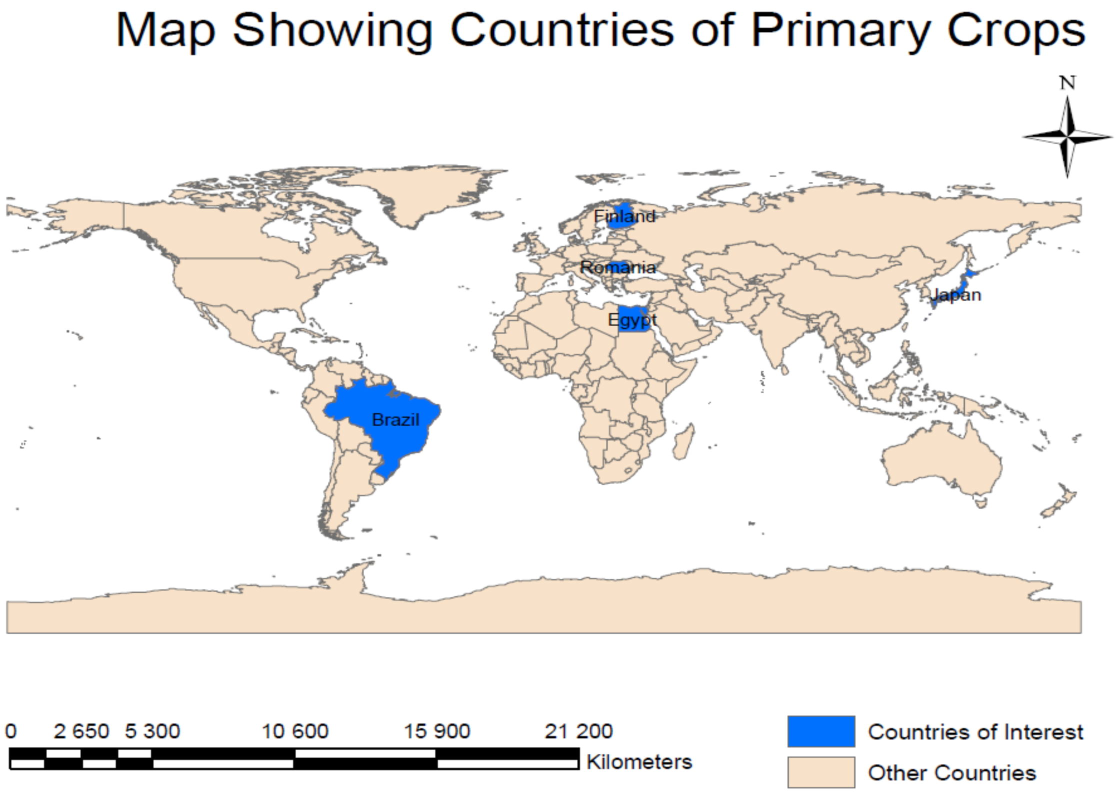


Figure 3.2 *Geographic locations of origin of crops under investigation*

3.1.1 Source of freshwater

The company uses ground water for their operations. For this, they used water pumps which they installed within the parameters of the company for the withdrawal. On an average, the company uses 8 m³ (8 000 litres) of freshwater per day. This includes water used for soaking soybeans, whey water which results from crushed soybeans, and water used for cleaning tubes and general utensils.

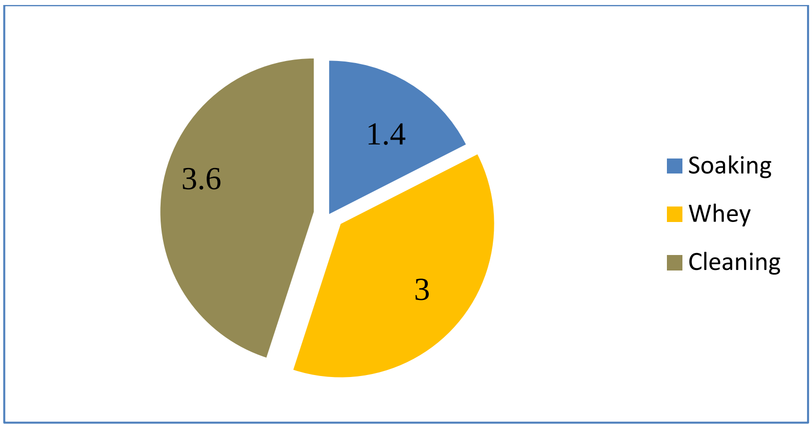


Figure 3.3 *Daily water footprint (m³) of the activities of OY Soya AB.*

3.1.2 Production days per year (2009)

According to the management of OY Soya AB, active production takes place during four days per week, Mondays to Thursdays. This gives rise to 16 days in a month. It is also important to note that there are also national holidays which are enjoyed by all people in Finland and the management of Oy Soya AB is not different. On the basis of this, the study considered 200 working days per year (2009) in the analysis. Therefore, we multiply 8 m^3/day by 200 working days. This yields us a total freshwater use for processing primary crops of 1 600 m^3 in 2009.

3.1.3 Production lines and volumes

On the average, 22 sacks of soybeans are processed per day, of which a sack weighs 30 kg. Therefore, about 660 kg of soybeans are processed per day. Approximately 510 kg of tofu are derived from processing 660 kg of soybeans, while Okara (chaff of soybeans) takes the rest of the fraction (150kg). A total of 3000 packages are produced per day with each package weighing 270 g (0.27 kg). At the time of this study the company engages in the production of four different brands of tofu in appropriate packages:

Natural Smoked Marinated Soft

Figure 3.4 *The production brands of tofu. Photo: Oy Soya Ab*

However, about 13% of total productions in 2009 which include all the above production lines were wasted, chiefly due to product development (PD) and testing to improve production lines which inevitably result in faulty packaging and leakages. In this regard, the study has also considered water footprint for wasted tofu. The most significant difference between the four product lines from the perspective of this study is the integration of soy sauce, which is included only in marinated and smoked tofu.

Table 3.2 *Production line and volume of tofu produced in 2009*

Product	Packages	% share	Source of information
Marinated	160354	27	Atte Lönn of Oy Soya Ab.
Smoked	108136	18	Atte Lönn of Oy Soya Ab.
Natural	205884	35	Atte Lönn of Oy Soya Ab.
Soft	45017	8	Atte Lönn of Oy Soya Ab.
Wasted & PD	75000	13	Atte Lönn of Oy Soya Ab.
Total	**594391**	**100**	

The 8 000 litres of soy sauce were distributed on a proportional basis between marinated and smoked tofu. Indeed, the distribution can be influenced by the volume of the production line. Therefore, a production line with relatively high volume in terms of packages can have a reciprocal large share of soy sauce.

It is also important to note that not all the wasted tofu has the inclusion of soy sauce. The calculations were therefore based on the assumption that the contribution of each of the production lines to the wasted tofu will be proportional to the production volume per production line. This means that a production line with relatively high volume will have a higher fraction of the wasted tofu and vice versa. In this regard, a total of 628 m^3 of water was wasted, representing 22 % of soy sauce WF of combined volume of marinated and smoked tofu (fig.4.3 A). Soy sauce distribution per PL was calculated based on the proportional contribution to the overall production and reciprocal contributions to the waster fraction (Table 3.3). By computation, a total of 402 litres, which represent 5% of purchased soy sauce (8000 litres), was wasted (fig. 4.3 B).

Table 3.3 *Share of soy sauce in the production line, 2009*

Share of soy sauce per product lines (pl)	Package/yr, 2009	Share (l)/pl	% share S. Sauce
Marinated	160354	4542	57
Smoked	108136	3056	38
Soft	45017	0	0
Natural	205884	0	0
Wasted & PD	75000	402	5
TOTAL	**594391**	**8000**	**100**

3.2 Primary crops

First of all, the study analysed per country the water footprints of the four primary crops: Soybeans (FAO crop code 236), garlic (FAO crop code 406), basil (*Ocimum basilicum*) and hempseed (FAO crop code 336) as well as water footprint associated with the production of soy sauce in Japan (wheat – FAO crop code of 15, and soybeans).

In this study, the water footprint calculations of the primary crops were based on the methodology developed by Hoekstra et. al., (2009). It indicates the difference between blue, green and grey water footprints in the production process of primary crops. However, as the company uses organic crops for the production of their products, thus, absence of nitrogen-based fertilizers and pesticides, grey water footprint in the production of primary crops is nil. The total crop water requirement, effective rainfall (the part of rainwater that does not end up in rivers, lakes, sea, etc. but stays in the soil for crop use) and irrigation requirements using the FAOSTAT models from *water footprint of nations* by Chapagain & Hoekstra, (2004) were used.

3.2.1 Soybeans

Soybeans (FAO crop code 236) belong to the family of legumes and are native to East Asia. It is one of the most essential world crops necessary for oil and protein (FAO, 2010). The crop grows in a variety of soils and in different climatic conditions, ranging from tropical Brazil to the snowy island in the north of Japan. As the crop matures in a pod, they ripen into hard, dry beans. The most common species is yellow in colour; there are also rare varieties that are brown, green and/or black. The crop is mainly widely cultivated under rain-fed conditions but supplemental irrigation is evolving rapidly (FAO, 2010). Currently, the global world production of soybeans is about 176.6 million tons over a total of 75.5 hectares of land (FAO, 2010).

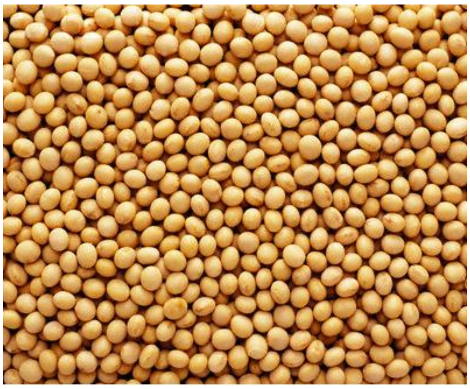
 

Figure 3.5 *(a): Brown soybeans. Photo: Bloomimage (b): green soybeans. Photo: Chris (2008)*

(c): black soybeans. Photo: Ningxia

The product is cultivated in Capanema, a relatively small village in southern Brazil; and imported by OY Soya Ab through Gebana, a company also situated in Capanema. The green water footprint of the crop (m^3/ton) has been estimated as the ratio of the green water used (m^3/ha) to the crop yield (ton/ha). The study further reveals that the cultivation of soybeans in Capanema (a town in southern Brazil) is entirely rain-fed (green water). However, since data on rain-fed and irrigation production per crop were not available, the Crop Water Requirement (CWR) per length of growing period (lgp) was therefore assumed to be fully met.

3.2.2 Soybean Water Requirements

The soybean is widely grown under warm conditions and is relatively resistant to low and very high temperatures. However, the growth rates decrease at temperatures above 35˚C and below 18 ˚C (FAO, 2010). Crop evapotranspiration depends on the climatic condition of the region. High humid areas especially in the tropics and subtropics have relatively high evapotranspiration. Therefore crop yield is highly dependent on Crop Water Use (CWU) and soil. Crop water deficiency has a significant impact on the output (yield) (FAO, 2010). If there is evidence of inadequate, effective rainfall, blue water by means of irrigation is applied.

The Crop Water Requirement (CWR) value used in this study was taken from FAOSTAT database in *water footprint of nations* by Hoekstra & Chapagain. This value is in mm/lgp (length of growth period) as such, it cannot be directly equated to yield in terms of m^3/ha or m^3/ton. The guideline for calculating water footprint per hectare by Hoekstra et al., 2009 was used. It is calculated as effective rainfall (mm/length of growing period) multiplied by ten (10) equals water footprint per hectare (Hoekstra et al., 2009).

The average evapotranspiration in Brazil is 3.11, and soybeans' water requirement (mm/crop period) is 261(Hoekstra & Chapagain, 2004). This figure is largely dependent on the climatic parameters of individual countries. The Crop Water Requirement value can be found in **Appendix V-6.**

3.2.3 Yield

Oy Soya Ab purchases soybeans through a wholesale company (Gebana) who engages many farmers in their transactions. It is therefore difficult to ascertain how much soybeans (ton/ha) an individual farmer produces. Based on this difficulty and lack of information regarding the exact farmer from whom the soybean was purchased, the study focused on the average yield from three different sources in Brazil.

Table 3.1 *Cultivation water footprint of purchased soybeans*

Crop	**Country**	**Yield (t/ha.)**	**Purchased t/yr, 2009**	**WF m^3/yr, 2009**	**Source**
soybeans	Brazil	3.6	132	95700	The Amazon, Brazil's final soybeans frontier
soybeans	Brazil	2.4	132	143550	World agriculture and environment
soybeans	Brazil	2.1	132	164062.8	Soybeans planting pace in Brazil
Average	**Brazil**	**2.7**	**132**	**127604.4**	

Detail calculations of the above table can be found in ***Appendix III-1***.

3.3 Garlic

Garlic (FAO crop code 406) is used as both medicinal and food crops. It is one of the winter crops in Egypt, cultivated between January and April (Allam, 2002). The North African country, like other water-scarce countries is confronted with significant water demand versus inadequate fresh water resources (Allam, 2002). The crop has been integrated as an ingredient in the production of *tofu*. The crop is organically cultivated in Egypt and imported by Oy Soya Ab through *Organic Flavour Company BV*, based in the Netherlands. The Egyptian summer is hot and dry in most parts of the country. This invariably results in high evapotranspiration from crops and other vegetations. The crop water requirement (mm/growing period) of garlic, which was also taken from FAOSTAT, is 641. Garlic water requirement is presented in **Appendix V-7.**

Figure 3.6 *Garlic (FAO crop code 406). Photo: Hester*

3.3.1 Yield

As a winter crop cultivated between November and March, garlic is widely cultivated in Egypt, including Beni Ebeid command areas. Invariably, this made Egypt one of the countries with a relatively high yield of garlic cultivation per hectare (Allam, 2002).

Table 3.2 *Cultivation water footprint of purchased garlic*

Crop	Country	Yield (t/ha.)	Purchased t/yr, 2009	WF m^3/yr, 2009	Source
Garlic	Algeria	3.69	0.36	724.9	Water footprint of nations – Volume 2
Garlic	Argentina	9.82	0.36	294.0	Water footprint of nations – Volume 2
Garlic	Armenia	9.52	0.36	236.7	Water footprint of nations – Volume 2
Garlic	**Egypt**	**22.23**	**0.36**	**103.8**	Water footprint of nations – Volume 2

Calculations of the above purchased garlic WF is found in ***Appendix III-2***

3.4 Basil

In general, basils are cultivated as a culinary herb, spices or condiment. The leaves, which can be used fresh or dried, are primarily applied in foods as a spice ingredient. The crop also contains essential oils extracted from fresh leaves, and flowers are seldom used as aroma additives in food, pharmaceuticals and cosmetics (Javanmardi, Stushnoff, Locke & Vivanco, 2002). Basil has been traditionally used as a medicinal crop in the treatment of headaches, coughs, diarrhoea, constipation, warts, worms and kidney-related problems (Kandil, Khatab, Ahmed & Schnug, 2009). The Egyptian weather conditions and soils are good for the cultivation of the crop, which plays a significant role in the export of the country (Kandil et al., 2009).

Basil (*genus Ocimum*) includes about 11 species, and subspecies are predominantly native to tropical and subtropical regions of the world. The species *Ocimum bassilicum L*. which this study is focusing on, is widely cultivated primarily for the production of important oils and it is also available on sale as a herb, either fresh, dried or frozen (Kandil et al., 2009).

Figure 3.7 *(a): Sweet Basil (Ocimum basilicum). Photo: Marie* ***Figure.3.7*** *(b) Holy Basil or tulsi (ocimum sanctum. Photo: Leslie.*

The CWR value of basil in Egypt was not available at the time of this study. This is assumed to have the same water requirement as garlic which is 641 mm/lgp (length of growing period) since both crops are cultivated in the same country (Egypt). This assumption was based on the fact that the CWR value was calculated based on the evapotranpiration in Egypt. By deduction, the study assumed that, there will not be a significant difference in CWR between the two crops.

3.4.1 Yield

In 2003 and 2004, a research was conducted, based on the yield of the plant (basil) by the Institute of Medicinal and Aromatic Plants Production Department (MAPPD), National Research Centre, Dokki, Cairo, Egypt. The research aimed at comparing the yield between cultivation of the plant under organic condition versus conventional (nitrogen-based fertilizer application and pesticides) in Egypt (Kandil et. al, 2009). The focus of the study was to find out the variation in the crop yield (ton/ha) as well as oil output (l/ha) based on different rates (25%, 50%, 75% and 100%) of fertilizer applications relative to control (cultivation without fertilizer application) (MAPPD, 2003, 2004). In this study however, the average of the two control (organic) values for the study periods (2003/2004) were used since the product (*tofu*) under investigation stems from organic primary crops.

Table 3.3 *Cultivation water footprint of purchased basil.*

Crop	Country	Yield (t/ha.)	Purchased t/yr, 2009	WF m^3/yr, 2009	Source
Basil	Egypt, 2003	19.8	0.18	58.3	MAPPD, Cairo, Egypt.
Basil	Egypt, 2004	19.3	0.18	59.8	MAPPD, Cairo, Egypt.
Average	**Egypt**	**19.5**	**0.18**	**59.2**	

Detail calculations of basil cultivation water footprint can be found in ***Appendix III-3***

3.5 Hempseed

Hemp (*cannabis sativa L*) belongs to the *Cannabaceae* family with about 22 different species (Small & Marcus, 2002). The crop is used, among other things, as crop fibre, textiles, pulp and paper, plastic composites used in automobiles and other manufacturing companies, building material, and animal bedding (Small & Marcus, 2002). In the European Union (EU), the cultivation of the crop is heavily weighted in the production of fibre rather than oilseed. The 1999 statistics indicate that approx. 27 000 tons of hemp fibre was produced in the EU but only about 6,200 tons of hempseeds stemmed from the total cultivation, predominantly in France (Small & Marcus, 2002).

Figure 3.8. *(a): Hempseed. Photo: Loakes* ***Fig.3.8*** *(b).Hemp. Photo: Kristen*

Today hempseed is being used as an integral part of certain foods including snack bars, spreads, bread, pretzels, cookies, yogurts, pancakes, porridge, fruit crumble, frozen desert (ice cream), pasta, burgers, pizza, salad dressing, mayonnaise, etc. In alcoholic beverages, hempseeds are seldom used as flavourants (Small & Marcus, 2002). The seeds contain most of the essential amino acids, i.e. the building blocks of protein, which the body of humankind cannot produce on its own (Kristen, 2009). In this regard, Oy Soya Ab purchases the organic hempseed from *Canah Green Living*, a company in Romania and uses it as an ingredient in the production of *tofu*.

3.5.1 Yield

Romania has a temperate and continental climate with some oceanic influences from the west, the Mediterranean from the south-east and continental-excessive from the north-east (Pintilie, 2004). This induces the average annual temperature to be highly dependent on the latitude (between 8ºC in the north and 11 ºC in the south) and altitude (between 2.5 ºC in the mountain areas and 11.6 ºC in the plain). However, the average annual precipitation decreases between 600-500 mm from west to east in Romanian plain areas and increases in the mountain areas from 1000-1400 mm (Pintilie, 2004).

When the soil temperature is 5 ºC, the sowing takes place between 1-15 April. However, with a temperature level of 7-8 ºC, at 4-5 cm depth, the sowing period is from the end of March to the beginning of April and seed harvesting is mostly done between September and October (Pintilie, 2004). Ideally, the crop grows better when mean daily temperatures are between 13ºC and 22 ºC (Cochran et al., 2000).

According to the project report which was carried by Ecological Agricultural Projects (EAP), 1994, in the Eastern Europe and Asia seeking to find out the history, uses, cultivation, yield and future prospects of hemp, revealed, inter alia, that most countries in these regions have improved hemp yield characteristics. For instance, dry stem yield was 15 t/ha, while hemp fibre and hemp seeds were 2.6 t/ha and 0.94 t/ha respectively (EAP 1994). According to Erin Michelle Young of Lund University, Sweden, who quoted Pate, 1999 and Callaway, 2004 as stating, among other things, that the average yield of hemp seed in Europe ranges from 0.5 – 1.0 t/ha. However, up to 2.0 t/ha has been recorded in the northern climate of Finland. According to FOASTAT 1997-2001, hempseed (FAO crop code 336) CWR is 397 mm/lgp (length of growing period). This value can be traced in **Appendix V-9.**

Table 3.4 *Cultivation water footprint of purchased hempseed.*

Crop	**Country**	**Yield (t/ha.)**	**Purchased t/yr, 2009**	**WF m³/yr,2009**	**Source**
Hempseed	Eastern Europe	0.94	2.1	8869.1	EAP, 1994
Hempseed	Europe	0.5	2.1	16674	Young, 2005
Hempseed	Europe	1.0	2.1	8339.1	Young, 2005
Hempseed	Finland	2.0	2.1	4168.5	Young, 2005
Average		**1.1**	**2.1**	**7579.1**	

Detail calculations of water footprint for purchased hempseed can be found in ***Appendix III-4***

3.6 Soy sauce

In 2009, the company (Oy Soya Ab) purchased 8 000 litres of soy sauce which is originally produced by Japan-based Company *Shoyu* through *Clearspring ltd*, a retail company based in England. All effort to find out production process and freshwater use from Shoyu proved futile. As a result of the difficulty in getting information from this company, the study took into consideration the general production process of soy sauce and recipe.

3.6.1 Soy sauce production process

The product (soy sauce) is a dark brown salty liquid with a unique aroma primarily used to season oriental foods. The four main ingredients of soy sauce are water, salt, wheat and soybeans (Luh, 1995). It is important to understand that salt is mainly produced from saline water; meanwhile, the idea behind the concept of water footprint is to ensure freshwater appropriation without regard to saline water. On the basis of this fact, however, this study did not take into account the water footprint of salt since the product (salt) does not make a significant material contribution to the overall water footprint of soy sauce. The rule of thumb according to Hoekstra et al., 2009 states that you should "include the water footprint of all processes within the production system (production tree) that 'significantly' contribute to the overall water footprint". However, the question that may be asked is, what is the significant level? In this regard a level larger than 1% for a relatively small production as in this study (8 000 litres) is significant. A 10% threshold is assigned for the largest component of a production process (Hoekstra et al., 2009).

In this process, a 50:50 proportion of wheat and soybean is needed for the production of soy sauce. The wheat is roasted and crushed to release the nutrient (Luh, 1995). The soybeans are soaked, steamed until it is softened enough and amenable to processing. Salt is then dissolved in water and the two combined ingredients (crashed wheat and soybeans), known as *koji*, which is a dry mash, is added to the dissolved salt. The result of these three recipes (crashed soybeans, wheat and dissolved salt) is commonly referred to as *moromi* (Kikkoman, 2011). A complex fermentation process is required for the production of soy sauce where carbohydrates are converted (fermented) to alcohol and lactic acid. In this process, the proteins are further broken down to peptides and amino acids. Fermented *Moromi* is then poured into clothes and pressed. The result is liquid raw soy sauce, which is brown in colour and is further refined and pasteurised (Luh, 1995).

Figure 3.9 *Soy sauce. Photo: Kikkoman*

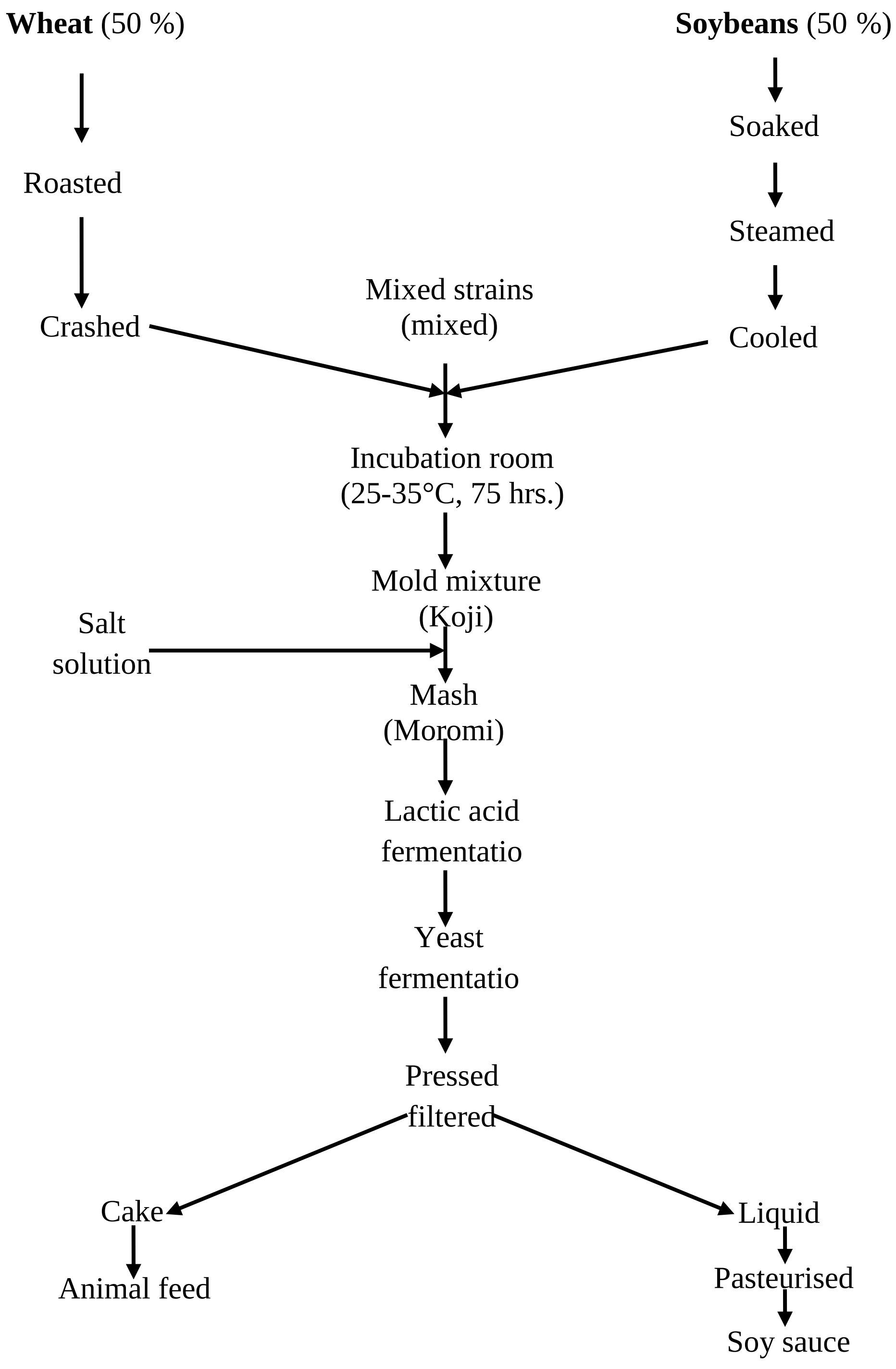


Figure 3.10 *Soy sauce production trees.* *Source: Luh (1995)*

The study estimated the total freshwater used to produce 8 000 litres of soy sauce based on ingredients and the production process. A total of 4 tons for each of the two main ingredients (wheat with FAO crop code of 15 and soybeans) was used in this study. An estimate of 1 m³ of water was assigned for soaking and another 1 m³ of water for steaming (boiling) a ton of soybeans. It is worth noting, that the above values were purely estimates and it does not represent ***Shoyu's*** volume of ingredients and water needed to produce 8ooo litres of soy sauce. However, the estimate (Table 3.5) took into account, among other things, OY Soya AB's own processing of soybeans.

The product stems from organically cultivated primary crops. However, there is limited information regarding provision of crop water use either irrigation or rain-fed. According to Japan Organic Agriculture Association (JOAA), annual precipitation is in the range of 1 200 to 3 000 mm per year. Meanwhile, details of the exact farmer from whom the primary crops were purchased are not known. Based on this fact, the study considered FAO's average yield of primary crops (t/ha) in Japan and FAO's crop water footprint (m^3/t) in this analysis. Average water footprint for primary crops per country can be found in **Appendix IV.**

Table 3.5 *water footprint for 8000 litres of soy sauce*

Crop/Activity	**Country**	**FAO crop WF (m^3/t)**	**WFm^3/yr,(2009)**	**Source**
Wheat	Japan	1334	5334	EAP, 1994
Soybeans	Japan	1789	7155	Young, 2005
Soaking beans		1	4	Young, 2005
Boiling beans		1	4	Young, 2005
Total			**12497**	

Detail calculations of soy sauce production process water footprint can be found in ***Appendix VII.***

4 RESULTS

In summing up the direct and the indirect use of freshwater, the annual (2009) water footprint associated with operations of Oy Soya Ab from both direct and indirect use of freshwater amounted to 149 445 cubic metres. However, water footprint for the production of primary crops contributed more than 91%. A package (0.27 kg) of tofu has on an average a water footprint of 250 litres (0.25 m^3). Detailed calculations of water footprint per package are found in **Appendix III-6.**

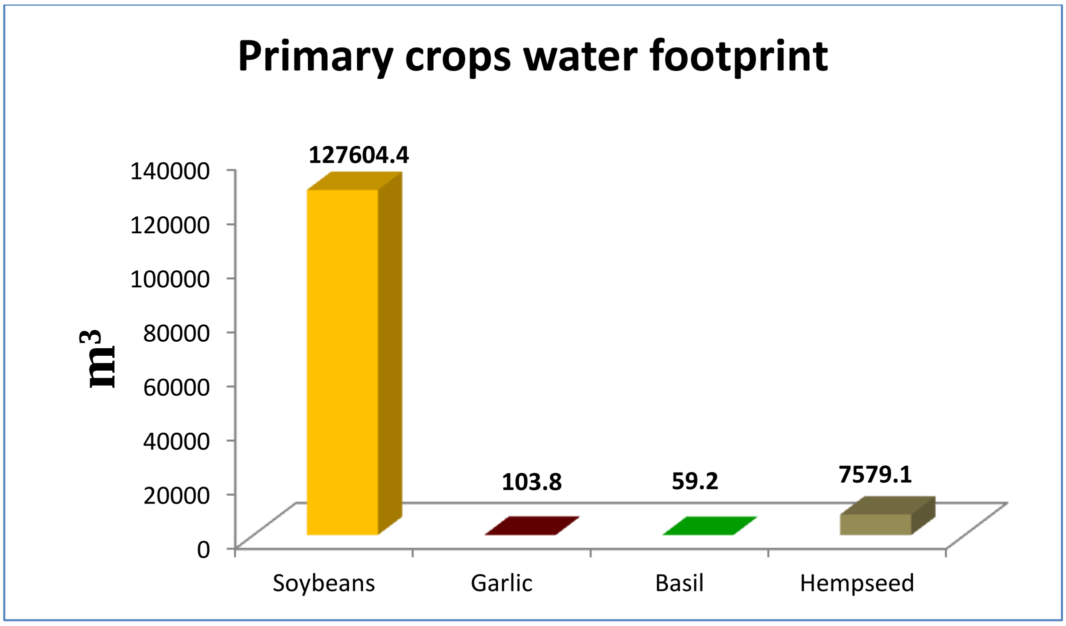


Figure 4.1 *Water footprint (m³) of purchased primary crops.*

The figure above (Primary crops water footprint) shows the green water component used in the cultivation of the products. It is important to understand that the calculations were done using the crop water requirement values in respective countries. Predictably, one will expect, among other things that soybeans will contribute significantly to the overall water footprint of primary crops since soybeans constitute approx. 98% of the ingredients used in the production of tofu.

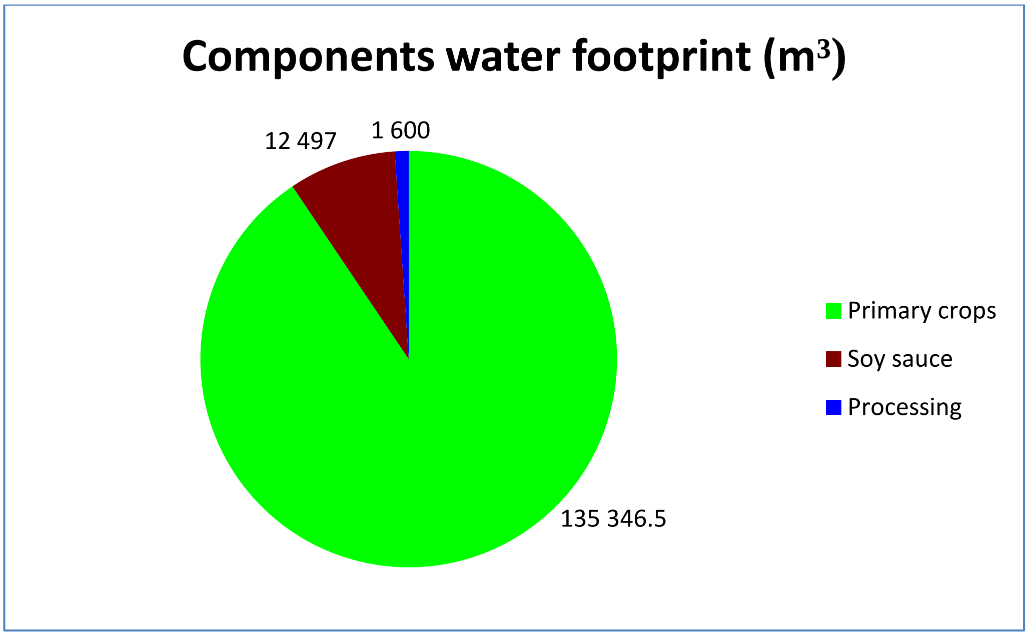
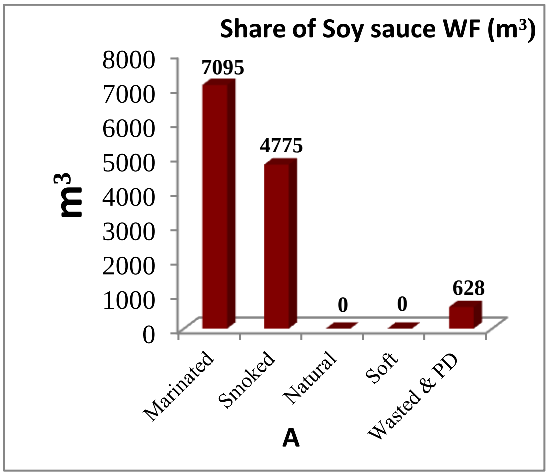


Figure 4.2 *WF (m³) per component.*

The component's water footprint summarizes the overall water use of Oy Soya Ab. However, the component soy sauce, which is relatively salty, has been estimated without regard to water use in the production of salt as indicated earlier in this study. This is a result of the fact that the source of water used in the production of salt is saline water (Sea water) which falls outside the scope of the water footprint concept.



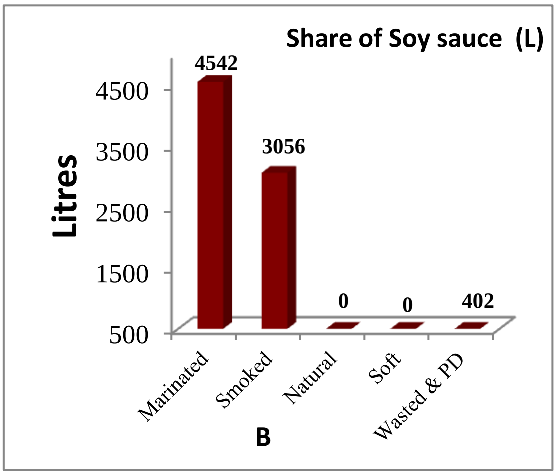


Figure 4.3 *Allocation of soy sauce(l) per production line (A) and soy sauce WF (m³) per production line (B).*

The above figure shows the distribution and allocation of soy sauce along the production line (**A**). The figure (**B**) on the right shows the corresponding water footprint. The calculations were done with reference to production volume per production line.

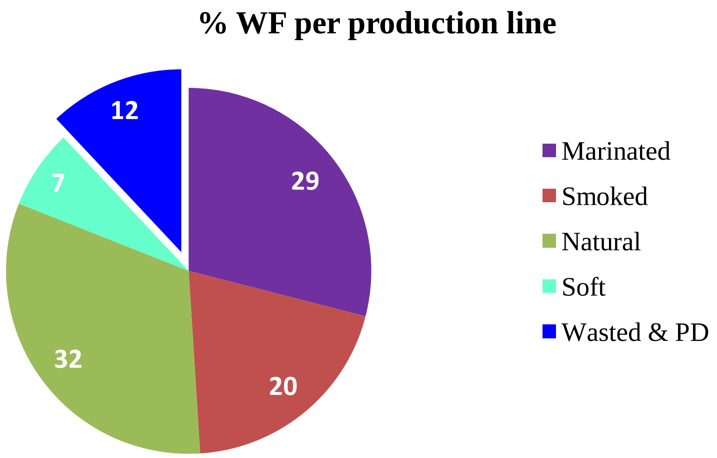


Figure 4.4 *Percentage WF (m³) per production line*

Figure 4.4 indicates the overall production line water footprint in percentages. It is important to understand that despite the exclusion of soy sauce in the production of natural tofu, the product line (natural tofu) still contributes with the greater proportion

(32%) of the annual (2009) water footprint. This is as a result of its larger share in the product line (natural tofu)

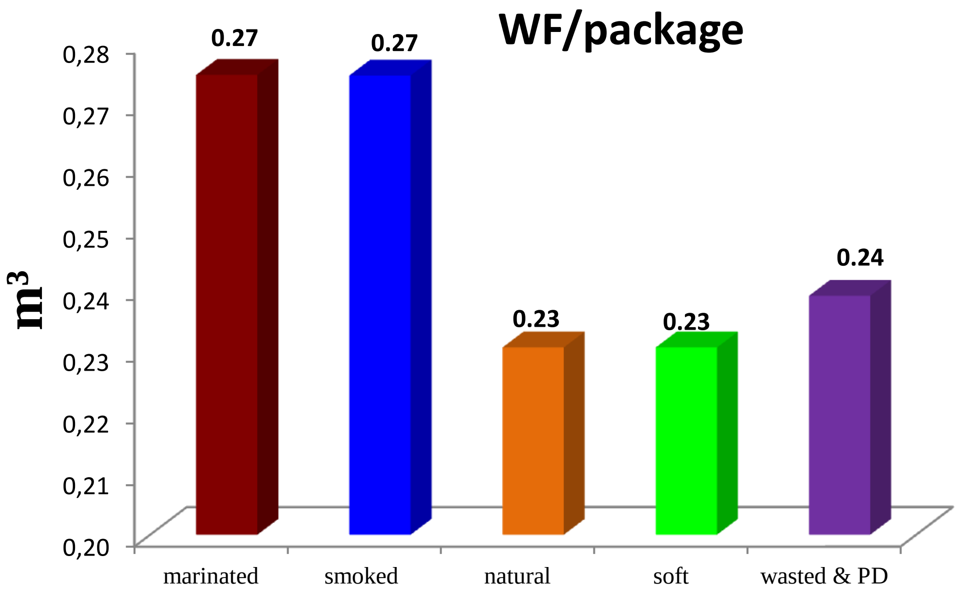


Figure 4.5 *WF (m^3) per package (0.27kg)*

The figure above (fig. 4.5) shows the water footprint per package of 270 g of tofu. It can be noticed that in figure 4.4 (percentage water footprint per production line), the water footprint of natural tofu represents the greater proportion; comparatively, it represents one of the lowest water footprints (230 litres) per package of the production lines. This is a result of total package of natural tofu, which is greater than the rest of the production lines.

However, assuming that there were an equal number of packages per production lines, water footprint per package would have remained the same but with a significant change in the production lines. This can be seen in the figure below:

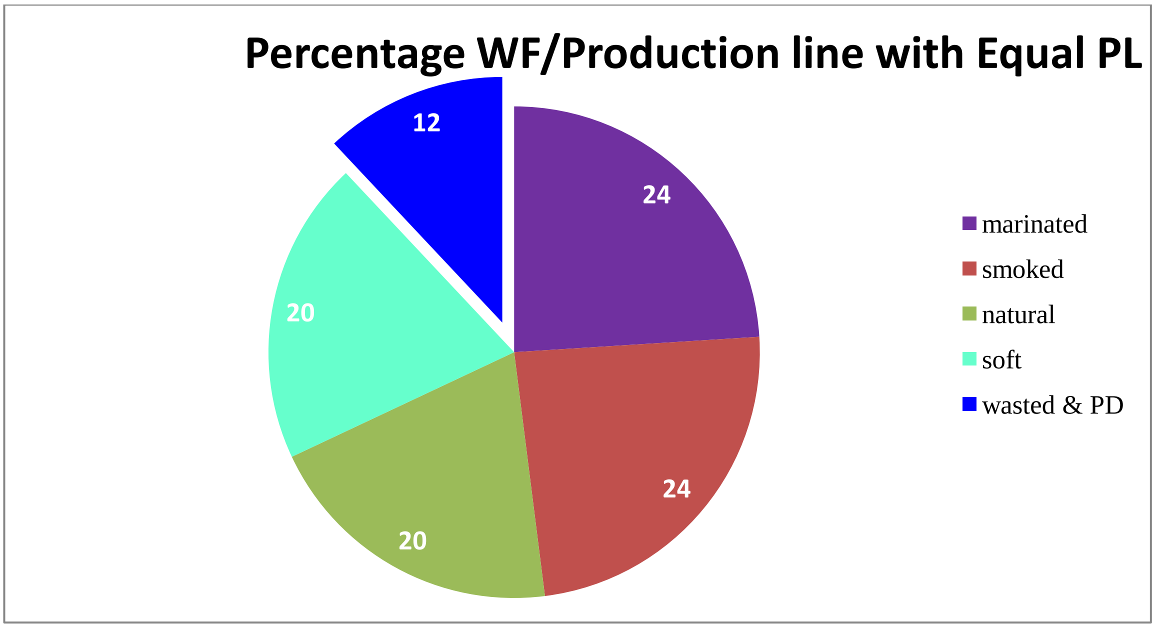


Figure 4.6 *Water footprints per production line with equal number of packages.*

The focus of the study aims at quantifying the water used to produce a package of Oy Soya products ranging from the entire production chain. The average water footprint per package tofu (270 g) is 250 litres.

5 DISCUSSION

This study demonstrates the importance of understanding the amount of virtual water (water embedded in products) associated with consumer goods and services and shows practically how corporate entities and organizations can assess their water footprint without difficulty. The results indicate clearly that a significant amount of water used in the production of consumer goods and services stems from an indirect water footprint in the supply chain of a product or service. In this study, however, about 91 per cent of the annual water footprint associated with the operations of OY Soya AB derived from the supply chain and not their own operations.

On the basis of the above, it is indeed paramount for policy-makers, water managers and all stakeholders to take advantage of this new concept of WF in addressing water-related problems. This could be achieved through a paradigm shift from the traditional approach of management of this all-important resource which seeks to concentrate only on water users, to the holistic approach that truncates the management measures and processes from ‘cradle to grave’ of a given consumer goods or services.

It will not be a misplaced priority if a comparison between tofu and some other product(s) is introduced here. This is important to the effect that the primary idea behind the WF concept is to inform producers, consumers as well as policy-makers, with regard to the need for prudent measures and better choices between products with the aim of ensuring sustainable use of the resource. I have, therefore, decided to introduce Italian pizza and pasta in this regard.

Although countries of origin of primary crops as well as ingredients used in the production of above-mentioned products differ significantly, I consider it important to illustrate a kind of comparison of the product of this study with a different product. All the primary crops needed to produce the pizza and pasta are conventionally cultivated in Italy (Aldaya & Hoekstra, 2010). WF in the cultivation of durum wheat, bread wheat and industrial tomato as well as the production process of durum wheat flour, bread wheat flour and puree from industrial tomato needed to produce Italian pizza and pasta were quantified (Aldaya & Hoekstra, 2010). Also included in the measurement is the WF impact in the production of feed ingredients for the dairy cows.

In the final analysis, a kilogram of pasta yielded a total water footprint of 1 924 litres (1.924 m^3), while a volume of 1 216 litres of water (1.216 m^3) is needed to produce 725 g of pizza margherita (Aldaya & Hoekstra, 2010). Comparatively, 270 g (0.27 kg) of pasta will yield a total WF of 519 litres (0.519 m^3) while the same quantity (270 g or 0.27 kg) of pizza will require 453 litres (0.453 m^3) of water to be produced. The difference between the WF of tofu on one hand, and pizza and pasta on the other, can be attributed to three reasons: a) differences in the countries of cultivation of primary crops (CWR); b) differences in ingredients and c) differences in the cultivation system (organic vs. conventional) which is by far the most significant.

5.1 Limitations

Water footprint is still an evolving concept with some information yet to be ascertained. In this regard, there were some gaps and difficulties in assessing the water footprint associated with some products and services. Water footprint of energy (electricity) with specific reference to different sources is lacking. Oy Soya Ab buys their electricity from ***Jyväskylän Energia*** that generates electricity from combustion of peat. Data regarding for e.g. water footprint for KWH or MWH electricity from some sources of energy including peat, were not available.

It is also important to understand that Oy Soya AB's products (tofu) are packaged in plastic films. However, as the concept of water footprint is still evolving, there is very little, if any, information regarding water footprint per unit (g, kg and/or ton) of plastic film. Hence, the packaging was excluded in this study.

Another limitation encountered during this study was the lack of direct interaction with the management of ***Shoyu***, the company from whom the soy sauce was purchased. All effort to have answers to our questionnaire regarding the amount of soybeans and wheat needed to produce 8 000 litres of soy sauce as well as the amount of water used in the production process of the product (soy sauce) proved futile. This we believe would have gone a long way in providing us with accurate as well as primary information and thereby reduce the rate of uncertainty in calculating WF of soy sauce.

It is imperative to mention the difficulty in contacting the farmers whose products are used in the production of tofu. Direct interaction with these farmers from various countries would have gone a long way in solving the problem of using average values in the calculations. They would have been in the best position to provide us with the exact yields per hectare of their respective crops. It would also have confirmed or contradicted, the source of freshwater (rain-fed or irrigation) they used in the cultivation of the crops.

5.2 Significance of the study

It is indeed difficult, if not impossible, to claim to have improved on one's environmental performance if the current performance is unknown. The study has undoubtedly set a benchmark for Oy Soya Ab by quantifying the annual water footprint of their products stemming from the production chain. The company can set reduction targets for the future with freshwater use and appropriation. The study has indeed placed the company in a position as one of the entities responding to the call for transparency in their operations.

The study has revealed that there is a need for a greater efficiency in the operations of OY Soya AB. It is worth noting that 17 280 m^3 of water – representing 13 % of the annual production of tofu goes to waste mainly due to the wrong packaging and other factors. In this instance, however, ensuring efficiency will drastically reduce water footprint per package of tofu and also maximize the profit base of the company.

Today, due to the growing scarcity of water in some parts of the world, it is extremely important for entrepreneurs to consider various factors including fresh water availability when establishing a business; especially businesses considered to be water intensive. One of the most significant features of the WF concept is that it offers an opportunity for entrepreneurs to decide where to locate a particular business. In fact, it will be disingenuous, if not suicidal to establish a pulp industry in Niger, West Africa, or a cotton industry in Palestine. These two industries are water intensive, and the two countries mentioned are already in water crises. Therefore, any plan to establish any of the industries in one of the countries means planning for collapse.

5.3 Achievements

The study has explained to a large extent the water footprint concept. Definitions of various components (blue, green and grey) as well as the scopes of water footprint have been unambiguously elaborated. A Brief comparison with carbon and ecological footprint has been outlined in this study.

It is worth mentioning that the study has succeeded in quantifying water footprint of organically cultivated soy beans, garlic, basil and hempseed in the respective countries of concern. This is indeed significant, especially in a comparative study regarding WF of organic and conventional production of primary crops.

As sustainable development (SD) continues to gain much recognition, many people are becoming environmentally conscious. The numbers of people, who are critical with regard to what they eat, drink, and wear as well as mobility options continue to grow disproportionately. The study has succeeded in bringing to the notice of the consumers the water footprint associated with 270 grams of OY Soya AB’s tofu. This achievement could, in one way or the other, influence consumer behaviour from three different perspectives: a) it could attract more consumers whom hitherto were patronizing different tofu other than that of OY Soya AB; b) it can influence consumers to switch to different tofu whose water footprint is said to be lower than that of OY Soya AB; and c) it could attract new consumers who are conscious of the environmental aspects of producers and people advocating for Corporate Social Responsibility (CSR).

5.4 Improvement strategies

One important strategy Oy Soya Ab can adopt is to establish a relatively small wastewater treatment plant in their company. This will enable the company to reuse the recycled water in their subsequent operations and thereby reducing drastically the water footprint of the operations. Indeed, the 3Rs (Reduce, Recycle, Reuse) are important as a complementary tool for sustainability, and one way of achieving this is for corporate entities to introduce their individual improvement strategies.

It is also worth noting that the total waste fraction of 13% (75 000 packages) of annual production of tofu resulted mainly from leakages and faulty packaging. This requires greater efficiency to minimize the amount of wasted tofu, if not total eradication. This will in turn reduce the amount of wasted freshwater.

Another improvement measure is a concerted effort from the management of Oy Soya Ab to investigate and find out different countries producing these primary crops (soybeans, garlic, basil, hempseed) but having a relatively low primary crops evapotranspiration. This will go a long way in reducing the water footprint of primary which has contributed approx. 90 % of the company's annual (2009) water footprint.

5.5 Applications of water footprint

It is clear from this study that an analysis of water footprint, like an analysis of carbon footprint, can be carried out on any product stemming from its production chain. The analysis can be conducted on consumer products produced within the nation as well as products from international communities. Understanding the concept of water footprint of a given product could help policy-makers in the formulation of their water management strategies.

6 CONCLUSION

Water is life it is said; as such its importance for the well-being of humanity cannot be over-emphasized. There is a significant variation in the spatial distributions of water both within and between nations. People in the northern part of Ghana, in West Africa, for e.g. cannot boast of adequate portable water like those down south. Likewise Israel and Palestine cannot have the same abundance of the resource compared to Canada. Therefore, understanding the growing scarcity of the resource through water footprint assessment from all spheres of life will help policy-makers to truncate management strategies through the entire production and supply chain of a product or activity. Finally, consumers and producers in general should take equal responsibility by demanding transparency and responding to the call for corporate social responsibility. It is my firm belief that this approach will go a long way in helping alleviate the suffering that over one billion people are facing today (Taylor, 2008).

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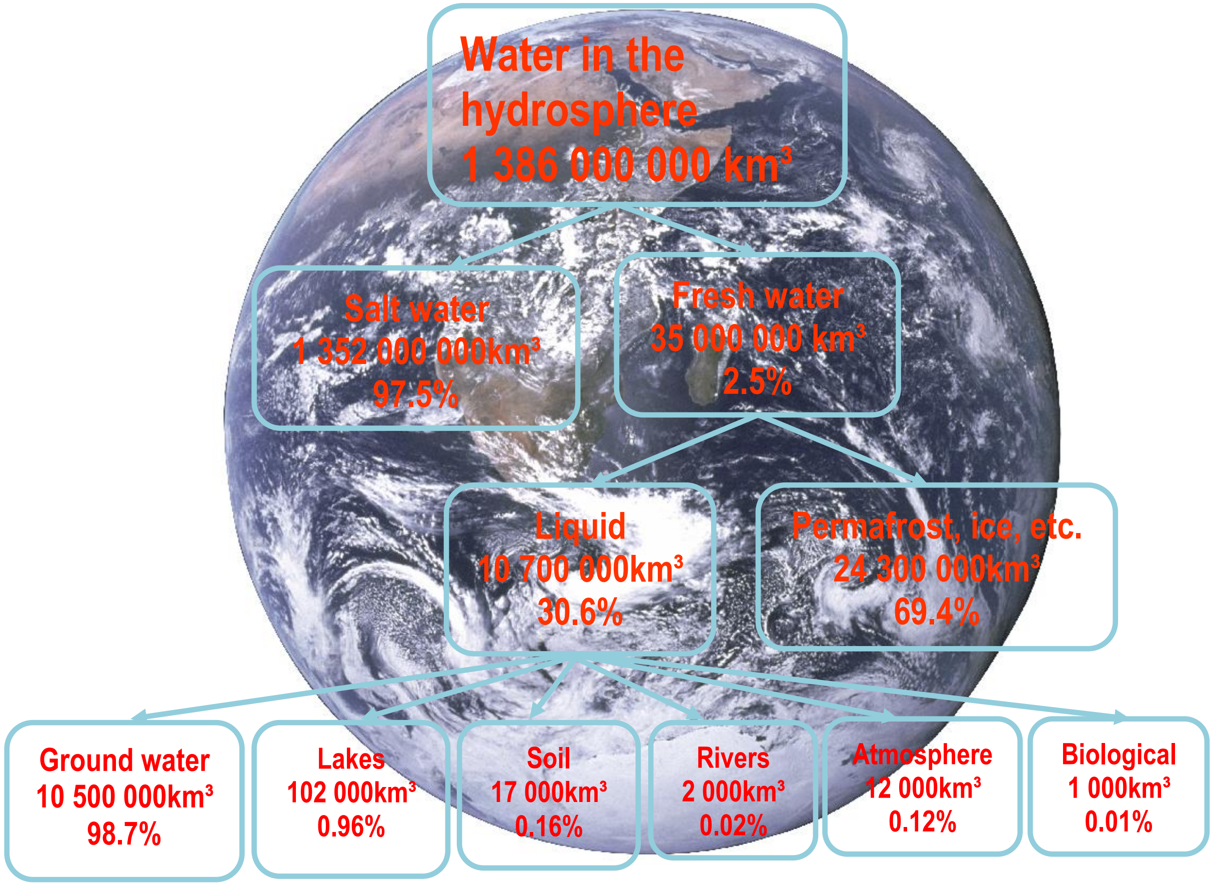
8. APPENDICES

Appendix I. Water distribution in the hydrosphere



Appendix II. QUESTIONNAIRE

1. Briefly describe the production process of your product(s)
2. How many production lines do you engaged in?
3. What is/are the name(s) of your product(s)?
4. What is/are the raw material(s) (primary crops) used in the production of your product(s)?
5. Where do you buy your raw material(s) from?
6. Which type of raw material(s) do you use in the production of your product(s), conventional or organically cultivated?
7. What was the total purchase of raw material(s) for 2009 fiscal year?
8. What type of freshwater does the company used in the production process, surface or ground water?
9. On the average, what is the quantity of freshwater (m³) do you use per production day?

9.1. What is/are the processing steps does the above freshwater is typically used?

10. How many production days do you have per year?
11. What is the average production volume (# packages) per production day?
12. What is the average weight (kg) per package of your product?

Appendix III-1. *Detail calculations of purchased soybeans WF.*

Crop	**Country**	**Yield (t/ha.)**	**CWR, mm/lgp**	**X 10**	**WF m³/ha**	**WF m³/t**	**Purchase t/yr (2009)**	**WF m³/yr (2009)**	**Source**
Soybeans	Brazil	3.6	261	10	2610	725	132	95700	The Amazon, Brazil's Final Soybean Frontier
Soybeans	Brazil	2.4	261	10	2610	1087.5	132	143550	World agriculture and the environment
Soybeans	Brazil	2.1	261	10	2610	1242.9	132	164062.8	Soybean Planting Pace in Brazil
Average	**Brazil**	**2.7**	**261**	**10**	**2610**	**966.7**	**132**	**127604.4**	

Appendix III-2. *WF of purchased garlic*

Crop	Country	Yield (ton/ha.)	CWR, mm/lgp	X 10	WF m³/ha	WF m³/t	Purchase t/yr (2009)	WF m³/yr (2009)	Source
Garlic	Algeria	3.69	743	10	7430	2013.5	0.36	724.9	Water footprint of nations Volume2
Garlic	Argentina	9.82	802	10	8020	816.7	0.36	294.0	Water footprint of nations Volume2
Garlic	Armenia	9.52	626	10	6260	657.6	0.36	236.7	Water footprint of nations Volume2
Garlic	**Egypt**	**22.23**	**641**	**10**	**6410**	**288.3**	**0.36**	**103.8**	Water footprint of nations Volume2

Appendix III-3. Yield and total water footprint of purchased basil at different time intervals in Egypt.

Crop	Country & year	Yield (ton/ha.)	CWR Mm/lgp	X 10	WF m³/ha.	WF m³/t	Purchase t/yr	WF m³/yr (2009)	Source
Basil	Egypt-2003	19.8	641	10	6410	323.7	0.18	58.3	Medicinal and Aromatic Plants Production Department, Cairo, Egypt.
Basil	Egypt-2004	19.3	641	10	6410	332.1	0.18	59.8	Medicinal and Aromatic Plants Production Department, Cairo, Egypt.
Average		**19.5**	**641**	**10**	**6410**	**328.7**	**0.18**	**59.2**	

Appendix III-4. *Hempseed* yield and WF in Europe.

Crop	Country	Yield (ton/ha.)	CWR, mm/lgp	X 10	WF m³/ha	WF m³/t	Purchase t/yr (2009)	WF m³/yr (2009)	Source
Hemp seeds	Eastern Europe	0.94	397	10	3970	4223.4	2.1	8869.1	EAP 1994
Hemp seeds	Europe	0.5	397	10	3970	7940	2.1	16674	Young 2005
Hemp seeds	Europe	1.0	397	10	3970	3970	2.1	8339.1	Young 2005
Hemp seeds	Finland	2.0	397	10	3970	1985	2.1	4168.5	Young 2005
Average		**1,1**	**397**	**10**	**3970**	**3609.1**	**2.1**	**7579.1**	

Appendix III-5. *Total water footprint in the production of 8000 litres of soy sauce***.**

Product/ activity	Country	Crop yield (t/ha)	WF (m³/t)	Purchased (t/yr)	Litre/yr (2009)	m³/yr (2009)	source
Wheat	Japan	1.8	1334	4		5334	FAO database
Soybeans	Japan	3.6	1789	4		7155	FAO database
Soaking beans			1	4		4	
Boiling beans			1	4		4	
purchased sauce					8000		
Total						**12497**	

Appendix III-6. *Detail calculations of water footprint for Oy Soya Ab products for 2009 fiscal year.*

Production Lines	**No. Of packages per year**	**WF (m^3)/PL (without soy sauce)**	**% share without soy sauce**	**Share of soy sauce**	**% share of soy sauce**	**WF (m^3)/PL with soy sauce**	**% share with soy sauce**	**WF (m^3) per package**	**% share per package**
Marinated	160354	36945	27	7095	57	44040	29	0.27	22
Smoked	108136	24914	18	4775	38	29689	20	0.27	22
Natural	205884	47435	35	0	0	47435	32	0.23	18
Soft	45017	10372	8	0	0	10372	7	0.23	18
Wasted &PD	75000	17280	13	628	5	17908	12	0.24	19
TOTAL	**594391**	**136947**	**100**	**12497**	**100**	**149445**	**100**	**1.25**	**100**

Appendix IV. *Global average water footprints of primary crops (m³/ton) over the period 1997-2001*

FAO crop code	Crop	Global production (ton/yr	Global water consumption (106 m³/yr)	Average water footprint (m³/ton)	Share in global water consumption for crop production.
15	Wheat	594594467	792917	1334	12.4%
27	Rice, Paddy	593173644	1358732	2291	21.3%
44	Barley	139624574	193760	1388	3.0%
56	Maize	603140262	548387	909	8.6%
71	Rye	22039337	19866	901	0.3%
75	Oats	27315146	43616	1597	0.7%
79	Millet	28078732	129057	4596	2.0%
83	Sorghum	59471080	109660	2853	2.7%
89	Buckwheat	3194238	7538	2360	0.1%
92	Quinoa	50097	166	3306	0.003%
94	Fonio	243399	1219	5008	0.02%
97	Triticale	8918570	2035	228	0.03%
101	Canary Seed	211684	533	2519	0.01%
103	Mixed Grain	5160032	5703	1105	0.1%
108	Cereals nes	2156489	7033	3261	0.1%
116	Potatoes	309166871	78832	255	1.2%
122	Sweet Potatoes	135528398	41043	303	0.6%
125	Cassava	172162312	104174	605	1.6%
135	Yautia (Cocoyam)	274204	253	922	0.004%
136	Taro (coco Yam)	8403549	9566	1138	0.1%
137	Yams	37054604	14072	380	0.2%
149	Roots and Tubers nes	7308442	3043	416	0.05%
156	Sugar Cane	1258303380	219999	175	3.4%
157	Sugar Beets	253329446	28706	113	0.4%
161	Sugar Crops nes	752324	645	858	0.01%
176	Beans, Dry	16625282	70706	4253	1.1%
181	Broad Beans, Dry	3694817	7573	2050	0.1%
187	Peas, Dry	11286838	16955	1502	0.3%
191	Chick-Peas	8241196	26623	3230	0.4%

Appendix IV-1

FAO crop code	Crop	Global production (ton/yr	Global water consumption (106 m³/yr)	Average water footprint (m³/ton)	Share in global water consumption for crop production.
195	Cow Peas, Dry	3374903	36602	10845	0.6%
197	Pigeon Peas	2941131	12067	4103	0.2%
201	Lentils	2993099	18456	6166	0.3%
203	Bambara Beans	48947	202	4123	0.003%
205	Vetches	960110	3673	3826	0.1%
210	Lupins	1656525	3090	1865	0.05%
211	Pulses nes	3314462	13024	3929	0.2%
216	Brazil Nuts	61115	12	196	0.0002%
217	Cashew nuts	1457185	28082	19271	0.4%
220	Chestnuts	886672	2743	3094	0.04%
221	Almonds	1503454	14687	9769	0.2%
222	Walnuts	1202524	5092	4235	0.1%
223	Pistachios	434748	4723	10864	0.1%
224	Kolanuts	216260	4780	22103	0.1%
225	Hazelnuts (Filberts)	754423	5187	6876	0.1%
226	Area nuts (Betel)	621441	5593	8999	0.1%
234	Nuts nes	599678	4613	7692	0.1%
236	Soybeans	160094723	286371	1789	4.5%
242	Groundnuts in Shell	33172799	104329	3145	1.6%
249	Coconuts	50828645	129353	2545	2.0%
254	Oil Palm Fruit	111579670	117452	1053	1.8%
260	olives	14826152	65128	4393	1.0%
265	Castor Beans	1237818	12997	10500	0.2%
267	Sunflower seed	24815556	76161	3069	1.2%
270	Rapeseed	37881111	61011	1611	1.0%
277	Jojoba Seeds	400	5	12344	0.0001%
280	Safflower Seed	730600	4068	5567	0.1%
289	Sesame Seed	2768107	24602	8888	0.4%
292	Mustard Seed	497252	783	1575	0.01%
296	Poppy Seed	58398	102	1741	0.002%

Appendix IV-2

FAO crop code	Crop	Global production (ton/yr	Global water consumption (106 m³/yr)	Average water footprint (m³/ton)	Share in global water consumption for crop production.
299	Melonseed	562617	2372	4215	0.04%
310	Kapok Fruit	382541	2512	6568	0.04%
328	Seed Cotton	54643172	199111	3644	3.1%
333	Linseed	2392679	10577	4420	0.2%
336	Hempseed	33640	103	3052	0.002%
339	Oilseeds nes	1632423	3345	2049	0.1%
358	Cabbages	54628782	11542	211	0.2%
366	Artichokes	1273954	1089	855	0.02%
367	Asparagus	4124145	6073	1473	0.1%
372	Lettuce	17108911	2269	133	0.04%
373	Spinach	8163112	1178	144	0.02%
388	Tomatoes	101019065	18571	184	0.3%
393	Cauliflower	14069374	2239	159	0.04%
394	Pumpkins, Squash, Gourds	15669868	3674	234	0.1%
397	Cucumbers and Gherkins	30995626	7506	242	0.1%
399	Eggplants	24634989	5120	208	0.1%
401	Chilies & Peppers, Green	19498241	6293	323	0.1%
402	Onions + Shallots, Green	3921305	841	214	0.01%
403	Onions, Dry	45925829	15900	346	0.2%
406	Garlic	10067021	5218	518	0.1%
407	Leeks and Oth. Alliac. Veg.	1477132	295	200	0.005%
414	Beans, Green	5285835	1897	359	0.03%
417	Peas, Green	7947915	2725	343	0.04%
420	Broad Beans, Green	983258	772	785	0.01%
423	String Beans	1603523	647	403	0.01%
426	Carrots	19749408	2586	131	0.04%
430	Okra	4846380	2025	418	0.03%
446	Green Corn (Maize)	8489281	4325	509	0.1%
461	Carobs	225602	1296	5746	0.02%
463	Vegetables Fresh nes	199804422	54484	273	0.9%

Appendix IV-3

FAO crop code	Crop	Global production (ton/yr)	Global water consumption (106 m³/yr)	Average water footprint (m³/ton)	Share in global water consumption for crop production.
486	Bananas	63859046	54842	859	0.9%
489	Plantains	30547811	75682	2478	1.2%
490	Oranges	64405126	29416	457	0.5%
495	Tang. Mand. Clement. Satsma	17577225	10156	578	0.2%
497	Lemon and Limes	10494779	5863	559	0.1%
507	Grapefruit and Pomelos	5181384	1845	356	0.03%
512	Citrus Fruit nes	5247605	9839	1875	0.2%
515	Apples	57944530	40416	697	0.6%
521	Pears	15694965	11418	727	0.2%
526	Apricots	2541712	3535	1391	0.1%
530	Sour Cherries	934289	1255	1343	0.02%
531	Cherries	1770325	2732	1543	0.04%
534	Peaches and Nectarines	12531350	14960	1194	0.2%
536	Plums	8548286	13783	1612	0.2%
541	Stone Fruit nes, Fresh	374222	704	1881	0.01%
544	Strawberries	3045746	840	276	0.01%
547	Raspberries	362871	259	713	0.004%
549	Gooseberries	174250	85	488	0.001%
550	Currants	636089	235	369	0.004%
552	Blueberries	195850	77	395	0.001%
554	Cranberries	300249	46	152	0.001%
558	Berries nes	481043	232	482	0.004%
560	Grapes	60514393	39609	655	0.6%
567	Watermelons	69288603	11080	160	0.2%
568	Cantaloupes & oth Melons	19440734	3566	183	0.1%
569	Figs	1086378	3433	3160	0.1%
571	Mangoes	24135800	38212	1583	0.6%
572	avocados	2439312	3132	1284	0.05%
574	Pineapples	13619660	3441	253	0.1%
577	Dates	5733931	17376	3030	0.3%

Appendix IV-4

FAO crop code	Crop	Global production (ton/yr)	Global water consumption (106 m³/yr)	Average water footprint (m³/ton)	Share in global water consumption for crop production.
591	Cashew apple	1608203	5888	3661	0.1%
592	Kiwi Fruit	942329	406	430	0.01%
600	Papayas	5412553	3583	662	0.1%
603	Fruit tropical Fresh nes	13344102	19022	1426	0.3%
619	Fruit Fresh nes	22288589	31293	1404	0.5%
636	Maize for Forage + Silage	404096136	57937	143	0.9%
637	Sorghum for forage + Silage	23203584	2731	118	0.04%
638	Rye Grass, Forage + Silage	33383525	3886	116	0.1%
639	Grasses nes, Forage + Silage	266002100	44482	167	0.7%
640	Clover for Forage + Silage	83426949	11489	138	0.2%
6412	Alfalfa for Forage + Silage	481260838	64504	134	1.0%
642	Green Oilseeds for Fodder	57785040	11968	207	0.2%
643	Leguminous nes, For + Sil	43560752	7517	173	0.1%
644	Cabbage for Fodder	3179735	320	100	0.005%
646	Turnips for Fodder	2745117	372	135	0.01%
647	Beets for fodder	11513377	316	27	0.005%
648	Carrots for Fodder	15066	2	140	0.00003%
649	Swedes for Fodder	2324208	143	62	0.002%
655	Vegetables + Roots, Fodder	24766501	1926	78	0.03%
656	Coffee, Green	6835469	118750	17373	1.9%
661	Cocoa beans	3176682	86464	27218	1.4%
667	Tea nes	2978704	27419	9205	0.4%
674	Tea	170480	4255	24960	0.1%
677	Hops	103044	282	2736	0.004%
687	Pepper, White/Long/Black	264013	1299	4921	0.02%
689	Pimento, Allspice	2211046	23438	10601	0.4%
692	Vanilla	4800	465	96949	0.01%
693	Cinnamon (Canella)	91998	1664	18083	0.03%
698	Cloves, Whole + Stems	94417	5788	61304	0.1%
702	Nutmeg, Mace, Cardamoms	65257	2678	41041	0.04%

Appendix IV-5

FAO crop code	Crop	Global production (ton/yr)	Global water consumption (106 m³/yr)	Average water footprint (m³/ton)	Share in global water consumption for crop production.
711	Anise, Badian, Fennel	326746	1828	5594	0.03%
720	Ginger	899134	1611	1792	0.03%
723	Spices nes	1046463	3976	3800	0.1%
748	Peppermint	62936	35	557	0.001%
773	Flax Fibre and Tow	494420	1549	3134	0.02%
777	Hemp Fibre and Tow	61962	155	2507	0.002
780	Jute	2800765	7512	2682	0.1%
782	Jute-Like Fibres	445445	1662	3732	0.03%
788	Ramie	151972	611	4021	0.01%
789	Sisal	338816	2530	7468	0.04%
800	Agave fibre nes	58546	369	6302	0.01%
809	Abaca (Manila Hemp)	98551	1663	16878	0.03%
821	Fibre Crop nes	289953	2091	7210	0.03%
826	Tobacco Leaves	7147923	15815	2213	0.2%
836	Natural Rubber	6712513	87655	13058	1.4%
	Total		**6391398**		**100%**

Appendix IV-6

Appendix V. *Crop Water Requirements in respective countries (mm/crop period)*

FAOSTAT Country codes	Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	15	27	44	56	71	75	79	83	89	92	94	97	101	103	108	116	122	125	135	136	137	149	156	157	161	176	181	187	191	195	197	201	203	205	210	211	216	217	220	221	222	223	224	225	226
2	Afghanistan		435	1313	405	737			648									762							1498	743												597				1104	1366	1227			
3	Albania		763		659	516	258	659										515								577		324								365		372			853						
4	Algeria		679	1541	621	928		621		571				317				813										704	626	602	380			1028		650		657				1471					
5	American Samoa																			577		677	202		1114																						
7	Angola		446	996		452			318									511	447	737					1348			329												1112							
8	Antigua and Barbuda					466													422	801		863	332																								
9	Argentina		179	712	161	252	278	161	155	190					170		138	334	567	366					1022			153	170	170	96			412			113					828	1062				
1	Armenia		309		288	589	97	288									386	583										397		404				607		419		427				828					
10	Australia		309	898	282	378	413	282	249	301				293	288			463	625						1297			251	274	274	170	241		555		301	207					1039	1344				
11	Austria		499		437	342	169	437						37		283		348								380			189	240													548				
52	Azerbaijan, Republic		303	1112	284	605	85	284	529	475								611								601		408	338					634				456				844	1044			1044	
12	Bahamas					420													331	734					1228								340														
13	Bahrain																	1110																				917									
16	Bangladesh		305	895	303	307			223	269								371	288						987		582	234		249	174		240	408				238		865							1061
14	Barbados					434													426	757		818	338		1315													373									
57	Belarus		160		155	333	19	155			253			40			253	368								312		223		278													562			562	
15	Belgium-Luxembourg		567		493	381	202	493						44		313		392								423		230	213	269								286					622				
23	Belize			1006		377				337								395	300	670	701		299	299	1120			283		317										976							
53	Benin			1024		366			261	317			330					661	509	679		762	374		1354			280										469		1189					1433		
17	Bermuda																	468	592																												
18	Bhutan		643	819	496	325			262		199						199	348						197	818													253									
19	Bolivia		324	988	321	388	358	321		321		265					253	451	464	607				238	1211			308	331	297	189								1209		1209						
80	Bosnia and Herzegovina		677		588	561	229	588										463										288		315	224	266		454		329						610	751				
20	Botswana		283			371			234	286														228														441									
21	Brazil		280	900	278	337	301	278		279	194							398	420	525			199		1065			269	289	257									1063	860			1063				
239	British Virgin Islands																																														
26	Brunei Darussalam			939															348	593				260																							
27	Bulgaria		238	909	224	454	61	224		356				89			307	460								448		305		326	229			477							786	636	786				
233	Burkina Faso			1341		503			363	444			455					839	674	992			544		1901							355			365			586		1669							
29	Burundi		362	996		400			291	344								344	337	622		701	202		1093			309		324			314														
115	Cambodia			917		323													388	580				292	1103			246																			
32	Cameroon		276	866		288			204	247								494	420	526			276	276	1070			222	239			199						363			1113				1113	1113	
33	Canada		339		329	253	329	329			183			8	234	235		290								292		172	213	190	124			274													
35	Cape Verde					443												592	483	797					1462													420									
36	Cayman Islands																		488	622			262																								
37	Central African Republic			947		335			238	289								533		603		675	308		1179													386									
39	Chad		569	1385		562			413	497							402	641	532	1016		1093	450		1776			424										442									
40	Chile		578	595	342	137	390	342										142	168							184		103		87	83			144			78					576	739				
357	China		266	830	251	383	68	251	334	298	259			101			259	394	455	552		541		197	798	393		251	234	295	226			409				313		669	734	600	734	669		734	737
43	Cocos (Keeling) Islands																																														
44	Colombia		309	906	307	332				286								440		554			238	238	1062			256						441				329									

FAOSTAT Country codes	Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	15	27	44	56	71	75	79	83	89	92	94	97	101	103	108	116	122	125	135	136	137	149	156	157	161	176	181	187	191	195	197	201	203	205	210	211	216	217	220	221	222	223	224	225	226
45	Comoros			1021		398												448	462	641		757	257										298					331									
250	Congo Democratic Republic		334	964	331	364			260	312								417	382	603		681	243	243	1120			282		290								309									
46	Congo Republic			832		290												382	339	483			210	210	932			226		229																	
47	Cook Islands																		426	464				205																							
48	Costa Rica			1003		373												542		666			329	329	1229			283																			
107	Côte d'Ivoire			896		305			221	267			275						394	561		617	288		1084													359	1130	944		907			1130		
98	Croatia		665		579	455	225	579	369	322	292					379		459								505		280		314		265		447		328						596	733				
49	Cuba			1073		416				371								442	346	730	772		319		1239			311																			
50	Cyprus		364		332			332										573				924						535	459		253	374		757		462		472				1000	1239	1104		1239	
167	Czech Republic		527		466	368	174	466	295					31		303	237	377								407		221	206	260				361		273		276					573				
54	Denmark		485		438		147	438						18		287		362								383				253								269									
72	Djibouti					611																			1769																						
55	Dominica					352												394	317	605	651	651	255		1056													276									
56	Dominican Republic			1102		436				390								491	393	751	805		315		1301			326	343	369			355							1124							
58	Ecuador		284	859	282	307	320	282		264		236						362	334	510				211	958	516		237	252	247				408			226										
59	Egypt		570	1387	518	771	660			509								707	860			1108		396	1634	879		575	543	531	338	467		867		571	526	575					1581				
60	El Salvador			1063		398				356								595	457	729	778				1351			297												1185							
61	Equatorial Guinea																		312	454				221																							
178	Eritrea		565		561	571			414	500							401	656						466				435	464	464	324			753		498		449									
63	Estonia		142		137		16	137			240			34		290		343								280		201		265																	
238	Ethiopia		367	1040	364	390		364	277	335							265	540	460				324	324	1303			302	323	309	211			532		333		387									
64	Faeroe Islands																	200																													
66	Fiji Islands			910		340				287								422	416	540		635	202	202	1074													330									
67	Finland		398		383		407	383								270		326								330				248																	
68	France		630	901	546	425	220	546		302	273			58		354		430								474		262	231	295				418			294	312			697	566	697			697	
69	French Guiana			1064		439														670		793			1252																						
70	French Polynesia																	405		573				200	1111																						
74	Gabon			783		260													304	444		499	204		849													263									
75	Gambia			1261		466			344	420										933																		517									
73	Georgia		249		233	455	72	233			299							454								459		305		319												651	806			806	
79	Germany		563		494	386	193	494						37		317		397								426			217	273													611				
81	Ghana			973		341		323	241	292									517	626		713	339	339	1291													472		1121					1364		
84	Greece		289	1130	266	657	529	266		378						535		509	684							715		512	415	371	215			701		408	445	420			1088	875	1088	972		1088	
86	Grenada					469													469	818			367	367	1472			356					372														
87	Guadeloupe																		369	728			305	305	1258													319									
88	Guam					326													316					303																							
89	Guatemala		405	1057	403	398				354								513		720					1277			299	316									354									
90	Guinea			997		353			256	310			318						421	666		717	366		1247													400									
175	Guinea-Bissau			1118		401			291	355			362							791				448	1466													452		1310							
91	Guyana			1070		426													455	697		796	296	296	1314				356	334		293															
93	Haiti			1032		398				357								431	337	687			287	287	1176			297				297	325														
95	Honduras		415	1079		411				365								500	373	743				357	1286			310												1129							
97	Hungary		221	835	211	390	40	211	346	304	275			74	358			409								380		261	238	302				422			299	320			685	560	685			685	
99	Iceland																	217																													

Appendix V-2

FAOSTAT Country codes	Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	15	27	44	56	71	75	79	83	89	92	94	97	101	103	108	116	122	125	135	136	137	149	156	157	161	176	181	187	191	195	197	201	203	205	210	211	216	217	220	221	222	223	224	225	226
100	India		438	852	380	354			264	320								378	245	696					1101			279		297	217		284	447				177		988			1105				1159
101	Indonesia			932		348												410	391	570				237	1092		583	272										301		907							1155
102	Iran Islamic Republic		506	1306	473	731			634									742							1562	766		478			405			772				583				1155	1427	1277		1427	
103	Iraq		539	1836	493	1171		493	961	704								938							2141	1292		905	764		401	612		1264		759						1627	2023				
104	Ireland		442		379		172	379										300								318		169		208																	
105	Israel		488		441	761		441		465								653	827											485	297			837				534				1171					
106	Italy		762	1019	652	263	652		353								324	506	551							564		316	270	345	241			499		360	348				854	689	854	765		854	
109	Jamaica			1033		397												452	352	691			299	299	1195			295	310	337		295	324														
110	Japan		263	791	242	367		242	310		224							355	415			525	172	172	795	393		242	194	249								265			722						
112	Jordan		540		492	934				558								787											625		353			1022		634						1378					
108	Kazakhstan		209	1089	203	570	21	203	516	444	428						428	618								530		383		458	313																
114	Kenya		356	1047	353	407		353	283	341								599	533	672				299	1358			321			207	276	305	564						1140							1493
83	Kiribati																					789		255																							
116	Korea People's Democratic Republic		290	822	272	376	79	272	323	292								380	444									244													756						
117	Korea Republic		333	872	310	419	107		357	326	265						265	416	485									273										324			854		854				
118	Kuwait		734		666	1356												1137																													
113	Kyrgyzstan		769	1097	734	544	722	734		427								624								627												401				768	951			951	
120	Laos			900		316												391	310	565					1006			241										265									
119	Latvia		158		153		19	153			246			40		301	246	356								299		212		273						288											
121	Lebanon		377		341	686		341		421								567				298			1317	761		527	455	420	249			747		457	468	467				1009	1254				
122	Lesotho		237		214	295		214		234								362										193		213																	
123	Liberia			928															385	581		648	268		1098													329									
124	Libyan Arab Jamahiriya		719		653	990			831									899										746	696	673	420											1583					
125	Liechtenstein																																														
126	Lithuania		176		169		27	169			254			49		316		373								319		225		283						299	278	301									
154	Macedonia, the fmr Yug Rp		258	928	243	467	65	243	409	367								474								461		314		338	239	284		491		352						663	819				
129	Madagascar		282	920		341				280								466	464	549		661			1142			273		256		225		487				353		938				938			
130	Malawi		345	1070		435			292	352								420		666				241	1301			351			203	283	314														
131	Malaysia			890		317													328	548				243	999															855							1075
132	Maldives								264										456	642		719		295														390									1356
133	Mali		673	1590		664			487	58			597				476		672	1211			559		2157							477			349			574									
134	Malta		353		321													501										468								401											
127	Marshall Islands																																														
135	Martinique																		406	731			327	327	1302									537													
136	Mauritania		855	1851	850	786			598	715								908	714				684					575				587						613									
137	Mauritius					271												421	412	440		536			955																			786			
138	Mexico		496	954	440	427		440	321	383				420	451			453	331	770	805			332	1272			340	360	360	253			536		384		253		1105		1031	1276	1105			
145	Micronesia Federal States			919		324				284									344	588																											
146	Moldova Republic		211		202	435	38	202	386	339	306							455								420		292		332						348						601	736			736	
141	Mongolia		606		578													489																				358									
142	Montserrat					443												491	398																												
143	Morocco		446	1245	406	700	591	406	573	440							387	579	474					301	1374	784		537	455	423	261			762		460	470	469				1067	1327	1167			
144	Mozambique		297	996		392			258	312								498	546	597				237	1286													385		1028							
28	Myanmar		287	873		294			211								204	466	343	548					1026		685	225		236	163	207	227	401													1156

FAOSTAT Country codes	Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	15	27	44	56	71	75	79	83	89	92	94	97	101	103	108	116	122	125	135	136	137	149	156	157	161	176	181	187	191	195	197	201	203	205	210	211	216	217	220	221	222	223	224	225	226
147	Namibia		351			406			270	327														254														460									
148	Nauru																																														
149	Nepal		319	707	282	267			202									278						221	769			214			162		217	326				113				621					
150	Netherlands		496		432	335	175	432						38				344								371		201	188	236																	
153	New Caledonia		259			307				254								428	426	482		584	191															337									
156	New Zealand		424		365	105		365									54	105	116											70				122													
157	Nicaragua			1049		390				347								547		718				367	1286			293																			
158	Niger		851	1912		830			613	738			746				598	920	772	1514					2624			623				600						634									
159	Nigeria		375	1047		370			267	325			334					697	566	706		782	384		1434							262						517		1251					1508		
160	Niue																		402	442		533	197																								
162	Norway		351		336		350	336						25				284																													
221	Oman		608							518							421	560																													
165	Pakistan		741	1182	656	583			455	543								582	266					401	1577	899		488		513	377			682				177				1237	1520	1367			
166	Panama			943		346				304								454		603	652		281		1093			263					274					320									
168	Papua New Guinea			977		379				322								403	400	601		695	212	212	1132													309									
169	Paraguay		283	957		384				305								562	594	564					1292			315	339	281																	
170	Peru		278	874	275	319	307	275		268		228					214	374	380	512	602			204	1008			251	269	249	160			439			215	282	1008	825	1008		1008				
171	Philippines			926		326												422	312	600		631	303	303	1051			246										281		928							
173	Poland		172		166	328	23	166			241			52		304		355								312		220		265						279	262	282					563				
174	Portugal		268	965	248	521	420	248						114				424	554				208		941	571		403	339		186						355				902	728	902			902	
177	Puerto Rico					436													389	752			308	308	1305			326					353														
179	Qatar		823		740	1170												1046																													
182	Reunion			716		261												316	397	420					916			179										318									
183	Romania		208	835	198	393	45	198	347	307							273	407								386		263		295								314			683		683				
185	Russian Federation		401	725	389	297	396	389	270	232	226						226	342								354		201	237	238	156			331		248	242	253			450		450			450	
184	Rwanda		346	818		342			249	295								373	320	545		614	190		982			260		277																	
187	Saint Helena																																														
188	Saint Kitts and Nevis																	476	387				309	309	1298													335									
189	Saint Lucia																		408	735	789	789	330	330														363									
190	Saint Pierre & Miquelon																																														
191	Saint Vincent/Grenadines					448													433	791			355	355	1402													381									
244	Samoa																			575		666	224	224	1118																						
193	Sao Tome and Principe					231														409		453	194	194																							
194	Saudi Arabia		890		805	1234			1027	755								1082																				879									
195	Senegal			1523		565			413	508							405	1206	884	1205					2380							405						837		2152							
186	Serbia and Montenegro		240		229	433	59	226		339								443								427		291		317		267				331					761		761				
196	Seychelles																			668																											
197	Sierra Leone			854		282			203	246							196		406	522		576			1048				231	227								379							1107		
200	Singapore																							244																							
199	Slovakia		187		179	334	34	179	296	261				63				352								326		223	205	260				362		273		276					587				
198	Slovenia		215		205	365	42	205	323		258					332		383								356		244		283											649		649				
25	Solomon Islands			928															388	559		647	207															299									
201	Somalia		625	1499		662				576									666	1099					2006			508																			
202	South Africa		332	929	299	396	432	299	260	316	204							488	645						1395			262		287		252					226										

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FAOSTAT Country codes	Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	15	27	44	56	71	75	79	83	89	92	94	97	101	103	108	116	122	125	135	136	137	149	156	157	161	176	181	187	191	195	197	201	203	205	210	211	216	217	220	221	222	223	224	225	226
203	Spain		307	1083	283	612	498	283	500	359				132	511	499		486	644					234	1100	671		475	390	354	212			658		387	413	397			1052	847	1052			1052	
38	Sri Lanka			1077		420			309	368								531	425	725					1311			319				302								1128							
206	Sudan		639	1495		618			461	553								791	612	1131			529		1998			462	490		366							548									
207	Suriname			1003		398													395	626				238	1166													295									
209	Swaziland		289	832		340				274								411	504						1147			229				220						402									
210	Sweden		460		439		448	439						39		292		372								374		212		251																	
211	Switzerland		444		422	302	426	422						63		272		350								353				227											555		555				
212	Syrian Arab Republic		463		424	1071		424		625								842							1903	1170		833	688	617	359			1148		677	730	696				1444		1604			
208	Tajikistan		779	1109	744	550	727	744		433	357							630												378				566				400				783				973	
215	Tanzania Unite Republic		340	1002	337	393			275	330								419	429	619			222		1186			310		306	198	268	297					320		964							
216	Thailand		332	945	330	334				293					341		238	540		615		664		333	1156			253										371		1026							1309
176	Timor-Leste			943		356												421	407	577								280																			
217	Togo			992		359			254	307							245		507	641		730	340					277										485		1136							
218	Tokelau																							257																							
219	Tonga																		412	457		552	195	195																							
220	Trinidad and Tobago			979		368													369	362	690	690	286	286	1144							262	289					318									
222	Tunisia		397		363			363		411				181			392	577								765		540	460	425	256			761		463		473				1013		1115		1255	
223	Turkey		319	1137	299	630	95	299	546						549	557		624				848				632		425	337	433	298			650		449		458			1090	877	1090	975		1090	
213	Turkmenistan		404	1333	378	762												769												552												1095					
227	Tuvalu																							241																							
226	Uganda		404	1112		439			313	376								642	558	739					1461			341		348	234	305	337														
230	Ukraine		185	846	178	397	27	178	355	310	287						287	423								378		267		311						327					662	542	662			662	
225	United Arab Emirates		837															480																								1613					
229	United Kingdom		381		361		372	361						53		232		297								299			239	203								215									
231	United States of America		237	863	224	411	58	224	361	321	285							424	486			565			808	412		273		310		265		439								602	741	673		741	
234	Uruguay		190	696	170	240		170		186					179			314	561						1023			152	167	167																	
235	Uzbekistan		349	1294	330	730	81		642	571							503	750								722			430	541	379											1016	1252	1141		1252	
155	Vanuatu					329																		196																							
236	Venezuela, Bolivia Republic		368	1020		388				337								528	424	668	738		310	310	1245	747		298		314			303														
237	Viet Nam			923		332												344	278	586					995			250										231		859							
243	Wallis and Futuna Islands																			576		666	219	219	1114																						
205	Western Sahara				714																																										
249	Yemen		584		580	584			433	518							421	503	435									441	465	485	338			730				341				1318					
251	Zambia		501	1156	453	569			389	467								651	495	858					1552													339									
181	Zimbabwe		425	1074	383	502		383	335	404								597	565	757					1501			338			227							409			1480						

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Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	234	236	242	249	254	260	263	265	267	270	275	277	280	289	292	296	299	305	310	328	333	336	339	358	366	367	372	373	388	393	394	397	399	401	402	403	406	407	414	417	420	423	426	430	446	449
Afghanistan	1366					948			691					514						855	709																									
Albania	853	560				592			448											546									560										328		410					
Algeria			752			1306			340	741										793				784	1763				544	258	380	603	873	366	277	778	743		349	442	574		973			
American Samoa				1161																																									419	
Angola			484		1319			1187	378					361						721									454						355											
Antigua and Barbuda																				706				600					537		306	393	415	449		797			224				448			
Argentina		261	345			814			502	552			670							522	228				1088	729			379		281			591		837	802		306	466		415	520			
Armenia																								638					638	593		543				657	626			451			291			
Australia	1344	406	457			1009			584	623			771		187					683	365			743		940	486	499	440	484	347	614		667		944			329	528			607		633	
Austria		369							296	347						54							296	362		450	244	135	368			304		327		451			218	265			345			
Azerbaijan, Republic	1044	699				719			556											687				656					656			565	599	603		683	650			479			274			
Bahamas																													472							655										
Bahrain	2418																							1062			318		781	359	520	787	1171	475		959							1308			
Bangladesh			287	1061				933		348				250						489	344		273	418			206	211	430	218	224	260				587	561		158							
Barbados			442	1457																				575			323		550		297	366		458		816						299	463	293	503	
Belarus	562								334	48											326			363					359			328				417							116			
Belgium-Luxembourg			285							386											357			405		508	284	160	410	373		340		365	209	507		209	241	296			390			
Belize		200	311	1185																				468					457		239	318		321	234								331	205		
Benin		357	554	1548	1469			1388						293			445			643									643					562		989								352		
Bermuda																								548					386							543			250				564			
Bhutan		357													132																			316												
Bolivia		282	413						388											651				575			338		414	356	318	330		467		739	708			346	458		414		439	
Bosnia and Herzegovina		500							400	475														491					499					440		609	200		292				456			
Botswana			471						475											688																866										
Brazil	1063	261	375	1117	1060	786		953	353	350				265						571	343		353						353							653	626									
British Virgin Islands				1477																																										
Brunei Darussalam				1149																																										
Bulgaria	786	525	378						419	123										513			419	491		650	322	175	491	461	325	424	450	453	507	525	499		305	363	386		211			
Burkina Faso		458	697											406						877									878					724	529				367					468		
Burundi		211	310		1053															599																										
Cambodia	1140	272	405	1220				1088						263						530			389																							
Cameroon	1113	293	431	1198	1137									230			337			507			412	451					473		240	244	420	453		760		326	225					2911		
Canada		294							239	251			230		90						246			287		321	160	88	309	269	178	247		264		264		310	181	211			55		336	
Cape Verde				1589				1407																616			367		615	369	325	374				916	876		254				518			
Cayman Islands				1161																									524		315															
Central African Republic			456		1249									269			379			570			437								268								232							
Chad			529											461			628			882																1014										
Chile	739					568			112	222											124	124		208	796	631	199		184	149	143	121		139		312	591		71	96	231		173		132	
China	734	451	324	737	699	518		721	355	133			348	267	157		159			448	367	388	355	432	696	603	329	186	424	397	275	361	385	389	480	505	481	480	258	323	349	284	237			
Cocas (Keeling) Islands				1183																																										
Colombia		269	390	1150	1092									270						533				465		813	296	303	413	295	244	281	384	413		677							399			
Comoros			407	1306																									430						370											
Congo Democratic Republic		252	370		1124									294			337			580				502			285		408		269	308				662							375			
Congo Republic			338	1009	958									232			275							415			257		363										181				345			
Cook Islands				1097																									383					452												
Costa Rica	1277		449	1366	1296									307						589				508					549					455		812										

Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	234	236	242	249	254	260	263	265	267	270	275	277	280	289	292	296	299	305	310	328	333	336	339	358	366	367	372	373	388	393	394	397	399	401	402	403	406	407	414	417	420	423	426	430	446	449
Côte d'Ivoire			287	422	1213	1151									248						511			406						488				401	433	302										356	
Croatia			491				509			394	463						78								480			317		489			403		433		597	190		290	348			453			
Cuba				351	1310																				526					495		267	351	337	366		690	660									
Cyprus				561			867								472										559	1156		127	130	377	145	264	452	656	195	160	429	410	160	250	305	320		692	134		
Czech Republic			396							319	367					131	48					344		319	386			262	148	393	358		327		351		480	129		235	287			373			
Denmark											339					131						330			361			248		369	340		313				447				278			355			
Djibouti																									781			363		619		406	515	477	517	402								488	350		
Dominica					1123																				453			238		412		233	297											343			
Dominican Republic				407	1393	1322																			559			298		512		281	368	390	422		755	722						426			
Ecuador			218	320	1016	964			883	304					249						492	330			427			249		354	256	226	260		348	262		551		181	264	372		326			
Egypt		1581	754	652			1131			273					546						725	722			701	1536		209	215	550	237	362	521	742	320		670	641		334	423	490		827	219		
El Salvador			332	493	1500		1057								332						633				549					608			336		501		897										
Equatorial Guinea					961	912																																									
Eritrea				540											465							638		513																							
Estonia											40											298			331					327	322		303				387	368			290			100			
Ethiopia		1334	309	461					1251		489			632	313						645	423		440	563			347		539						359	840	804									
Faeroe Islands																																															
Fiji Islands				395	1140																				493					368		266	289	405	434										288		
Finland											268														329					354	317		297				355			223	272			81			
France			460				486			369	435					144	80					395	395	369	450	660	574	300	162	458	414	278	377	405	405	220	561	190	220	271	326	333	300	426		423	
French Guiana					1276																				612			296		392			374							239							
French Polynesia					1159																				520			305		359		282	311		424	324							291	380			
Gabon			212	312		881																								384				303													
Gambia				605		1796									383						762																										
Georgia			521	383						412											524				497					495			421				523							230			
Germany			415							334	385					141	55					361			405		500	282	159	412	376		344				506		212	246	301	294		394			
Ghana		1364		555	1474	1399															608			533						597			289	529	572		958			273					356		
Greece			625	518			754			131					434			459			464				492	993	899	93	95	308	105	219	421	613	146	116	336	321	116	213	250	256		628			
Grenada					1585																732				628			354		598		326	396											505			
Guadeloupe		1271			1332																				537			276		489		274	354	364	394		711			196				397			
Guam		1081			1151																				433					474			275	314			652						220				
Guatemala		1308	275	417	1389	1318									331						618				528			301		551	302				428		786	752				545		440	271		
Guinea				469	1413	1341									287						586																									412	
Guinea-Bissau				531	1650	1565															670																										
Guyana				438	1401																				598					497		326	362	438	474	358				247					314		
Haiti				351	1245				1094						334						592				501			253	259	460				332			661	632									
Honduras			255	396	1390	1319									340						626				531			280		558	283	273	347	371	403		767	733						422			
Hungary			463							371	89						63					377	401	371	426		562	310	174	423	403	276	372		397	472	487	463		273	333			182		463	
Iceland																									219					234	207		192											82			
India			419	347	1159				1024	242	233			389	293		237				529	417		242	393			170		488	182	229	238	234	259		574	548		134	183			278	167		
Indonesia		1097	246	364	1155	1096			996											1155	570				498				295	398		271	295	373	402		661	633	310	214				370		397	
Iran Islamic Republic		1427	852	623			1005			670				650	509						875	697		670	831	1355	1177	604	328	815	752	528	682	730	734		946	901	887	488	603	677		478			
Iraq		2023	1123	947			1403			243					790						894	1082			927			183	187	576	216	437	763	1107	289	243	643	615		417		478	456	1139	201		
Ireland											286														303			228		306	280		256		274		382		163	183	228			304			
Israel		1451		615			1028			240					525						648			240	644	1381	1176	188	193	469	209	311	493	716	280	225	574	549		284	361	416		780		874	
Italy		854	549				595			439	524											468		439	539	811	706	348	184	548	493	337	448	482	482		673	254	256	322	383	405		497			

Appendix V-7

Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	234	236	242	249	254	260	263	265	267	270	275	277	280	289	292	296	299	305	310	328	333	336	339	358	366	367	372	373	388	393	394	397	399	401	402	403	406	407	414	417	420	423	426	430	446	449
Jamaica				369	1277																				503			267	274	481	268	251	334	351	380	272	692						247	389		463	
Japan			412	317							172														413		600	282	158	407	370	268	332	360	360	421	451			226	276			259		428	
Jordan							1202								640										756			193	198	542	217	357	601	877	203	236	632	604		334	414	470		946	200		
Kazakhstan			693	458						563	62			547		227					611	557		563	613					612			556	578	588		648		647	422	506	464		144			
Kenya		1401		538	1493				1314	515					322						686	425		515	604			409		539			346				919	879	412	281	446	582					
Kiribati		1268			1317																																										
Korea People's Democratic Republic		756	439																		453				432					421		272	351	378	381	481	511	486									
Korea Republic		854	480	361							197				293									373	479			362	206	468	429	304	385	416	418	522	560	533						318			
Kuwait							1717																		1096			267	273	742	307	522	865	1270	409		870	832		486		636		1361	284		
Kyrgyzstan		951		459						476											717	517			619					654	558	393	502				606	576		354				257			
Laos			204	316											258						498																										
Latvia			397								47											313		323	349					345			316				408	388			299			114			
Lebanon		1254		558			879			180					467										571	1173		142	145	376	162	275	449	649	216		449	429		256	318	325		683	150		
Lesotho																																															
Liberia		1125	263	391	1195	1134																								449																383	
Libyan Arab Jamahiriya				790			1397																		829					688	289	402	629	928	396	307	830	793			468	612		1056			
Liechtenstein																																															
Lithuania											60					149						329			369					365	356		332	345			432	410			310			132			
Macedonia, the fmr Yug Rp										432	132				332		97				528				506					506			437		466		551	524		314	375			229			
Madagascar		1155	296	428	1227	1165			1060												595			404	530			345		421	358		290	444	476	367	751	720		254	359			430			
Malawi		1274		389						360											733				645					403							728				323	442					
Malaysia				334	1075	1020																		319	430					400		224	268														
Maldives		1275			1356																														489		812										
Mali		2194		685											544			758			1060									889					718		1290			362							
Malta							781																		496					346	145	232					414	396				302					
Marshall Islands					1299																																										
Martinique					1406																				550			309		535			353	405						215				450			
Mauritania				730														959																													
Mauritius				392	1045																				438			314		366	319	242	231	401	430		667	639	323	222	331			393			
Mexico		1276	499	414	1332	1264	938		1169	323	321		1029	486	356	180		475			635	489			484	1311	1004	241	246	504	250	272	324	322	351	260	676	646	260	177	260	477	226	359	226	467	
Micronesia Federal States					1173																																										
Moldova Republic		736	516							414															472					470	449	307	415	437	442		513			304	367			169			
Mongolia																																	415														
Montserrat																					668									514			374		426		758							429			
Morocco		1327	670	578			940		1142	222	570				468						598			222	599	1260	1074	164		425	182	289	468	666	251	197	520	498	197	268	335	378	303	704			
Mozambique				474	1358				1151	444					299						700			444						429		361					828										
Myanmar			237	369	1156					354					237	130					487																706	675									
Namibia				488						493											730																										
Nauru					1227																																										
Nepal			314		788											112					383	310													165			351									
Netherlands											337						54					313			354		443	248	140	359	327	212	299	319	321		443	137	184	212	260	259		343			
New Caledonia					1095																																										
New Zealand											149											95			272		409	261	268	223	257	156			354	254		475	254	114	189	282		130		125	
Nicaragua			288	440	1422	1349									323						610				523					588							827										
Niger				760											683						1299				1107			565		1032					810	609	1471	1407						791			
Nigeria		1508	419	607	1630	1547									299			472			652			584						664					625	434	1051							627	390	434	
Niue					1037																																										

Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	234	236	242	249	254	260	263	265	267	270	275	277	280	289	292	296	299	305	310	328	333	336	339	358	366	367	372	373	388	393	394	397	399	401	402	403	406	407	414	417	420	423	426	430	446	449
Norway										241														286			197		306	270		250			299			310	183	224			91			
Oman																													691							926										
Pakistan	1520	700	512	1533				1323	232	241			383	500						794	702		232	385			173	177	533	195	310	235	240			592	565		146	178			267	180		
Panama		251		1195										285										462			271		464			292		386		687							395			
Papua New Guinea	1130		373	1177	1117																								370		282								216						433	
Paraguay		381	537		1327			1202	508					296						686									452		346			604	469	905	867						536			
Peru	1008	237	344	1060	1006	746								255						532	332			469	1032	751	280	288	349	293	254	271		386		613	587	302	210	290	382	270	344		363	
Philippines	1078	214	332	1148	1089			1023												506			319	431		839			473		223	275	311	338	243	648	620		166	258						
Poland										58											319	348	322	357		460			354	343		319				413			239	292	274		132			
Portugal	902		412			632			122														122	399			83	85	282	94	182	334	487	132	102	309	295		175	209	237		517			
Puerto Rico				1375																				559					495		284			413												
Qatar																								1019			330	338	779	368	504	747	1096	487		975							1232	338	1355	
Reunion			312	998																				482	956	679	301		343	307	235		385		312	635	608		215	317			374			
Romania		463						674	370	95					147	70				441	378	397		428			295		426		279	372		397		470	447		271	327						
Russian Federation	450	350						455	294	287			285		116						291	315		341					368	324		300				324	308			263			53			
Rwanda		387	347																												236															
Saint Helena																																														
Saint Kitts and Nevis			397	1374																656				557					499			368		414		736							415			
Saint Lucia				1411																																										
Saint Pierre & Miquelon																																														
Saint Vincent/Grenadines			451	1507																											304			465									473			
Samoa				1188																			379																						407	
Sao Tome and Principe				857	813																																									
Saudi Arabia			994											851															822		515	798	1160			1035							1290	344		
Senegal	2530		982	2763	2622									460			897			1018									1253							1806			468							
Serbia and Montenegro		504				528			403	120						89						430		470					469			407		434		516	490		294	352			211			
Seychelles				1381																									504																	
Sierra Leone			443	1196	1135									228															489																	
Singapore				1096																												264														
Slovakia		398							319	76					132	54					323		319	366			266	149	363	346		319		340		417	396		234	286			154			
Slovenia		433				452			348	91														399			293	162	396	377		348		371		462	439	445	256	312			180			
Solomon Islands	1070			1118	1061																																									
Somalia			680	2139										543						1021																										
South Africa	1417	246	487					1301	555											730			555	747		1013	487		490	500	374	598		660		979			353	507			582		631	
Spain	1052	584	487			735			142	476			234			149				450	563	563		471	974	865	98	101	319	110	214	396	573	155	120	354	338	120	206	245	269		598			
Sri Lanka		304	451	1421										345	183									556					535		288	354	429	464		807		326	221				470			
Sudan			649					1921	622					512			717			968									847		423		611	664		1212	1159									
Suriname		237	360	1214	1152																			551					400			339							218							
Swaziland			404																	602									411																	
Sweden										327											309			374			249		396	345		315				388				276			134			
Switzerland		347							281	312														349			235	127	370	319		290			358				208	251			169			
Syrian Arab Republic	1793	1024	848			1240			201					716						780				823	1636		152		503	181	374	687	1001	240	203	550	526		358	430	416			168		
Tajikistan	973	621	467						476	579			456	392						724				625					659			503				607	577		355				272			
Tanzania Unite Republic	1181	267	389	1231	1168			1050	367					313						641			367						386							684	656								448	
Thailand	1214	283	435	1309	1242			1178						272					1309	547				476		925	304		554	301	248	282	401	436		805	769		208	340	559				389	
Timor-Leste		257	378																					513					402			302					651		223							
Togo			567	1497	1420			1346						287						623				552					610																	

Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	234	236	242	249	254	260	263	265	267	270	275	277	280	289	292	296	299	305	310	328
Tokelau				1249																
Tonga			399	1063																
Trinidad and Tobago				1234																
Tunisia	1255					883			194	542										540
Turkey	1090	717	530			753			569	188			525	450		142				722
Turkmenistan	1354																			880
Tuvalu				1331																
Uganda		401	577					1421	553					353						725
Ukraine	662	477						663	384	65					157					
United Arab Emirates																				
United Kingdom										260										
United States of America	741	483	344			515			384	119			370		156					471
Uruguay		253	324			824			512											
Uzbekistan	1252		608			858			681	173			649	515						825
Vanuatu			376	1099																
Venezuela, Bolivia Republic		297	447	1366	1296				429					316						619
Viet Nam	998	178	276	1045				915						275						500
Wallis and Futuna Islands				1177																
Western Sahara																				
Yemen														484						862
Zambia		621	617						373											892
Zimbabwe	1480	542	580						445											842

Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	333	336	339	358	366	367	372	373	388	393	394	397	399	401	402	403	406	407	414	417	420	423	426	430	446	449
Tokelau																										
Tonga									364		242															
Trinidad and Tobago				494			278		466	282	259	311	365	359												
Tunisia	648			552	1178	1026	142	145	396	154	255	446	652	217	166	460	440		239	295	341		699			
Turkey	600	602		683	1019	905	422	224	683	634	455	581	619	622	672	699	665	672	411	483	542	460	297	747		
Turkmenistan				841					834			711				882	840						367			
Tuvalu																										
Uganda			553						581							976										
Ukraine	385	413	384	430			299		428	412	279	383	401	407		472	449		284	344			141			
United Arab Emirates				882			269	275	670	300	439	661	366	400	325				221				384			
United Kingdom	245			299		387	217		316	276		252		271	321	339		323	180	223	220		145			
United States of America	395			455	692	610	319	174	451	423	294	388	412	415		505	480		282	342		311	209	509	487	
Uruguay	227			666					406		262			590		853	816		300				534		566	
Uzbekistan	701		681	799	1150		523		795			689	729	736		835	794	815	498	598	629		300			
Vanuatu																										
Venezuela, Bolivia Republic				536			324		524	323		329	425	460		802	767					297	467			
Viet Nam				423						210						545										
Wallis and Futuna Islands																									408	
Western Sahara																										
Yemen				720			309		583		375	492	410	446		817	782	344	235				429	298		
Zambia					1495				466							783										
Zimbabwe				637	1479	1099	397		478	431		487		555		870	834	454	314	398	529		473			

Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	459	461	463	486	489	490	495	497	507	512	515	521	523	526	530	531	534	536	541	544	547	549	550	552	554	558	560	567	568	569	571	572	574	577	587	591	592	600	603	619	636	637	638	639	640
Afghanistan			741			917				917	1209	1209		1136			1209	1209	1136							409	755	590	535	917										1209					
Albania			492			572					756	756		710	756	756	756	756									483	377		572										756	489				
Algeria		1752	366			1267	1267	1267	1267	1267	1617	1617		1515		1617	1617	1617	1515								1073	630		1267				1769						1617	928				1078
American Samoa			422	1331						793																							428							977					
Angola			453	1590						950																							513							1179					
Antigua and Barbuda			449	1685				1015																					340		1504		557						1504						
Argentina			591	1325		793	793	793	793		929	929		859		929	929	929		486							435	451	349	793	1214	875	434					875			252	190		167	250
Armenia			581								911	911		857		911	911	911	857								578	441													589			505	
Australia			667	1642		980	980	980	980	980	1168	1168		1083		1168	1168	1168		648	719		387			265	595	521	408	980	1491	1094	535				1227	1094	1491					270	
Austria			327								487	487		459	487	487	487	487		274		274	206			178	320														326			295	
Azerbaijan, Republic			603			694	694			694	925	925		870		925	925	925			631		347		297	297	600	466												925	605				
Bahamas			346	1457				878	878																														1295						
Bahrain			475	2772				1657																			1462	877	809					2321						2141					
Bangladesh			300	1201		729	729	729	729																	342			245		1078		404					829	1078	893					
Barbados			458	1655																									352			1135							1484	1221					
Belarus			347								500	500			500	500		500		271					196																333				
Belgium-Luxembourg			365								553	553				553		553		305	346		245			210	359														364				92
Belize			321	1343	1343	812			812																			461	262		1197		448					930		1004					
Benin			562	1751		1068																									1595		600	1467						1268					
Bermuda			299	1387																																									
Bhutan			316			529					663																													663					
Bolivia			467	1457	1457	870	870	870	870		1067	1067				1067	1067	1067		653							610	499		870	1305	990	470					992		1067				332	
Bosnia and Herzegovina			440			505					667	667		627	667	667	667	667		385	439						431	337		505										667	437				117
Botswana			580			926																																		1119					
Brazil			425	1280		763	763	763	763		935	935					935			571							532	388	262	763	1148	870	412			935		870	1148						
British Virgin Islands				1680																																				1248					
Brunei Darussalam			367	1307		788		788																									433							964					
Bulgaria			453								697	697		656	697	697	697	697		410	468		270			231	452	351												697	454			405	
Burkina Faso			724			1459	1459	1459	1459																						2171								2171	1750					
Burundi			345	1272																																				948					
Cambodia			419	1384		840		840	840																						1251		467							1010					
Cameroon			453	1359	1359				825	825				915			984	984	915									506	327	825	1235	920	460	1135				920		984					
Canada			264								343	343		324	343	343	343	343		204	233			109	109		252	207	187								369				253				
Cape Verde			520	1803																								640			1622									1326					
Cayman Islands			425	1321	1321					796																					1180	909													
Central African Republic			473	1493	1493	906		906	906																						1353	1014	505												
Chad			560																												1909			1785						1587					
Chile			139			554		554			647	647		598		647	647	647		434							188	87	87			609					678	609		647	122			115	493
China			389	837		502	502	502	502	502	655	655		615		655	655	655	615	365						248	404	303	278	502	724	599	270	704				599	724	655					
Cocos (Keeling) Islands																																													
Colombia			413	1311	1311	789														564							531	444	291		1179	892	434					892	1179	957					
Comoros			462	1494																																				1099					
Congo Democratic Republic			401	1351	1351	811		811	811																						1209	924	442					924		995					
Congo Republic			361	1150	1150	692	692	692	692																						1035	782	380							840					
Cook Islands			452	1253		753		753																				426			1135	843	414					843		902					
Costa Rica			455	1547	1547	940		940	940											653						407		576	360		1397	1054	524					1054		1131					

Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	459	461	463	486	489	490	495	497	507	512	515	521	523	526	530	531	534	536	541	544	547	549	550	552	554	558	560	567	568	569	571	572	574	577	587	591	592	600	603	619	636	637	638	639	640
Côte d'Ivoire				433	1374	1374	835			835	835																					1245	933	467						1245	999					
Croatia				433			493	493	493			651	651		613	651	651	651	651		371	423						424	334		493											432				111
Cuba				366	1487	148	898	898	898	898	898																		504	293		1326	1027	494					1027	1326	1109					
Cyprus			1206	195	1409		839	839	839	839	839	1098	1098		1031		1098	1098	1098		717							778	454	427	839		1004					1161		1216	1098	696			590	
Czech Republic				351								510	510		480	510	510	510	510		282	321	282	221			192	341													510	352				68
Denmark				334								460	460				460		460		249	282		204																		338		334	309	45
Djibouti				517			1240	1240	1240				1549																633	371		1834			1724					1834						
Dominica				339	1277	1277	770		770	770																			428			1140	878								946					
Dominican Republic				422	1584	1584	955		955	955																				325		1415	1089	525					1089		1174					
Ecuador				348	1159	1159	696	696	696	696	696	852	852		794			852	852		519						266	488	376	239	696	1038	792	380					792	1038	852					
Egypt				320	1831		1097	1097	1097	1097	1097	1407	1407		1319			1407	1407	1319	862						501	943	550	508	1097	1603			1534					1603	1407					907
El Salvador				501	1699	1699	1033	1033	1033																				636	395		1534	1158	576					1158		1242					
Equatorial Guinea					1091	1091																																								
Eritrea				576																																					1622					
Estonia				319								457					457		457		245	275	245	204			180	321														302			319	
Ethiopia				489	1613		975	975	975																			656				1454	1100						1100	1454	1181					
Faeroe Islands																																														
Fiji Islands				434	1305		780																						406	279		1171		424					886	1171	951					
Finland				314								408									218	243	218	181																						
France				405			470	470	470	470	470	619	619		582		619	619	619		352	401		256	218		218	398	312	285	470		565					652				404	323	402	363	114
French Guiana				420	1465	1465	870	870	870	870	870																					1301	1005	466					1005	1301	1086					
French Polynesia				424	1328		792	792		792	792																		393	268			906	427						1187	975					
Gabon				328	1056	1056					638																							353							771					
Gambia				607																												1934									1568					
Georgia				451			540					715	715		672	715	715	715	715		426							453	344												715	455			399	
Germany				369								544	544		512	544	544	544	544		299	339	299	240				359														369				81
Ghana					1671	1671	1017		1017																							1523	1127	570					1127		1204					
Greece			1062	146	1227		728	728	728	728	728	962	962		904	962	962	962	962	904	651	719		361			303	698	406	388	728		878					1018			962	657	473		544	
Grenada				502	1800	1800	1088		1088	1088	1088	1328							1328													1615	1234							1615	1328					
Guadeloupe				394	1514	1514	913	913	913	913					1049														505	305		1351	1043	502					1043	1351						
Guam				341	1302		792				792																		483	282		1171									962					
Guatemala				428	1574	1574	954		954		954	1161									694							659	568	340		1414	1080	530					1080		1161					
Guinea				468	1596	1596					975																					1449		548						1449						
Guinea-Bissau				537	1862	1862	1138		1138																							1689		640					1272		1363					
Guyana				474	1598	1598	960		960	960	960						1174												526			1433	1092	525			1174			1433						
Haiti				361	1416	1416	854	854	8543	854																				286		1263	976	470							1053					
Honduras				403	1574	1574	955		955	955	955	1167																674	569	331		1412	1084	530					1084		1167					
Hungary				397								610	610		574	610	610	610	610		339	386	330	363				402	317	289											610	390			372	90
Iceland																											111																			
India				259	1306		796		796	796	796	989	989		925		989	989	989	925							422	611	471	236	796	1164		442					914	1164	989					
Indonesia				402	1319		791																									1182	901	431					901	1182	969					
Iran Islamic Republic				734	1628		973	973	973	973	973	1267	1267		1190	1267	1267	1267	1267	1190	729						446	762	570	522	973	1411			1365			1334	1160		1267					
Iraq				289			1355	1355	1355	1355		1789	1789		1682			1789	1789									1296	749	707	1355				1908						1789					1295
Ireland				274								427									229	258		199			170														427					
Israel			1402	280	1667		996	996	996	996	996	1286	1286		1206		1286	1286	1286		810							878	513	480	996	1450	1180		1394			1356	1180	1450	1286					
Italy			832	482	966		756	756	756	756	756	756	756		710	756	756	756	756	710	443	504		296	249			474	370	338	575							799			756	479	384		427	160

Appendix V-12

Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	459	461	463	486	489	490	495	497	507	512	515	521	523	526	530	531	534	536	541	544	547	549	550	552	554	558	560	567	568	569	571	572	574	577	587	591	592	600	603	619	636	637	638	639	640
Jamaica				380	1451	1451	876	876	876	876																			497			1296	998	483					998	1296						
Japan				360	831		495	495			495	642	642				642	642	642	602	384							373	265	249				264				678				367	278		318	
Jordan				293	1951		1164	1164	1164	1164		1513	1513		1420		1513	1513	1513		980							1053	621	583	1164				1632					1690	1513					1064
Kazakhstan				588								804	804		759		804	804	804		457							579	485												804	570				
Kenya				572	1701	1701	1025	1025	1025	1025	1025		1233														379					1538		565	1414					1538	1233					
Kiribati				424	1504																																			1338						
Korea People's Democratic Republic				381								675	675					675											290	269											675					
Korea Republic				418				590				761	761					761	761		436							441	314	294				318				800			761					
Kuwait				409			1661		1661												1422							1528	903	845					2332						2169					
Kyrgyzstan				543								843			793			843	843						267			545	409												843	544				
Laos				330	1231		745	745	745	745										849									438	259		1105		412							910					
Latvia				334								486							486					219		193	193															318			331	
Lebanon			1217	216	1429		850	850	850	850		1110	1110		1042		1110	1110	1110		708							781	449	422	850		1016								1110					
Lesotho				486																																					904					
Liberia				412	1358	1358	821																											454						1223						
Libyan Arab Jamahiriya				396			1357	1357	1357			1734	1734		1025			1734	1734									1152	701	649	1357				1894						1734					
Liechtenstein																												325																		
Lithuania				352								520	520						520		281				205																520	336			345	
Macedonia, the fmr Yug Rp				466								727	727		683	727	727	727	727		434							468	362		549											467				130
Madagascar				476	1403		841		841	841		1019	1019		941			1019	1019									559				1265	950	459			1019			1265	1019					
Malawi				461	1522	1522					903																					1356								1356	1125					
Malaysia				351	1223		738		738	738	738																		419			1097		407					837	1097	900					
Maldives				489	1542																																				1125					
Mali				718																												2357									1945					
Malta				198							756	981								921							323	681		374	756										981					
Marshall Islands																																														
Martinique				439	1596	1596	965		965	965	965																			343		1431	1094	533												
Mauritania				760																									1055						2545						2264					
Mauritius				430	1194						717																							393							861					
Mexico			1208	351	1511		913	913	913	913	913	1133	1133		1059		1133	1133	1133		720	817			415		415	690	506	284	913	1344	1049	502	1266				1049	1344	1133	427	383	626	490	669
Micronesia Federal States				369	1329	1329																																			977					
Moldova Republic				442								654	654		615	654	654	654	654		372	423	372	268			235	442	352	321											654	435			410	
Mongolia				446																																					654	415			411	
Montserrat				426	1600		964		964																							1429									1186					
Morocco			1281	251	1525		910	910	910	910	910	1175	1175		1102		1175	1175	1175	1102	739	814			384		384	804	452	429	910	1325	1078		1275				1078	1325	1175					
Mozambique				546	1558		928	928	928	928																						1402		501					1055	1402	1132					
Myanmar				374		1306																																			955				395	
Namibia				599																								662													1212					
Nauru				403																																				1249						
Nepal				165			540					679																													679				322	
Netherlands				321								482	482				482		482		265	302		213	184		184	314		226												320				
New Caledonia				444	1254	1254																																			907					
New Zealand				354			456	456	456	456	456	528	528		487		528	528	528	487	167	171	167	185	124		124	235	70	67			498					551		700	528	105	99			
Nicaragua				444	1608	1608	979																											547							1183					
Niger				810																															2624						2338					
Nigeria				625		1846					1124																					1682		630					1248		1333					

Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	459	461	463	486	489	490	495	497	507	512	515	521	523	526	530	531	534	536	541	544	547	549	550	552	554	558	560	567	568	569	571	572	574	577	587	591	592	600	603	619	636	637	638	639	640
Niue				424	1185				712																															1073	854					
Norway				266								370	370				370		370		202	228	202	161																				266		
Oman				488	2097				1266																				686			1864			1758				1461		1580					
Pakistan				264	1740		1046	1046	1046			1350	1350		1267		1350	1350	1350								513	924	499	226	1046	1517			1463				1238	1517	1350					
Panama				386	1356	1356	821																						485	301		1219	927	455					927		996					
Papua New Guinea				413	1348																													435						1203	993					
Paraguay				604	1605		958	958	958	958		1152	1152					1152	1152		659							604	515	370		1451	1077	520					1077	1451	1152					
Peru				385		1213	725	725	725	725	725	889	889		827		889	889	889		543							508	377	246	725	1086	827	393	1005				827	1086	889					
Philippines				338	1298		789	789	789	789																		547	482	280		1167	893	440					893	1167	960					
Poland				338								501	501			501	501		501	473	473	310	273	222	194		194														501	328				
Portugal			877	132	1025		611	611	611	611		799	799		750	799	799	799	799	750	536	593					268	566	334	318	611		730	326				841			799	521	373			
Puerto Rico					1564	1564	942		942	942																				311		1395	1078	516					1078		1162					
Qatar				487							1606																	1384	820	758	1606				2246						2062					1367
Reunion				412	1141		685	685	685			823						823		762	472						235	436	381	264		1033	769	375					769	1033	823					
Romania				397								607	607		572		607	607	607		348	397		248	215		215	399		287											607	393			365	92
Russian Federation				319								397	397		375	397	397	397	397		227	257	227	152				307	255												397	297				
Rwanda				335		1166																																			863					
Saint Helena																																														
Saint Kitts and Nevis				414																									517											1394						
Saint Lucia				440	1601	1601	969		969	969																						1436	1099							1436	1182					
Saint Pierre & Miquelon				#N/A																																										
Saint Vincent/Grenadines				465	1711	1711	1035		1035	1035		1265	1265																			1534														
Samoa				435	1358						813																					1218	924	443					924	1218						
Sao Tome and Principe				300	973																																				711					
Saudi Arabia				513							1688																	1439	844	792					2359						2160					
Senegal				984	3111		1912																						1306			2846								2846	2253					
Serbia and Montenegro							511					676	676		635	676	676	676	676		392	447						436	339		511											433				118
Seychelles				478	1573		948		948																							1416	1074	520						1416	1154					
Sierra Leone				451		1354					825																					1233									978					
Singapore				375																																					911					
Slovakia				340								522	522		492	522	522	522	522		291	331	291	225				345	272	248											522	334				76
Slovenia												578	578		544	578	578	578	578		321	366						377			438											365				95
Solomon Islands				399	1280																								389	258											941					
Somalia				714	2438		1466		1466	1466																			798			2182			2029						1793					
South Africa				660	1732		1035	1035	1035	1035		1244	1244		1154		1244	1244	1244		711						324	652	556	400	1035	1569	1163	563					1163		1244					
Spain			1023	155	1194		711	711	711	711	711	930	930		874	930	930	930	930		622	686		362	303		303	662	384	366	711		851		999			981		1027	930	612	441	559	511	677
Sri Lanka				464		1615	976		976																							1450		540							1187					
Sudan				664	2452		1487	1487	1487	1487																			873	525		2203		825	2055						1813					
Suriname				400	1389	1389	829			829	829																		424					449												
Swaziland				519	1422		850		850	850																								463							1025					
Sweden				338								495	495				495		495		280	318		206	179		179																			
Switzerland				312								492	492		462		492	492	492		283	322	283	201			170	323										519			492	302				
Syrian Arab Republic				240	2020		1198	1198	1198		1198	1586	1586		1491		1586	1586	1586	1491								1158	672	641	1198				1688						1586	1071			894	1177
Tajikistan				544			648		648			861			810			861	861									544	410												861	550			471	
Tanzania Unite Republic				438	1411	1411					841																	609				1260		454						1260	1038					
Thailand				436	1480		903	903	903	903	903																	577	578			1342		507					1007	1342	1079					

Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	459	461	463	486	489	490	495	497	507	512	515	521	523	526	530	531	534	536	541	544	547	549	550	552	554	558	560	567	568	569	571	572	574	577	587	591	592	600	603	619	636	637	638	639	640
Niue				424	1185				712																															1073	854					
Norway				266								370	370				370		370		202	228	202	161																				266		
Oman				488	2097				1266																				686			1864			1758				1461		1580					
Pakistan				264	1740		1046	1046	1046			1350	1350		1267		1350	1350	1350								513	924	499	226	1046	1517			1463				1238	1517	1350					
Panama				386	1356	1356	821																						485	301		1219	927	455					927		996					
Papua New Guinea				413	1348																													435						1203	993					
Paraguay				604	1605		958	958	958	958		1152	1152					1152	1152		659							604	515	370		1451	1077	520					1077	1451	1152					
Peru				385		1213	725	725	725	725	725	889	889		827		889	889	889		543							508	377	246	725	1086	827	393	1005				827	1086	889					
Philippines				338	1298		789	789	789	789																		547	482	280		1167	893	440					893	1167	960					
Poland				338								501	501			501	501		501	473	473	310	273	222	194		194														501	328				
Portugal			877	132	1025		611	611	611	611		799	799		750	799	799	799	799	750	536	593					268	566	334	318	611		730	326				841			799	521	373			
Puerto Rico					1564	1564	942		942	942																				311		1395	1078	516					1078		1162					
Qatar				487							1606																	1384	820	758	1606				2246						2062					1367
Reunion				412	1141		685	685	685			823						823		762	472						235	436	381	264		1033	769	375					769	1033	823					
Romania				397								607	607		572		607	607	607		348	397		248	215		215	399		287											607	393			365	92
Russian Federation				319								397	397		375	397	397	397	397		227	257	227	152				307	255												397	297				
Rwanda				335		1166																																			863					
Saint Helena																																														
Saint Kitts and Nevis				414																									517											1394						
Saint Lucia				440	1601	1601	969		969	969																						1436	1099							1436	1182					
Saint Pierre & Miquelon				#N/A																																										
Saint Vincent/Grenadines				465	1711	1711	1035		1035	1035		1265	1265																			1534														
Samoa				435	1358						813																					1218	924	443					924	1218						
Sao Tome and Principe				300	973																																				711					
Saudi Arabia				513							1688																	1439	844	792					2359						2160					
Senegal				984	3111		1912																						1306			2846								2846	2253					
Serbia and Montenegro							511					676	676		635	676	676	676	676		392	447						436	339		511											433				118
Seychelles				478	1573		948		948																							1416	1074	520						1416	1154					
Sierra Leone				451		1354					825																					1233									978					
Singapore				375																																					911					
Slovakia				340								522	522		492	522	522	522	522		291	331	291	225				345	272	248											522	334				76
Slovenia												578	578		544	578	578	578	578		321	366						377			438											365				95
Solomon Islands				399	1280																								389	258											941					
Somalia				714	2438		1466		1466	1466																			798			2182			2029						1793					
South Africa				660	1732		1035	1035	1035	1035		1244	1244		1154		1244	1244	1244		711						324	652	556	400	1035	1569	1163	563					1163		1244					
Spain			1023	155	1194		711	711	711	711	711	930	930		874	930	930	930	930		622	686		362	303		303	662	384	366	711		851		999			981		1027	930	612	441	559	511	677
Sri Lanka				464		1615	976		976																							1450		540							1187					
Sudan				664	2452		1487	1487	1487	1487																			873	525		2203		825	2055						1813					
Suriname				400	1389	1389	829			829	829																		424					449												
Swaziland				519	1422		850		850	850																								463							1025					
Sweden				338								495	495				495		495		280	318		206	179		179																			
Switzerland				312								492	492		462		492	492	492		283	322	283	201			170	323										519			492	302				
Syrian Arab Republic				240	2020		1198	1198	1198		1198	1586	1586		1491		1586	1586	1586	1491								1158	672	641	1198				1688						1586	1071			894	1177
Tajikistan				544			648		648			861			810			861	861									544	410												861	550			471	
Tanzania Unite Republic				438	1411	1411					841																	609				1260		454						1260	1038					
Thailand				436	1480		903	903	903	903	903																	577	578			1342		507					1007	1342	1079					

Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	459	461	463	486	489	490	495	497	507	512	515	521	523	526	530	531	534	536	541	544	547	549	550
Niue			424	1185				712															
Norway			266								370	370				370		370		202	228	202	161
Oman			488	2097				1266															
Pakistan			264	1740		1046	1046	1046			1350	1350		1267		1350	1350	1350					
Panama			386	1356	1356	821																	
Papua New Guinea			413	1348																			
Paraguay			604	1605		958	958	958	958		1152	1152					1152	1152		659			
Peru			385		1213	725	725	725	725	725	889	889		827		889	889	889		543			
Philippines			338	1298		789	789	789	789														
Poland			338								501	501			501	501		501	473	473	310	273	222
Portugal		877	132	1025		611	611	611	611		799	799		750	799	799	799	799	750	536	593		
Puerto Rico				1564	1564	942		942	942														
Qatar			487							1606													
Reunion			412	1141		685	685	685			823						823		762	472			
Romania			397								607	607		572		607	607	607		348	397		248
Russian Federation			319								397	397		375	397	397	397	397		227	257	227	152
Rwanda			335		1166																		
Saint Helena																							
Saint Kitts and Nevis			414																				
Saint Lucia			440	1601	1601	969		969	969														
Saint Pierre & Miquelon			#N/A																				
Saint Vincent/Grenadines			465	1711	1711	1035		1035	1035		1265	1265											
Samoa			435	1358						813													
Sao Tome and Principe			300	973																			
Saudi Arabia			513							1688													
Senegal			984	3111		1912																	
Serbia and Montenegro						511					676	676		635	676	676	676	676		392	447		
Seychelles			478	1573		948		948															
Sierra Leone			451		1354					825													
Singapore			375																				
Slovakia			340								522	522		492	522	522	522	522		291	331	291	225
Slovenia											578	578		544	578	578	578	578		321	366		
Solomon Islands			399	1280																			
Somalia			714	2438		1466		1466	1466														
South Africa			660	1732		1035	1035	1035	1035		1244	1244		1154		1244	1244	1244		711			
Spain		1023	155	1194		711	711	711	711	711	930	930		874	930	930	930	930		622	686		362
Sri Lanka			464		1615	976		976															
Sudan			664	2452		1487	1487	1487	1487														
Suriname			400	1389	1389	829			829	829													
Swaziland			519	1422		850		850	850														
Sweden			338								495	495				495		495		280	318		206
Switzerland			312								492	492		462		492	492	492		283	322	283	201
Syrian Arab Republic			240	2020		1198	1198	1198		1198	1586	1586		1491		1586	1586	1586	1491				
Tajikistan			544			648		648			861			810			861	861					
Tanzania Unite Republic			438	1411	1411					841													
Thailand			436	1480		903	903	903	903	903													

Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	552	554	558	560	567	568	569	571	572	574	577	587	591	592	600	603	619	636	637	638	639	640
Niue																1073	854					
Norway																				266		
Oman					686			1864			1758				1461		1580					
Pakistan			513	924	499	226	1046	1517			1463				1238	1517	1350					
Panama					485	301		1219	927	455					927		996					
Papua New Guinea										435						1203	993					
Paraguay				604	515	370		1451	1077	520					1077	1451	1152					
Peru				508	377	246	725	1086	827	393	1005				827	1086	889					
Philippines				547	482	280		1167	893	440					893	1167	960					
Poland	194		194														501	328				
Portugal			268	566	334	318	611		730	326				841			799	521	373			
Puerto Rico						311		1395	1078	516					1078		1162					
Qatar				1384	820	758	1606				2246						2062					1367
Reunion			235	436	381	264		1033	769	375					769	1033	823					
Romania	215		215	399		287											607	393			365	92
Russian Federation				307	255												397	297				
Rwanda																	863					
Saint Helena																						
Saint Kitts and Nevis					517											1394						
Saint Lucia								1436	1099							1436	1182					
Saint Pierre & Miquelon																						
Saint Vincent/Grenadines								1534														
Samoa								1218	924	443					924	1218						
Sao Tome and Principe																	711					
Saudi Arabia				1439	844	792					2359						2160					
Senegal					1306			2846								2846	2253					
Serbia and Montenegro				436	339		511											433				118
Seychelles								1416	1074	520						1416	1154					
Sierra Leone								1233									978					
Singapore																	911					
Slovakia				345	272	248											522	334				76
Slovenia				377			438											365				95
Solomon Islands					389	258											941					
Somalia					798			2182			2029						1793					
South Africa			324	652	556	400	1035	1569	1163	563					1163		1244					
Spain	303		303	662	384	366	711		851		999			981		1027	930	612	441	559	511	677
Sri Lanka								1450		540							1187					
Sudan					873	525		2203		825	2055						1813					
Suriname					424					449												
Swaziland										463							1025					
Sweden	179		179																			
Switzerland			170	323										519			492	302				
Syrian Arab Republic				1158	672	641	1198				1688						1586	1071			894	1177
Tajikistan				544	410												861	550			471	
Tanzania Unite Republic				609				1260		454						1260	1038					
Thailand				577	578			1342		507					1007	1342	1079					

Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	641	642	643	644	646	647	648	649	655	656	661	667	671	674	677	687	689	692	693	698	702	711	720	723	748	754	773	777	780	782	788	789	800	809	821	826	836	839
Costa Rica										1300	1300					455							500											1549		438		
Côte d'Ivoire										1156	1156					433	1212							416												383	1213	
Croatia	388					173																					203									374		
Cuba										1244	1244																			559		720	720			416		
Cyprus	172		277																																	354		
Czech Republic	320				356	148									368		565										147											
Denmark	309					143																334																
Djibouti																	1814																					
Dominica										1066	1066								1123		1123		461	461														
Dominican Republic										1323	1323												575	575								773				417		
Ecuador										964	964	1171										348		381									576	1159		281	1016	
Egypt																	1609					320					607		805									
El Salvador										1429	1429																			580			825			488		
Equatorial Guinea										915	915																							1093				
Eritrea																								773														
Estonia									150																		339											
Ethiopia										1350		1637				489	1419				1419	489	505	505						512		574			771	430		
Faeroe Islands																																						
Fiji Islands										1080	1080					434							399													275		
Finland								299																														
France	363	313	300	450	418	162			169						426												202	274								349		
French Guiana																																						
French Polynesia										1097								1158																				
Gabon										883	883																										929	
Gambia																																						
Georgia									182			919			481	451						451			819											391		
Germany	337	298				159									386																					316		
Ghana										1407	1407					572	1474						455													458	1475	
Greece			226														1074					146		683			307									292		
Grenada											1506						1584		1584	1584	1584			618														
Guadeloupe										1264								1332																				
Guam																																						
Guatemala										1321	1321	1602				428					1388	428		545						562			762			453	1389	
Guinea										1349	1349																					770				486		
Guinea-Bissau																																						
Guyana										1330	1330												514	514												394		1401
Haiti										1183	1183																					689				379		
Honduras						286				1323	1323					403					1390															466		
Hungary	372		302		388				181								678					397		449				273								351		
Iceland																																						
India										1102	1102	1337				259	1158				1158	259	532	532					564	564						377	1159	
Indonesia										1096	1096	1332				402		1155	1155	1155	1155		421	421						402		659		1320		315	1155	
Iran Islamic Republic	676											1650					1430					734														633		
Iraq	250		456																																	548		
Ireland				303	278	127			132						287																							

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Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	641	642	643	644	646	647	648	649	655	656	661	667	671	674	677	687	689	692	693	698	702	711	720	723	748	754	773	777	780	782	788	789	800	809	821	826	836	839
Israel																																							
Italy		427		357		502	185																					255	329								417		
Jamaica											1213	1213						1277						530	530								705			641	394		
Japan				253		384				165			840			381																					301		
Jordan		263																																			503		
Kazakhstan										242																											535		
Kenya											1419		1721				572	1492	1492		1492	1492	572	490	490								852		1706		406		
Kiribati																																							
Korea People's Democratic Republic																409													249								319		
Korea Republic													1000			446								472					278								350		
Kuwait																									1433														
Kyrgyzstan										212							543	935							597												465		
Laos											1032		1252					1085				1085										815					353		
Latvia										160																		352											
Lebanon		185																					216		727												350		
Lesotho																																							
Liberia											1136	1136																										1196	
Libyan Arab Jamahiriya																																					625		
Liechtenstein																																							
Lithuania										168																		367											
Macedonia, the fmr Yug Rp		419		350			183																														409		
Madagascar											1165	1165	1415				476	1227	1227	1227	1227	1227	476	394	394						375		709			680	321		
Malawi											1254		1528				461	1325	1325			1325	461		479								774				320		
Malaysia											1022	1022	1240				351	1075			1075	1075		412													322	1075	
Maldives																		1355																					
Mali													2671				718	2315													935						733		
Malta				242																																			
Marshall Islands																																							
Martinique											1336							1405																					
Mauritania																																							
Mauritius													1205											314	314											607	272		
Mexico		329				461	278		461		1264	1264					351	1332	1332				351		591								726	726			432	1332	1332
Micronesia Federal States												1117																											
Moldova Republic										191																											392		
Mongolia										208																													
Montserrat																																							
Morocco																		1337					251		741	1451							733			474	384		
Mozambique											1287		1565																		378		800				321		
Myanmar											1103		1334					1156												437	437					654	407	1156	
Namibia																																							
Nauru																																							
Nepal											748		910					788				788		382	382					391							277		
Netherlands		293					141																321					153											
New Caledonia											1039																												
New Zealand		318			272	267	55		267							116																				454			

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Country list (FAO)	Crop codes FAOSTAT (see Appendix IX)	641	642	643	644	646	647	648	649	655	656	661	667	671	674	677	687	689	692	693	698	702	711	720	723	748	754	773	777	780	782	788	789	800	809	821	826	836	839
Israel																																							
Italy		427		357		502	185																					255	329								417		
Jamaica											1213	1213						1277						530	530								705			641	394		
Japan				253		384				165			840			381																					301		
Jordan		263																																			503		
Kazakhstan										242																											535		
Kenya											1419		1721				572	1492	1492		1492	1492	572	490	490								852		1706		406		
Kiribati																																							
Korea People's Democratic Republic																409													249								319		
Korea Republic													1000			446								472					278								350		
Kuwait																									1433														
Kyrgyzstan										212							543	935							597												465		
Laos											1032		1252					1085				1085										815					353		
Latvia										160																		352											
Lebanon		185																					216		727												350		
Lesotho																																							
Liberia											1136	1136																										1196	
Libyan Arab Jamahiriya																																					625		
Liechtenstein																																							
Lithuania										168																		367											
Macedonia, the fmr Yug Rp		419		350			183																														409		
Madagascar											1165	1165	1415				476	1227	1227	1227	1227	1227	476	394	394						375		709			680	321		
Malawi											1254		1528				461	1325	1325			1325	461		479								774				320		
Malaysia											1022	1022	1240				351	1075			1075	1075		412													322	1075	
Maldives																		1355																					
Mali													2671				718	2315													935						733		
Malta				242																																			
Marshall Islands																																							
Martinique											1336							1405																					
Mauritania																																							
Mauritius													1205											314	314											607	272		
Mexico		329				461	278		461		1264	1264					351	1332	1332				351		591								726	726			432	1332	1332
Micronesia Federal States												1117																											
Moldova Republic										191																											392		
Mongolia										208																													
Montserrat																																							
Morocco																		1337					251		741	1451							733			474	384		
Mozambique											1287		1565																		378		800				321		
Myanmar											1103		1334					1156												437	437					654	407	1156	
Namibia																																							
Nauru																																							
Nepal											748		910					788				788		382	382					391							277		
Netherlands		293					141																321					153											
New Caledonia											1039																												
New Zealand		318			272	267	55		267							116																				454			

Country list (FAO) / Crop codes FAOSTAT (see Appendix IX)	641	642	643	644	646	647	648	649	655	656	661	667	671	674	677	687	689	692	693	698	702	711	720	723	748	754	773	777	780	782	788	789	800	809	821	826	836	839
Syrian Arab Republic	208		389																			240														483		
Tajikistan						199			206																											467		
Tanzania Unite Republic										1166	1166	1419					1231			1231	1231											713			616	298		
Thailand										1249	1249	1510				436	1309						455	455					489	489		716			748	444	1309	
Timor-Leste																	1181																					
Togo										1428	1428						1496				1496			468												463		
Tokelau																																						
Tonga										1010								1062						331														
Trinidad and Tobago										1172	1172										1233		474													377		
Tunisia																	1257					217		734												364		
Turkey	541		460			225						1237					1072	1072				622		686			602	436								540		
Turkmenistan									316																											661		
Tuvalu																																						
Uganda										1526	1526	1851				606	1605	1605					548													440		
Ukraine						172			178						442							407					413	282								364		
United Arab Emirates	352																																			613		
United Kingdom				299	275	120									284												266											
United States of America	382	334								690					447								467													364		
Uruguay																																				165		
Uzbekistan									302							736	1223												769							464		
Vanuatu										1042	1042													380														
Venezuela, Bolivia Republic										1299	1299																					762				414		
Viet Nam									223	992		1205				291	1045		1045			291							447						500	331	1045	
Wallis and Futuna Islands																								429												295		
Western Sahara																																						
Yemen	410									1604																										499		
Zambia										1467		1791				476	1553							629												438		
Zimbabwe										1464		1783				555	1545	1545				555		542												371		

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