The Water Footprint of Indonesian Provinces

The relation between water use and consumption in Indonesian provinces

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Abstract

The demand for agricultural products will increase in Indonesia, but the agricultural sector is dealing with the problem of water scarcity. This study will analyze the water use in the agricultural sector and the consumption of this water by the population. In order to do so, the study will make use of the concept water footprint and virtual water content. The water footprint indicates how much water people directly and indirectly consume. The amount of water that a crop uses during its growth period is called virtual water content.

The program CROPWAT has been used for the calculation of the virtual water content in crops. The method for calculating the water footprint is developed by Hoekstra and Chapagain. Data for this study have been taken mainly from the years 2000 till 2004.

There is a big variety in the virtual water content of crops between provinces. Rice produced on Jawa has the lowest virtual water content of all rice in Indonesia. The green water component is relatively high for all crops, only for rice and soybeans the contribution of the irrigation water relatively high compared with the other crops.

The interprovincial virtual water flows are primarily caused by rice. The products cassava, coconut, bananas and coffee have the largest interprovincial water flows relatively to the water use for production. The biggest amount of virtual water from provinces or countries will go to Jawa. Sumatra has the largest contribution in the interprovincial water flows and the flows to other countries.

The average water footprint in Indonesia is 1092 m^3/cap/yr, but there are large regional differences. The footprint varies between 841 and 1760 m^3/cap/yr. The average water footprint consists for 84% of domestic internal water. The remaining 16% comes from other provinces or countries.

Indonesian provinces are highly dependent on internal water resources. If there is more trade between the provinces and the location of crop production will depend on efficient water use, the water footprint could become lower.

Preface

Four months ago I started with the preparations for my research and stay in Indonesia. After a short preparation period, I went to LabMath in Bandung to do research on the water footprint of Indonesia. In three month I managed to finish this research. It is a topic with a lot of interesting side steps, because of the limited time I only could finish my objective. Although improvements can be made, I am very content with the results.

I would like to thank a number of people for their support and guidance during this study.

First of all, I would like to thank my supervisors Martijn Booij, Sena Sopaheluwakan and Andonowati for their support, advice and guidance.

I would also like to thank everyone at LabMath-Indonesia, for their kindness and interest. I had a wonderful time at the institute and in Indonesia.

Next, I would also like to thank Gullit and Mees. With the three of us, we worked together on this subject. It was really inspiring, motivating and helpful. In the weekends we had a lot of time to explore the country together.

Finally, I want to say thank you to my family, friends and Hannah for their support during my period in Indonesia.

Rik Bulsink

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1 Introduction

1.1 Background

Agriculture is of great importance to Indonesia. The sector counts only for 11% to the GDP in 2002, but 44% of the labor force is working in the agricultural sector, making it the largest sector in terms of employment. Developments in this sector can lead to a reduction of poverty and the generation of broad-based economic growth (ADB, 2006). The sector has a strategic role concerning stability, economic growth and food security. To emphasize the important role of agriculture, the Ministry of Agriculture (2006) developed the following vision for the years 2005-2025: realizing a competitive, fair and sustainable industrial agricultural system to guarantee food security and community welfare.

To develop the agricultural sector and achieve the abovementioned vision from the ministry, there are some challenges and problems to overcome. The agricultural sector is faced with increasing demand for agricultural products, caused by an increasing population and hence a higher consumption. Water resources for agricultural activities are also getting more scarcer, due to the impact of natural resources capacity degradation. Moreover, water use competition is also increasing due to increasing use of water for households and industries (Ministry of Agriculture, 2006).

To measure and analyze the water use by the agricultural sector and consumption of water by the population the water footprint has been developed.

The water footprint is a consumption-based indicator of water use and has been introduced by Hoekstra in 2002 (Chapagain & Hoekstra, 2004). This method indicates the water use of inhabitants from a country or province in relation to their consumption pattern. The traditional production-sector-based indicators show the water withdrawal in the domestic, agricultural and industrial sector. But this traditional method does not give information about the actual need of water by the people in a country in relation to their consumption pattern. So, the water footprint is a useful addition to the traditional production-sector-based indicators.

The concept of the water footprint is based on the principals of the ecological footprint, developed by Wackernagel and Rees (1996). The ecological footprint indicates the human demand on the Earth’s ecosystem and natural resources. It represents the area of productive land and aquatic ecosystems required to produce the resources used, and to assimilate the waste produced, by a certain population at a specified material standard of living, wherever on earth that land may be located. The ecological footprint shows the area needed to sustain people’s living, the water footprint indicates the annual water volume required to sustain a population (Chapagain & Hoekstra, 2004).

A nation’s water footprint exists of two parts, namely the internal and the external water footprint. The internal water footprint is defined as the use of domestic water resources to produce goods and services consumed by inhabitants of the country. The external water footprint is defined as the annual volume of water resources used in other countries to produce goods and services consumed by inhabitants of the country concerned (Hoekstra & Chapagain, 2007).

The external water footprint is the result of trade between nations. This trade can cause water savings if the product that is traded has a higher virtual water content in the importing nation than in the exporting nation (Chapagain et al, 2006a). However it can also occur that there is a water loss, than the virtual water content of a product in the importing nation is lower than in the exporting nation. The trade of products applies for nations as well as provinces within a nation or any other spatial scale.

The footprint can be divided into three components, an agricultural, an industrial and a domestic component. The agricultural component is the water use in the agricultural sector to produce agricultural products, the industrial component corresponds with the water use for industrial products in the industrial sector and the domestic component is the water use in the domestic sector (Kampman, 2007). In this study the focus will be only the agricultural component.

The water footprint is closely linked to the virtual water concept. This concept has been introduced in the early 1990s by Allan (Allan, 1993). Virtual water represents the amount of water needed to raise a certain quantity of food (Allan, 1999). Virtual water is thus the amount of water that a crop needs during its growth and not the amount of water contained in the crop. The virtual water content of a product is measured at the place where the product is actually produced. Allan also suggests that trade of virtual water (coming along in the products) can release the pressure on the available water resources of a country. The water footprint is using the concept of virtual water in combination with the consumption rate of a population to determine the water consumption of this particular population.

Virtual water content can be divided into a blue, green and gray component. The green component is the volume of water taken up by plants from the soil insofar it concerns soil water originating from infiltrated rainwater. The blue component refers to the water take up by plants from the soil insofar it concerns infiltrated irrigation water. The gray part covers the water required to dilute waste flows to such an extent that the quality of the water remains below agreed water quality standards (Chapagain et al, 2006b). The green and blue water footprints are based on Falkenmark (2003) and the gray component on Chapagain et al (2006b).

The water footprint has been calculated already for different countries by Hoekstra and Chapagain (2007). Indonesia is also included in this study. But for some countries, like India and China, further research have been done on a more detailed scale. Those studies give a better view of the water flows, consumption and use within a country than the study of Hoekstra and Chapagain. For Indonesia the detailed study has not been done yet, this study will be the first research about the water footprint of Indonesian provinces.

1.2 Objective

The objective of this study is to determine the water footprint of Indonesian provinces.

The objective can be divided in the following sub questions:

1. What is the virtual water content of the crops cultivated in Indonesian provinces?
2. What are the virtual water flows between Indonesian provinces?
3. What are the water footprints of Indonesian provinces?

The study is focusing only on the production of agricultural products. The domestic and industrial water footprint contributes for only to about 10% to the global water footprint (Hoekstra & Chapagain, 2007).

This research is about the internal water footprint of Indonesian provinces and trade between Indonesian provinces. The external part of the water footprint has been studied by Mees Beeker. His work is about the flow of water into Indonesia and governmental policy in relation with virtual water.

The report will start with an explanation of the used method in chapter 2. In chapter 3 the study area and the data will be given. The results of the calculation of the virtual water content can be found in chapter 4. In the next chapter the virtual water flows will be presented. In chapter 6 the water footprints of Indonesian provinces are presented. Chapter 7 contains the discussion and finally in chapter 8 the conclusions and recommendations will be presented.

2 Method

The method for determining the water footprint of Indonesia exists of several steps. First of all, the virtual water content of crops in the different provinces must be calculated. After the calculation of the virtual water content of primary crops, the calculation of the virtual water content of processed crops will be given. Subsequently, the calculation steps for the virtual water flows between provinces caused by trade will be shown. Finally, the water footprints of Indonesian provinces can be calculated. Throughout this chapter the following symbols will be used:

$c = crop$

$p = province$

$n = national$

$t = time, steps\ of\ 10\ days\ in\ a\ month$

$T = time, in\ days$

2.1 Virtual water content

Crops require a certain amount of water during their growth period. The actual amount of water that a crop uses is called virtual water. The virtual water content can be calculated in the following five steps: evapotranspiration, green crop water use, blue crop water use, gray crop water use and virtual water content.

2.1.1 Evapotranspiration

Evapotranspiration is a combination of two separate processes whereby water is lost on the one hand from the soil surface by evaporation and on the other hand from the crop by transpiration (Allen et al, 1998). The evapotranspiration ($ET_{c,opt}$, mm/day) gives the amount of water evaporated by a crop under optimal conditions, there is an abundant of water in the soil. The $ET_{c,opt}$ depends on location, crop and time. The formula for the evapotranspiration is as follows:

$$ET_{c,opt}[c,p,t] = K_c[c,T] * ET_0[p,t] \quad (1).$$

Here, K_c is the crop coefficient $(-)$ and ET_0 is the reference evapotranspiration in a province ($mm/10\ day$). For this calculation $ET_{c,opt}$ is calculated for every time step of 10 days over the full growing period. The assumption is made that a month consists of 30 days.

The reference evapotranspiration (ET_0) is the evapotranspiration of a hypothetical grass. The only factors affecting ET_0 are climatic parameters. Water is abundantly available at the surface and soil factors do not affect the ET_0. The ET_0 depends on location and time. The ET_0 will be calculated with the FAO Penman-Monteith method. The formula is as follows:

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)} \quad (2).$$

Where, R_n is the net radiation, G is the soil heat flux, $(e_s - e_a)$ represents the vapour deficit of the air, ρ_a is the mean air density at constant pressure, c_p is the specific heat of the air, Δ represents the slope of the saturation vapour pressure temperature relationship, γ is the psychrometric constant and r_s and r_a are the (bulk) surface and aerodynamic resistances. The parameters will not be further defined, cause this study is not focussing on this equation. Reference here can be made to the work of Gullit Widarta in which this equation is further researched and explained. This study will use this method, just like all the other studies related to the water footprint.

The reference evapotranspiration will be corrected by the crop coefficient (K_c). This coefficient depends on croptype, variety and development stage. The differences are mainly caused by the resistance to transpiration, crop height, crop roughness, reflection, ground cover and crop rooting characteristics. The crop development stage in relation with K_c can be visualised as follows:

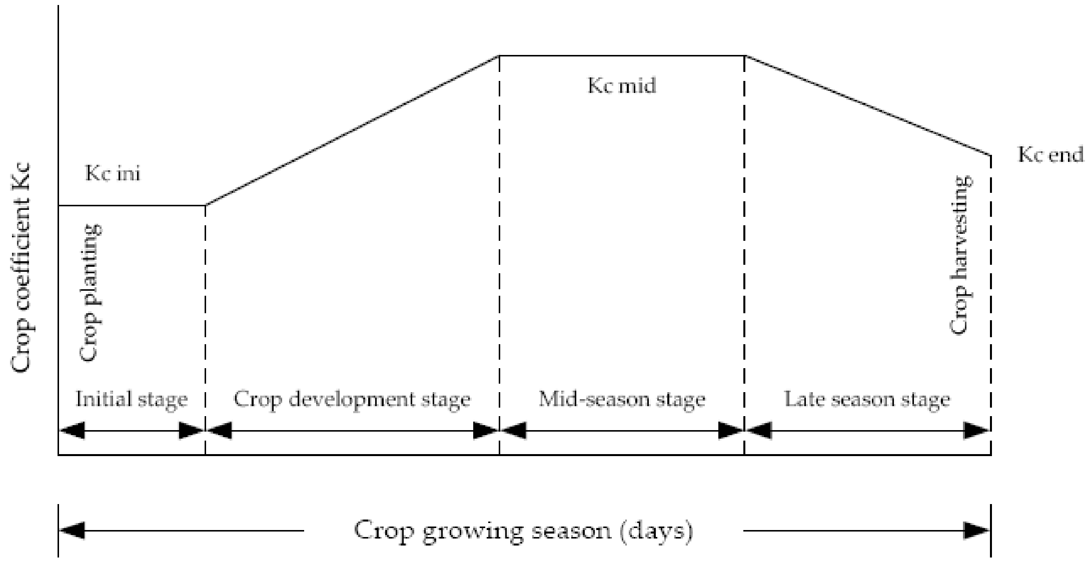

Figure 2.1: Development of K_c during the crop growing season (Chapagain & Hoekstra, 2004)

Here, the initial stage is the period from the planting date to approximately 10% ground cover, the crop development stage is the period from 10% ground cover to effective full cover, the mid-season stage is the time from effective full cover to the time the crop starts to mature and the late season is the time from the start of maturity to harvest.

2.1.2 Green crop water use

The green component is the volume of evaporated rainwater that is used for crop growth, the evapotranspiration. The green crop water use is the total amount of evapotranspiration of rainwater. The formula for the green crop water use (CWU_{green}, m^3/ha) is as follows:

$$CWU_{green}[c,p] = 10 * \sum_{t=1}^{lp} ET_{c,rw}[c,p,t] \quad (3).$$

Here, $ET_{c,rw}$ is the crop evapotranspiration under rain fed conditions (mm/day). The factor 10 is included to convert mm into m^3/ha and the summation is done over the full lenght of the growth period (lp, day) in time steps of 10 days.

The crop evapotranspiration under rain fed conditions ($ET_{c,rw}, mm/day$) is the evapotranspiration of rainwater by the crop and can be calculated as follows:

$$ET_{c,rw}[c,p,t] = Min(ET_{c,opt}[c,p,t], P_{eff}[s]) \quad (4).$$

Here, P_{eff} is the effective rainfall (mm/day). P_{eff} is the amount of the total precipitation ($P_{tot}, mm/day$) that can be used for evapotranspiration by the crop and the soil surface. The effective rainfall is the total rainfall minus runoff and deep percolation. Only the water retained in the root zone can be used by the plant and represents what is called the effective part of the rainwater. The effective rainfall is thus the fraction of the total amount of rainwater useful for meeting the water need of the crops (FAO, 1986).

2.1.3 Blue crop water use

The blue component is the use of groundwater and surface water for evapotranspiration during the production of a commodity. This component consists of evapotranspirated irrigation water. The blue component can be calculated as follows:

$$CWU_{blue}[c,p] = 10 * \sum_{t=1}^{lp} ET_{c,iw}[c,p,t] \quad (5).$$

Here, CWU_{blue} is the volume of irrigation water that is actually supplied to the crop field (m^3/ha) and $ET_{c,iw}$ is the actual crop evapotranspiration of irrigation water (mm/day). The factor 10 is included to convert mm into m^3/ha and the summation is done over the full lenght of the growth period (lp, day) in time steps of 10 days.

The actual crop evapotranspiration of irrigation water depends on the amount of irrigation water required by the crop and the fraction of land that is actually irrigated and foresees this requirement. This component can be calculated as follows:

$$ET_{c,iw}[c,p,t] = IWR[c,p,t] * iaf[c,p] \quad (6).$$

Here, IWR is the irrigation water requirement (mm/day) and iaf is the fraction of the total area of crop c that is irrigated $(-)$.

The fraction of total irrigated area can be derived from data. The calculation of the irrigation water requirement is as follows:

$$IWR[c,p,t] = ET_{c,opt}[c,p,t] - ET_{c,rw}[c,p,t] \quad (7).$$

Only the irrigation water use on the field is taken into account, which means that the loss of irrigation water is excluded.

2.1.4 Dilution water requirement

The dilution water requirement is the amount of water that is required to dilute pollutants to such an extent that concentrations are reduced to agreed maximum acceptable levels during the production of the commodity. To stimulate the growth of a crop, fertilizers are applied to the crops. These fertilizers can be distinguished in nitrate, potassium and phosphorus. Only nitrate is taken into account in this study, because the mobility and the impact of the others are too low (Mom, 2007). The calculation of the dilution water requirement is as follows:

$$DWR[c,p] = N_{leached}[c,p] * df \quad (8).$$

Here, DWR is the volume of water that is needed to dilute the nitrate that has leached to the groundwater to the desired concentration level (m^3/ha), $N_{leached}$ is the amount of nitrate that has leached to the groundwater $(ton\ N/ha)$ and df is the dilution factor (m^3/ton).

The factors determining the amount of nitrate that has leached to the groundwater are the amount of nitrate supplied to a field and the leaching factor. The calculation is as follows:

$$N_{leached}[c,p] = N_{used}[c,p] * lf \qquad (9).$$

Here, N_{used} is the total amount of nitrate supplied to the field $(ton\ N/ha)$ and lf is the leaching factor, which is the fraction of the total supplied amount of nitrate that eventually leaches to the groundwater $(-)$.

The dilution factor depends on the recommended level of nitrogen in the groundwater, the formula is as follows:

$$df = \frac{10^6}{rl} \qquad (10).$$

Here, df is the dilution factor (m^3/ton) and rl is the recommended level of nitrogen $(mg\ N/l)$. The factor 10^6 is added to the formula to convert l/mg into m^3/ton.

2.1.5 Virtual water content

The virtual water content of a crop has three components, namely the green, blue and gray component. The calculation of the virtual water content is as follows:

$$VWC_{tot}[c,p] = VWC_{green}[c,p] + VWC_{blue}[c,p] + VWC_{gray}[c,p] \qquad (11).$$

Here, VWC_{tot} is the total virtual water content of a crop (m^3/ton), VWC_{green} is the green virtual water content of a crop (m^3/ton), VWC_{blue} is the blue virtual water content of a crop (m^3/ton) and VWC_{gray} is the gray virtual water content of a crop (m^3/ton).

The green component is calculated as follows:

$$VWC_{green}[c,p] = \frac{CWU_{green}[c,p]}{Y_c[c,p]} \qquad (12).$$

Here, CWU_{green} is the volume of the total rainfall that is actually used for evapotranspiration by the crop field (m^3/ha) and Y_c is the yield of a crop (ton/ha).

The blue component is calculated as follows:

$$VWC_{blue}[c,p] = \frac{CWU_{blue}[c,p]}{Y_c[c,p]} \qquad (13).$$

Here, CWU_{blue} is the volume of irrigation water that is actually supplied to the crop field and used for evapotranspiration (m^3/ha).

The gray component is calculated as follows:

$$VWC_{gray}[c,p] = \frac{DWR[c,p]}{Y_c[c,p]} \qquad (14).$$

Here, DWR is the volume that is needed to dilute the nitrate that has leached to the groundwater to the desired concentration level (m^3/ha).

2.2 Virtual water content of processed crops

The virtual water content of processed crops depends on the virtual water content of the primary crops. The virtual water content of the primary crop is distributed over the different products from that specific crop. The distribution model of virtual water over the products is based on the production fraction and value fraction. Distribution based only on the weight of product would be less meaningful (Chapagain and Hoekstra, 2004). For example, two processed products of the oil palm fruit are palm oil and the palm nut and kernel. The oil has a low weight fraction but a high value fraction, compared with the palm nut and kernels. The oil palm fruit is mainly cultivated for the oil. So if the distribution would only be based on the weight, the virtual water content of the processed products would be unrealistically distributed.

The production factor $(pf, -)$ of product a is calculated as follows:

$$pf[a] = \frac{W_a[a]}{W_{tot}} \qquad (15).$$

Here, W_a is the weight of the processed product (ton) and W_{tot} is the total weight of the root (input) product (ton).

The calculation of the value fraction $(vf, -)$ of product a is as follows:

$$vf[a] = \frac{v[a] * pf[a]}{\sum_{a=1}^{n}(v[a] * pf[a])} \qquad (16).$$

Here, v is the market value of the processed crop $(US\$/ton)$ and pf is the production factor $(-)$. The summation is to determine the aggregated market value of all products obtained from the root product.

The virtual water content of the processed crop $(VWC_{ac}, m^3/ton)$ is calculated as follows:

$$VWC_{ac}[c,p] = VWC[c,p] * \frac{vf[a]}{pf[a]} \qquad (17).$$

Here, VWC is the virtual water content of the root product in a province (m^3/ton).

2.3 Virtual water flows

Trade determines the external water footprint and thus virtual water flows. In this study two different sorts of trade are taken into account, international and interprovincial trade. The virtual water flow between provinces can be calculated with the flow of products between provinces and the virtual water content of these products. The international virtual water flow can be calculated with the flow of products between a province and a country and the virtual water content of these products. First, the method to determine the flows of products will be explained and after this the calculation of the virtual water flows. The trade model is based on the model used in the study of Ma et al (2006).

2.3.1 Trade

The calculation of the flow of products that are entering or leaving a province is based on the national food balance. The national food balance consists of supply and utilization. The domestic supply $(S, ton/yr)$ of a crop is equal to the utilization $(U, ton/y)$.

$$S[c,n] = U[c,n] \qquad (18).$$

$S[c,n]$ and $U[c,n]$ can be calculated as follows:

$$S[c,n] = P[c,n] + I_{in}[c,n] - SI[c,n] + SD[c,n] - E_{in}[c,n] \quad (19).$$

$$U[c,n] = F[c,n] + S[c,n] + M[c,n] + W[c,n] + O[c,n] + C[c,n] \quad (20).$$

Here, P is the production quantity (ton/yr), I_{in} is the international import quantity (ton/yr), SI is the stock increase (ton/yr), SD is the stock decrease (ton/yr), E_{in} is the international export quantity (ton/yr), F is the feed quantity (ton/yr), S is the seed quantity (ton/yr), M is the manufacture quantity (ton/yr), W is the waste quantity (ton/yr), O is the other use quantity (ton/yr) and C is the consumption quantity (ton/yr).

The structure of the national food balance applies also for a province, the provincial supply $(S, ton/yr)$ is equal to utilization $(U, ton/yr)$.

$$S[c,p] = U[c,p] \quad (21).$$

$S[c,p]$ and $U[c,p]$ can be calculated as follows:

$$S[c,p] = P[c,p] + I_{in}[c,p] + I_{ip}[c,p] - SI[c,p] + SD[c,p] - E_{in}[c,p] + E_{ip}[c,p] \quad (22).$$

$$U[c,p] = F[c,p] + S[c,p] + M[c,p] + W[c,p] + O[c,p] + C[c,p] \quad (23).$$

Here, I_{ip} is the interprovincial import quantity (ton/yr) and E_{ip} is the interprovincial export quantity (ton/yr).

The difference between the national and provincial balance is that in the provincial balance also the interprovincial trade is taken into account. This is the mutual trade between provinces.

The production and consumption differs per province. For each province it is possible to calculate whether there is a surplus or a deficit of a certain crop. If the production is higher than the consumption there is a surplus. A deficit occurs if the consumption is higher than the production. The surplus of a crop in a province $(Sp, ton/yr)$ is calculated as follows:

$$Sp_p[c,p] = (P[c,p] - S[c,p] - W[c,p]) - C[c,p] \quad (24).$$

The crop seed use and crop waste are derived for the national balance and can be calculated as follows:

$$S[c,p] = \frac{S[c,n]}{P[c,n]} * P[c,p] \quad (25).$$

$$W[c,p] = \frac{W[c,n]}{P[c,n]} * P[c,p] \quad (26).$$

The crop waste and seed use are assumed as a fixed percentage of the total production.

For the provinces the next assumption, regarding surplus and deficits, is made, the provincial production will first meet the domestic demand. If the production is higher than the consumption, there is a positive surplus. With a surplus there will be no import and the export will be equal to the positive surplus. The export will be international as well as interprovincial. The surplus will be negative, if the consumption in a province is higher than the production. To fulfil the demand products will be imported. The import will be equal to the negative surplus and there will be no export. The import comes through international trade as well as interprovincial trade. This assumption about surplus, deficit and trade is confirmed by Mr. Arifin, senior economist at the Institute for development of economics and finance in Jakarta (personal communication, June 26, 2008).

The international export E_{in} (ton/yr) and the interprovincial export E_{ip} (ton/yr), in case of a positive surplus $(Sp_{+}, ton/yr)$ of crop *c* in province *p*, are calculated as follows:

$$W[c,p] = \frac{W[c,n]}{P[c,n]} * P[c,p] \quad (27).$$

$$E_{in}[c,p] = E_{in}[c,n] * \left(\frac{Sp_{+}[c,p]}{\sum_{+=1}^{m} Sp_{+}[c,p]} \right) \quad (28).$$

$$E_{ip}[c,p] = Sp_{+}[c,p] - E_{in}[c,p] - (SI[c,n] + RU[c,n]) * \left(\frac{Sp_{+}[c,p]}{\sum_{+=1}^{m} Sp_{+}[c,p]} \right) \quad (29).$$

The summation will be done over the number of province that have a positive surplus of the crop (m) and $RU(ton/yr)$ is calculated as follows:

$$RU[c,n] = F[c,n] + M[c,n] + O[c,n] \quad (30).$$

These units apply to the country and can be derived from the national crop balance. The assumption is made that these units are relatively distributed over the provinces with a positive surplus.

In case of a deficit, negative surplus, $(S_{-}, ton/yr)$ the international import I_{in} (ton/yr) and the interprovincial import I_{is} (ton/yr) of crop *c* in province *p* are calculated as follows:

$$I_{in}[c,p] = I_{in}[c,n] * \left(\frac{Sp_{-}[c,p]}{\sum_{-=1}^{n-m} Sp_{-}[c,p]} \right) \quad (31).$$

$$I_{ip}[c,p] = Sp_{-}[c,p] - I_{in}[c,p] - (SD[c,n]) * \left(\frac{Sp_{-}[c,p]}{\sum_{-=1}^{n-m} Sp_{-}[c,p]} \right) \quad (32).$$

The summation will be done over all provinces (n) minus the provinces that have a positive surplus of crop (m).

The total interprovincial export E_{ip} is distributed over the total interprovincial import I_{ip}. The assumption is made that first it is distributed over the island groups, because of the relative short distance between provinces and the infrastructure on an island. Distribution will be done according to the relative seize of the surplus. The calculation of the flow of products from province 2 to province 1 is as follows:

$$I_{ip}[c,p_2,p_1] = I_{ip}[c,p_1] * \left(\frac{E_{ip}[c,p_2]}{\sum_{+=1}^{m} E_{ip}[c,p] + R[c,g]} \right) \quad (33).$$

The summation will be done over the provinces with a surplus in an island group (m). R is the sum of all the interprovincial import and export (ton/yr). R can be calculated as follows:

$$R[c,g] = \sum_{p=1}^{n} I_{ip}[c,p] + E_{ip}[c,p] \quad (34).$$

The summation will be done over all the provinces in an island group. The following distinction is made about R:

$$R = 0 \quad if \quad R \geq 0$$

$$R = |R| \quad if \quad R < 0$$

After the distribution inside an island group, some provinces have still a surplus or deficit. The provinces with a surplus are distributed over the provinces with a deficit. The distribution will be based on the relative seize of the surplus and will be done over Indonesia. The formula is as follows:

$$I_{ip}[c,p_2,p_1] = E_{ip}[c,p_2] * \left(\frac{I_{ip}[c,p_1]}{\sum_{-=1}^{n} I_{ip}[c,p]}\right) \quad (35).$$

Here, I_{ip} is the import from a province of crop *c* (ton/yr), E_{ip} is the interprovincial export quantity of a province that is leftover after the first distribution (ton/yr) and I_{ip} is the deficit of provinces after the first distribution (ton/yr). The summation will be done over all the provinces with the deficit after the first distribution (n).

2.3.2 Virtual water flow

The virtual water flow is the total amount of virtual water in the flow of traded products. The virtual water flow as result of crop trade between two provinces $(VWF_p\ , m^3/yr)$ is calculated as follows:

$$VWF_p[c,p_1,p_2] = E_{ip}[c,p_1,p_2] * VWC[c,p_1] - I_{ip}[c,p_1,p_2] * VWC[c,p_2] \quad (36).$$

Here, E_p is the interprovincial export from province 1 to province 2 of a crop (ton/yr), I_p is the interprovincial import from province 2 to province 1 of a crop (ton/yr) and VWC is the virtual water content in the exporting province of crop c (m^3/yr).

The total virtual water flow between two provinces $(VWF_{p,tot}, m^3/yr)$ is calculates as follows:

$$VWF_{p,tot}[p_1,p_2] = \sum_{c=1}^{n} VWF_s\,[c,p_1,p_2] \quad (37).$$

Here, the summation will be done over the total number of crops (*n*).

The net virtual water balance of a province is assessed in the form of the net virtual water import $(VWI_{net}, m^3/yr)$.

$$VWI_{net}[p_1] = -\sum_{p_2=1}^{n} VWF_{p,tot}[p_1,p_n] \quad (38).$$

Here, the summation has to be done over the number of the flows of virtual water from provinces (n) to province p_1.

2.4 Water footprints

The water footprint ($WFP_{tot}, m^3/yr$) is the total volume of water needed to produce the goods that are consumed by the inhabitants of a province. The water footprint consists of an internal and an external part. The calculation is as follows:

$$WFP_{tot}[p] = WFP_i[p] + WFP_e[p] \quad (39).$$

Here, WFP_i is the use of internal water resources to produce crops consumed by the inhabitants (m^3/yr) and WFP_e is the use of water resources of other province or other countries to produce crops consumed by the inhabitants of the province concerned (m^3/yr).

The internal water footprint ($WFP_i, m^3/yr$) footprint is calculated as follows:

$$WFP_i[p] = AWU[p] - VWE_{net}[p] \quad (40).$$

Here, AWU is the total agricultural water use in a province (m^3/yr) and VWE_{net} is the netto export of virtual water from a province (m^3/yr).

The external water footprint ($WFP_e, m^3/yr$) can be calculated as follows:

$$WFP_e[p] = VWI_{net}[p] \quad (41).$$

Here, VWI_{net} is the net import of virtual water into a province (m^3/yr).

To make the results more comparble and determine the water consumption of the inhabitants of a province, the water footprint per capita ($WFP_{cap}, m^3/cap/yr$) will be calculated as follows:

$$WFP_{cap}[s] = \frac{WFP_{tot}[s]}{Pop\ [s]} \quad (42).$$

Here, Pop is the total population of a province ($capita$).

3 Study area and Data

In the previous chapter the method has been explained, this chapter will focus on the data needed to carry out the calculations. Before the data will be presented, the study area will be explained.

3.1 Study Area

Indonesia is an archipelago of 17,508 islands between the Indian Ocean and Pacific Ocean. Indonesia borders with Timor-Leste, Malaysia and Papua New Guinea. The total land surface covers 1 826 440 km^2. Indonesia is located around the equator, the climate is therefore tropical. The total population of Indonesia is 237.512.355 (July 2008 est.). 59% of the total population is located on Jawa. The growth of the gross domestic product in 2007 was 6,3%. 43,4% of the labor force is employed in the agricultural sector, 18% in the industry and 38,7% is working in the services sector (CIA, 2008).

Figure 3.1: Map of Indonesia

Indonesia exists of 30 provinces, 2 special regions and 1 special capital city districts. The 30 provinces are, Sumatera Utara, Sumatera Barat, Riau, Jambi, Sumatera Selatan, Bengkulu, Lampung, Bangka Belitung, Riau Kepulauan, Jawa Barat, Jawa Tengah, Jawa Timur, Banten, Bali, Nusa Tenggara Barat, Nusa Tenggara Timur, Kalimantan Barat, Kalimantan Tengah, Kalimantan Selatan, Kalimantan Timur, Sulawesi Utara, Sulawesi Tengah, Sulawesi Selatan, Sulawesi Tenggara, Gorontalo, Sulawesi Barat, Maluku, Maluku Utara, Papua Barat and Papua. The two special regions are Nanggroe Aceh D. and D.I. Yogyakarta. The special capital city district is D.K.I. Jakarta. In figure 3.2 the location of these provinces and districts are visualized.

Figure 3.2: Map of Indonesian provinces, special regions and district

In the past few years a couple of new provinces were created. In 2003 Papua Barat was split from Papua, in 2004 Sulawesi Barat was separated from Sulawesi Selatan and in 2004 the Riau Kepulauan were split off from Riau as a separate province. For the largest part of this research data from 2000 till 2004 are used, thus before the creation of these provinces. There was an overall lack of data about these new provinces, so the new provinces will not be taken into account for this study.

The provinces can be divided into 7 islands or island groups: Sumatra, Jawa, Lesser Sunda Islands, Kalimantan, Sulawesi, Maluku islands and Papua. Sumatra consists of Nanggroe Aceh D., Sumatera Utara, Sumatera Barat, Riau, Jambi, Sumatera Selatan, Bengkulu, Lampung, Bangka Belitung and Riau Kepulauan. Jawa consists of D.K.I. Jakarta, Jawa Barat, Jawa Tengah, D.I. Yogyakarta, Jawa Timur and Banten. Lesser Sunda Islands consists of Bali, Nusa Tenggara Barat and Nusa Tenggara Timur. Kalimantan consists of Kalimantan Barat, Kalimantan Tengah, Kalimantan Selatan and Kalimantan Timur. Sulawesi consists of Sulawesi Utara, Sulawesi Tengah, Sulawesi Selatan, Sulawesi Tenggara, Gorontalo and Sulawesi Barat. Maluku islands consists of Maluku and Maluku Utara. Finally, Papua consists of Papua Barat and Papua.

3.2 Crop selection

According to the FAOSTAT database (FAO, 2008a) more than 56 crops are cultivated in Indonesia. For each crop the production quantity, producers value and harvested area are derived from FAOSTAT. The data are taken over the years 2000 to 2004 and the average of these values is used for the calculations. The virtual water content of these crops in Indonesia is taken from Chapagain & Hoekstra (2004). The water use of a crop is calculated by multiplying the production quantity with the virtual water content. For the water use, production value and land use the relative size is also calculated. In Appendix II the crops and the parameters are shown. The crops can be divided into 10 categories. Table 3.1 indicates the production quantity, water use, production value and land use by category.

Table 3.1: Crop categories and the production quantity, water use, production value and land use by category

Crop category	Abbreviation	Production	Water use		Production value		Land use	
		M ton/yr	*M m^3/ton*	*%*	*M US$/yr*	*%*	*M ha/yr*	*%*
Cereals	CE	62,2	124885	49	8518	37,6	15,0	51,7
Oilcrops	OC	65,5	67407	26	4484	19,8	6,9	23,7
Stimulants	ST	1,3	16179	6	1023	4,5	1,9	6,7
Fruits	FR	11,6	15693	6	3562	15,7	0,9	3,3
Roots and Tubers	RT	20,8	9274	4	1469	6,5	1,6	5,5
Spices	SP	0,4	8791	3	715	3,2	0,6	2,0
Nuts	NU	0,2	5564	2	125	0,6	0,5	1,6
Sugarcrops	SC	25,4	4577	2	475	2,1	0,4	1,5
Vegetables	VE	6,7	3383	1	2230	9,9	0,9	2,9
Pulses	PU	0,3	937	0	42	0,2	0,3	1,1
Total		*194*	*256689*	*100*	*22644*	*100*	*29,0*	*100*

For the study not all the crops will be taken into account, so the most important crops for this study are selected. The criterion for selection is that a crop should use more than 1% of the total water use. If an excluded crop has a production value above 5% or the land use is 2% or more, it will also be selected. The reason for the last two criteria is to make sure that important crops regarding land use and production value are not left out the study. The crops in table 3.2 are selected based on these criteria.

Table 3.2: Crop and the production quantity, water use, production value and land use per crop

Crop	CC	Production	VWC	Water use		Production value		Land use	
		1000 ton/yr	*m3/ton*	*M m3/yr*	*%*	*M US$/yr*	*%*	*1000 ha/yr*	*%*
Rice, paddy	CE	52015	2150	111832	43,57	7177	31,69	11643	40,21
Maize	CE	10158	1285	13053	5,09	1341	5,92	3326	11,48
Cassava	RT	17601	460	8096	3,15	1021	4,51	1276	4,41
Sugar cane	SC	25173	164	4128	1,61	471	2,08	362	1,25
Cashew nuts, with Shell	NU	106	26788	2838	1,11	77	0,34	260	0,90
Soybeans	OC	783	2030	1589	0,62	256	1,13	628	2,17
Groundnuts, with Shell	OC	1329	2231	2964	1,15	473	2,09	678	2,34
Coconuts	OC	15796	2071	32714	12,74	921	4,07	2686	9,27
Oil palm fruit	OC	47256	635	30008	11,69	2743	12,11	2673	9,23
Bananas	FR	4297	1074	4615	1,80	1172	5,18	281	0,97
Guavas, mangoes, mangosteens	FR	1233	2264	2792	1,09	494	2,18	189	0,65
Fruit, nec	FR	3546	1498	5312	2,07	1196	5,28	301	1,04
Coffee, green	ST	623	17665	11012	4,29	445	1,96	1326	4,58
Cocoa beans	ST	519	9959	5168	2,01	520	2,29	484	1,67
Cloves	SP	94	66387	6235	2,43	298	1,31	346	1,19
Other crops		13851		14335	5,58	4039	17,84	2500	8,63
Total		*194380*		*256689*	*100*	*22644*	*100*	*28957*	*100*
Selected crops		*150376*		*221049*	*86,12*	*16069*	*70,96*	*25000*	*86,34*

The shaded crops are also excluded from the study because these are a leftover category. This category contains more than one crop or the crops belong to a category with a low water use. The selected crops belong to the five categories with highest water use.

The selected crops represent 86% of the total water use, 71% of the production value and 86% of the total agricultural land.

3.3 Data

Specific data about the selected crops and provinces are used for the calculation. In this paragraph the collection and use of these data will be explained

3.3.1 Population

The population by province is taken from BPS (2008a). The data apply to the year 2000. In Appendix I the population per province is given.

3.3.2 Climatic parameters

For the calculation of reference evapotranspiration and effective rainfall data about the climate are needed. With the program CROPWAT (FAO, 2008b) the reference evapotranspiration and the effective rainfall can be calculated. For the calculation of the reference evapotranspiration CROPWAT uses the FAO Penman-Monteith equation. The data for these calculations are taken from CLIMWAT (FAO, 2008c). In this database information is available from 33 weather stations across Indonesia. The data cover humidity, mean maximum and minimum temperature, wind speed, daily sunshine, rainfall and location (altitude, latitude and longitude) of the weather station. The data are given for each month in the year. The provinces and accompanying weather stations are listed in Appendix III.

CLIMWAT does not provide enough weather stations, in some provinces there are no weather stations or the number of stations in a province is low. To get a reliable indication of the reference evapotranspiration and rainfall in all the provinces, supplementary data are used. These data are received from Badan Meteorologi dan Geofisika (BMG). BMG is the national weather institute of Indonesia. In Appendix III the supplementary weather stations are also listed.

For the weather stations Belwan, Jogjakarta, Kendari, Mengalla, Tahuna and Telukbentung, no data about the sunshine are available. The sunshine of nearby located weather stations are used as replacement. Furthermore, no weather stations are located in the province of Jambi. For Jambi the evapotranspiration is calculated as an average from the evapotranspiration in Riau and Sumatra Selatan, since those are two nearest-by provinces.

With these additional data from BMG, it is still no guarantee that the calculated reference evapotranspiration is the same as the actual reference evapotranspiration in a province. A cause for this difference could be the irregular distribution of those weather station across a province.

3.3.3 Crop parameters

The crop parameter (K_c) is used to correct the reference evapotranspiration, so the actual crop evapotranspiration under optimal conditions is determined. The crop parameter contains the length of the crop development stages and the height of the K_c value. These parameters are based on Allen (1998) and Chapagain and Hoekstra (2004). Because these sources contain general information for different climatic regions, additional information is used to determine the planting and harvesting date of the crops in Indonesia.

These parameters may differ per region in Indonesia, but for this study the parameters are taken as constant for every region within Indonesia. The assumption is made that a year has two seasons in Indonesia, a wet and a dry season. The wet season is from November till April and the dry season is from May till October. For annual crops the K_c value and the length of the growth period may differ per season. In Appendix IV the crop parameters are listed.

3.3.4 Irrigated area fraction

Data about the fraction of the total area of a crop that is irrigated in a province is not available. That is why an assumption is made about this fraction. For every province data about land utilization, including the amount of wetland and dryland, is available (BPS, 2008b). Wetland is agricultural land that is irrigated, dryland is not irrigated and planted with seasonal crops. The estate crops, like oil palm, coconut, banana, coffee and cocoa, do not belong to these categories. Irrigation of these crops is not common (FAO, 1999) and information about this is not available.

To allocate the fraction of irrigated land over the crops in a province, the method as explained below is used. First of all, the irrigated land of rice is taken of the total wetland. Information about wetland rice is taken from the Ministry of Agriculture (2008). This information consists of the harvested area of wetland rice. Because it is possible to harvest rice at least two times a year, this area is divide by two. The surplus of land is distributed over the other crops based on relative area of these remaining crops, including the crops that are not taken into account for this study. For rice the irrigated area fraction is determined by dividing the area of wetland rice by the total area of rice, the sum of the area of wetland and dryland rice. The fraction of the total area of a crop that is irrigated is given in Appendix V.

For the provinces Maluku, Maluku Utara and Papua data about area of dryland and wetland are not available. This is the reason that the fraction of the total area of a crop that is irrigated is assumed to be 0. Only for rice the fraction of irrigation could be calculated, because data about wetland and dryland rice is available for these provinces.

3.3.5 Dilution water requirement

Data about fertilizer use are taken from Fertistat (FAO, 2008e) and FAO (2005). The data makes no distinction between provinces. Therefore it is assumed that the fertilizer use per hectare in every province is the same. Because of differences in yields between provinces, the gray virtual water content will not be de same for every province. The fertilizer use by crop is shown in Appendix VI.

The leaching factor and recommended level of nitrate are taken from Chapagain et al (2006b). The leaching factor is assumed to be 10%. The recommended level of nitrogen is 10 mg/l, this is the standard recommended by EPA (2005) for nitrogen in drinking water.

3.3.6 Production quantity and harvested area

The production quantity and harvested area are taken from the Ministry of Agriculture (2008). In this database information about production quantity and harvested area from all the selected crops is available. The data makes distinctions between provinces. Data is taken from 2000 to 2004.

The figures are compared with the figures from FAOSTAT (FAO, 2008a) and BPS (2008c). Because the data from the Ministry of Agriculture for some products differs strongly with FAOSTAT en BPS, these numbers are corrected. The production quantity of coconut and oil palm and the harvested area of oil palm, banana and cocoa are corrected. The production quantity of these crops in the database from the Ministry of Agriculture represents processed crops and not the primary crops. The high harvested areas of these perennial crops were caused by the fact that these crops can be harvested several times a year.

The production quantity is shown in Appendix VII and the area is shown in Appendix VIII.

3.3.7 Weight and production fraction of processed crops

A crop can be processed into different products. The structure of processing a primary crop into other products is called the product tree. The product tree of a crop is taken from FAO (2008f). This source is also used to determine the weight factor of the processed crops. The data about the weight factor is based upon the years 1992 to 1996. For the study it is assumed that this data is still reliable and accurate. The value fraction is taken from Chapagain and Hoekstra (2004). The production and value fractions of the crops are shown in Appendix IX.

3.3.8 Food balance

The national food balance is taken from FAOSTAT (FAO, 2008a). The balance consists of domestic supply and domestic utilization. The domestic supply consists of production quantity, import quantity, stock variation and export quantity. The domestic utilization is feed quantity, seed quantity, food manufacture, waste quantity, other uses quantity and food quantity. For these quantities the average is taken from years 2000 till 2003.

The food balance is taken from FAOSTAT for the following products: rice (milled equivalent), maize, cassava, soybeans, groundnut (shelled equivalent), coconuts (incl. copra), palm kernels, soybean oil, groundnut oil, palm kernel oil, palm oil, coconut oil, bananas, coffee and cocoa beans.

In Appendix X the national food balance for Indonesia is shown.

No data about the consumption of a crop in a province is available. The assumption is made that each person consumes the same amount of a crop, independently of the location of living. The consumption, that is stated in the national food balance, is distributed over the provinces relative to the population.

3.3.9 Virtual water import

The import products from other countries will contain virtual water and will be a part of the water footprint. This international water flow coming into Indonesia is taken from Hoekstra and Mekonnen (2008). The virtual water import is an average of the years 2000 to 2003.

The virtual water import of the products palm oil and coconut oil consists of the crude products and refined products.

4 Virtual water content

With the method and data, as explained in the previous chapters, the virtual water content of the crops has been calculated. Firstly, the virtual water content of the primary crops will be given. Secondly, the virtual water content of the processed crops will be given and finally, there will be a comparison between these results and the result of previous studies.

4.1 Primary crops

Before the virtual water content of the different crops will be presented, the water use of the crops will be given. Most water is being used for the rice production. This is caused by the high production quantity and the high demand of water for the production. In figure 4.1 the water use of the selected crops are shown.

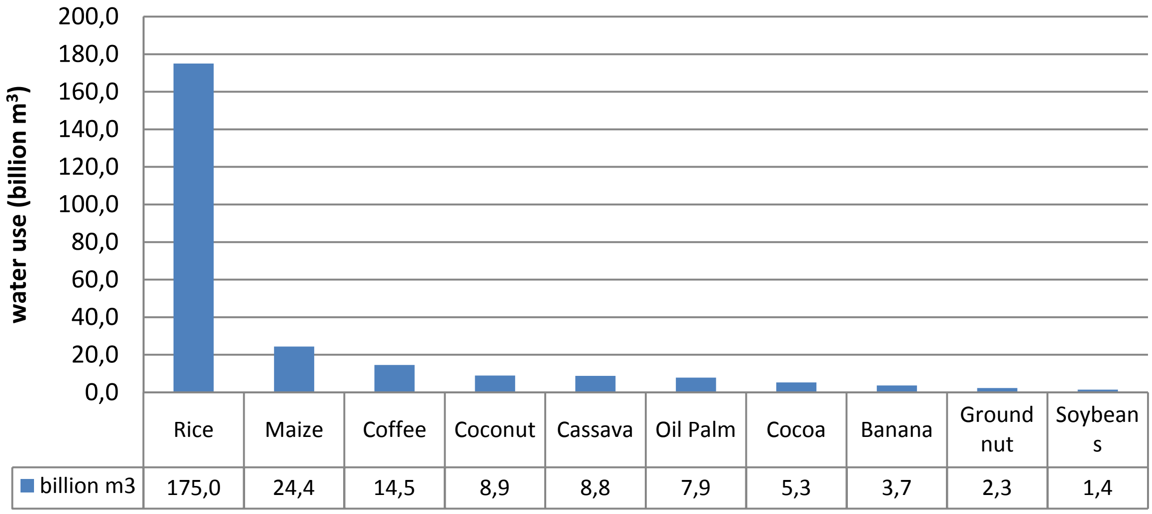

Figure 4.1: Water use by product in billion m^3

The virtual water content of the crops in a province are shown in Appendix XI. In each province the virtual water content is different, in some cases the differences are relative large. The differences are mainly caused by the evaportranspiration and yield. A high evapotranspiration contributes to a high virtual water content and a high yield will lead to a lower virtual water content.

The virtual water content in combination with the production will determine the average virtual water content of a crop in Indonesia. The virtual water content of cassava is the lowest of all crops, namely 497 m^3/ton, and in coffee the highest, 22910 m^3/ton. The other virtual water contents are listed in table 4.1.

Table 4.1: Virtual water content of crops and the components

Crop	Green	Blue	Gray	Total
		m^3/ton		
Rice	2460	668	212	3340
Maize	2315	68	13	2396
Cassava	471	7	19	497
Soybeans	1603	275	0	1878
Groundnut	2834	134	0	2968
Coconut	2838	0	16	2854
Oil Palm	797	0	51	848
Banana	849	0	0	849
Coffee	21907	0	1003	22910
Cocoa	8888	0	519	9406

The green component has the largest contribution to the virtual water content. The green component contributes for at least 85% of the total virtual water content, except for rice. For rice the green component is 74% of the total. The blue component is 20% for rice and 15% for soybean; for the other crops the contribution of the blue component to the virtual water content is marginal. Most crops are thus grown with rainwater. The crops rice, oil palm and cocoa have the largest gray component, because of the relative large amount of fertilizer application. This component counts for 6% of the total virtual water content for these crops.

In table 4.2 the virtual water content of the crops over the island groups are shown. Rice from Jawa has the lowest virtual water content; maize and soybeans from Jawa also have a low virtual water content, compared to other island groups. Cassava from Jawa and Sumatra has the lowest virtual water content. Coffee has the lowest virtual water content when it is originated from Sumatra. The products which are produced in Sulawesi with a low virtual water content are coconut, oil palm and cocoa. Coconut has also a low virtual water content in Maluku. In Maluku groundnuts are also being produced with a low virtual water content. Bananas originating from Nusa Tenggara have the lowest virtual water content compared with the other island groups. The regional differences in virtual water content are caused by climate and yield.

Table 4.2: Virtual water content over the island group

	Sumatra	Jawa	Nusa Tenggara	Kalimantan	Sulawesi	Maluku	Papua
				m^3/ton			
Rice	3990	2766	3543	4908	3926	4756	4643
Maize	2317	2237	2740	3707	3066	4199	4968
Cassava	477	475	649	576	596	549	633
Soybeans	2468	1675	2570	2445	1933	2334	2582
Groundnut	3107	2834	2968	3462	3652	1803	4147
Coconut	2958	2808	3128	3959	2440	2424	7140
Oil Palm	767	729		1485	407		1073
Banana	1160	745	699	1358	829	1869	3242
Coffee	21205	25135	26872	40885	24102	85554	30805
Cocoa	10692	15084	14381	15375	7958	14769	12860

Rice is an important and strategic crop in Indonesia. The virtual water content of rice is 3340 m^3/ton, but there are big differences in the virtual water content in different provinces. Figure 4.2 illustrates these differences. 55% of the total rice production is produced on Jawa. Beside the provinces in Jawa, high producing areas are Sulawesi Selatan and Sumatra Utara. In these provinces the virtual water content is 3756 m^3/ton and 3903 m^3/ton. This is higher than the virtual water content of rice in Jawa, which has an average of 2766 m^3/ton.

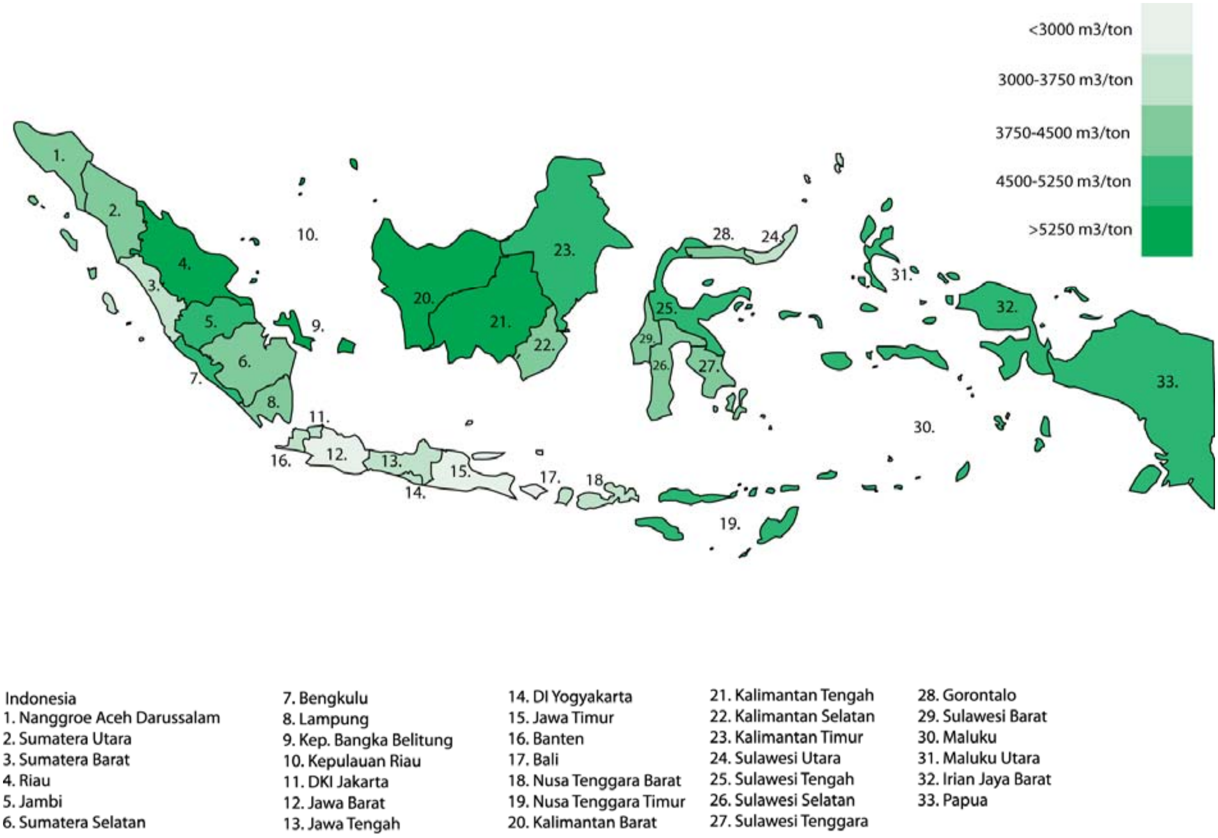

Figure 4.2: Virtual water content of rice in a province

4.2 Processed crops

The virtual water content of the processed crops is shown in table 4.3. The virtual water content of these crops is different than those of primary crops. Palm kernel oil has the largest virtual water content and soybean cake the lowest.

Table 4.3: Virtual water content of processed crops

	VWC
	m^3/ton
Rice (Milled Equivalent)	5138
Soybean Cake	117
Soybean Oil	154
Groundnut shelled	4388
Groundnut Oil	6547
Copra	14271
Coconut Oil	5618
Palm Oil	8414
Palm kernels	18862
Palm kernel Oil	19821

4.3 Comparison with other studies

Some other studies have already calculated the virtual water content of crops and also of crops in Indonesia. The comparison will be made with the results from Chapagain and Hoekstra (2004). This is the first study that calculated the virtual water content for each crop in a country. In table 4.4 the results of this study and the study from Chapagain and Hoekstra (2004) are listed.

Table 4.4: Virtual water content of this research and Chapagain and Hoekstra (2004)

	This research	**Chapagain and Hoekstra (2004)**
	m^3/ton	
Rice	3340	2150
Maize	2396	1285
Cassava	497	460
Soybeans	1878	2030
Groundnut	2968	2231
Coconut	2854	2071
Oil Palm	848	635
Banana	849	1074
Coffee	22910	17665
Cocoa	9406	9959

There is a difference between the results of both studies; caused by several reasons. First of all, Chapagain and Hoekstra used different climate data. They used data from the Tyndall Centre for Climate Change and Research (Mitchell, 2003), the average evapotranspiration according to their calculations is 3.23 mm/day. For this study data from CLIMWAT (FAO, 2008c) and BMG are used, the average evapotranspiration with this data is 4.79 mm/day. A higher evapotranspiration will lead to a higher virtual water content. Chapagain and Hoekstra also used one set of monthly evapotranspiration for whole Indonesia and this study uses different monthly values for each province. Secondly, Chapagain and Hoekstra do not include the gray component. The inclusion of the gray component led to a higher virtual water content in this study. Thirdly, the growth period and Kc-values are different than those in the study of Chapagain and Hoekstra. In that study general values for tropical zones have been used and in this study values which represent Indonesia have been used.

5 Virtual water flows

The flows of products in combination with the virtual water content as calculated in the previous chapter will give the virtual water flows. Before presenting these flows, the food balances of the provinces will be given.

Provinces can have either a deficit or a surplus of a certain crop. A surplus will create an outgoing flow of a product or crop to other provinces or countries. A deficit on the other hand will create an ingoing flow of products into the province, these products can originate from either a province or a foreign country. In Appendix XII the surplus or deficit of a product in a province is listed, and also the amount of interprovincial and international import or export is listed. On the basis of this table a few remarks can be made relating to the production and flows. The table points out that there is a lot of interprovincial trade of rice, maize, cassava, coconut and bananas. The conclusion can be drawn that the production of some products is mainly regionally based. For example, Maluku Utara has a high production quantity of bananas and thus a large surplus; consequently there is an outflow of bananas from the Maluku towards the provinces with a deficit. Secondly, the products rice and soybeans rely on international import. The domestic production of these products is too low to meet the demand. Finally, the large exporting products are palm kernel oil, palm oil, coconut oil, coffee and cocoa.

The flows of products also create flows of virtual water. In table 5.1 for each product the flow of virtual water is summarized. The difference between this table and Appendix XII is that this table represents the virtual water flow and the appendix shows the flow of a product quantity. The products with the relatively largest interprovincial flow of water are cassava, coconut, bananas and coffee. Bananas are by far the product with the largest interprovincial water flow relative to the water use for the production. Soybeans and groundnuts are the products with a high net import of virtual water. The products with a large amount of water that will leave the country are palm oil, coconut oil, coffee and cocoa beans.

Table 5.1: Water use and virtual water flows by crops

	Water use for production	Interprovincial trade	International Import	International Export	International Net
		billion m^3			
Rice (Milled Equivalent)	269,2	11,8	1,8	0,0	1,8
Maize	24,4	2,9	0,2	0,1	0,1
Cassava	8,8	1,4	0,2	0,2	-0,1
Soyabeans	1,4	0,0	2,6	0,0	2,6
Groundnuts (Shelled Eq)	3,4	0,4	0,4	0,0	0,3
Coconuts - Incl Copra	8,9	3,5	0,0	0,8	-0,8
Groundnut Oil	5,1	0,1	0,0	0,0	0,0
Palmkernel Oil	11,2	0,2	0,0	0,7	-0,7
Palm Oil	36,6	4,1	0,0	23,1	-23,1
Coconut Oil	52,1	0,4	0,0	7,8	-7,8
Bananas	3,7	2,5	0,0	0,0	0,0
Coffee	14,5	2,6	0,1	7,1	-7,0
Cocoa Beans	5,3	0,2	0,5	3,5	-3,0

The virtual water flows between provinces are represented in Appendix XIII. The province that has the largest virtual water out flow to other provinces is Sulawesi Selatan. This is mainly caused by the interprovincial export of rice. Other large interprovincial exporting provinces are Papua, Riau, Sumatera Utara, Lampung, Sumatera Barat and Jawa Timur. These provinces account for 56% of the total virtual water flow within Indonesia. These provinces have a large production and consequently a large surplus of one or more crops, so there is a big out flow of products to other provinces with a deficit.

According to Appendix XIII large interprovincial importing provinces are Jakarta, Jawa Barat, Jawa Tengah, Riau, Jawa Timur and Banten. These provinces represent 65% of the total interprovincial virtual water import. Because of the high consumption quantity and/or the low production of crops, these provinces have a high virtual water import.

The provinces Jawa Timur and Riau are both a large exporting and a large importing province. This is caused by the fact that the surplus of certain crops is high and the deficit of other crops is relatively large. For example, Riau imports a lot of rice and cassava and it has a large surplus in coconut and palm oil.

In table 5.2 the flows of virtual water between the island groups are represented. By far the most virtual water is imported in Jawa. The biggest interprovincial exporting island group is Sumatra.

Table 5.2: Flows of virtual water between provinces in million m^3

		Exporting							
		Sumatra	Jawa	Nusa Tenggara	Kalimantan	Sulawesi	Maluku	Papua	**Total**
Importing	Sumatra		93	82	0	56	1	1219	*1451*
	Jawa	7378		339	1472	3449	415	508	*13560*
	Nusa Tenggara	340	1		95	105	0	0	*540*
	Kalimantan	134	122	122		229	19	240	*866*
	Sulawesi	61	122	20	15		16	298	*532*
	Maluku	283	26	20	106	554		0	*989*
	Papua	399	32	31	141	12	655		*1272*
	Total	*8596*	*396*	*613*	*1829*	*4404*	*1107*	*2266*	

The net virtual water flow is the export of virtual water into a province minus the import of virtual water originating of that certain province. In figure 5.1 the largest flows are visualized.

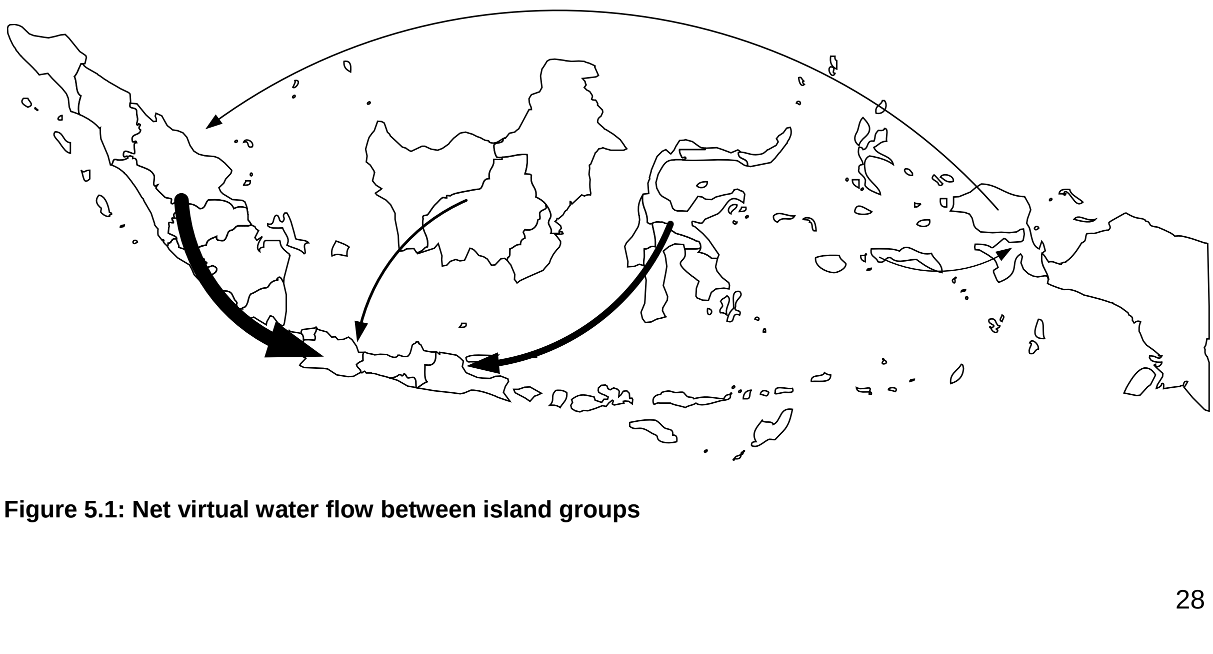

Figure 5.1: Net virtual water flow between island groups

Besides the relatively small flows from and to Papua, the biggest flows are to Jawa. The largest flow of virtual water is from Sumatra to Jawa. The deficit of products on Jawa is causing this flow.

Noteworthy is the flow of virtual water from Papua to Sumatra. The virtual water flow is caused by the trade of bananas from Papua to Sumatra. It is uncertain if the flow is realistic. Because of the large distance between Papua and Sumatra, trade between the regions could be really low. It could be a limitation of working with this model.

The island group that exports the most water to other countries is Sumatra. The other island groups also contribute to the water export, but not as significant as Sumatra. The large flow of water out of Sumatra exists mainly of palm oil, coffee and coconut oil.

Table 5.3: International export of water by island group

	International water export (million m^3)
Sumatra	29069
Jawa	933
Nusa Tenggara	1132
Kalimantan	5664
Sulawesi	5541
Maluku	541
Papua	653
Total	*43534*

6 Water footprints

The water consumption of a person in Indonesia will be presented in this chapter. After that the distribution of the water footprints over Indonesia will be visualized and the contribution of the different crops to the water footprint is presented. Finally, there will be a comparison to other studies.

6.1 Water footprint of Indonesian provinces

In Appendix XIV the water footprints of the Indonesian provinces are shown. To make a better comparison between the provinces, the water footprint in table 6.1 is per capita.

Table 6.1: Water footprint per capita

	Water footprint			
	Internal	**Interprovincial**	**International**	**Total**
	m^3/cap/yr			
Nanggroe Aceh D.	1196	72	4	1272
Sumatera Utara	1207	53	21	1282
Sumatera Barat	1083	69	24	1176
R i a u	658	457	80	1196
J a m b i	1279	131	35	1444
Sumatera Selatan	1179	106	31	1316
Bengkulu	1592	93	20	1706
Lampung	1159	5	19	1183
Bangka Belitung	352	620	109	1081
D.K.I. Jakarta	5	720	116	841
Jawa Barat	685	152	29	866
Jawa Tengah	1015	75	17	1106
D.I. Yogyakarta	898	152	19	1069
Jawa Timur	847	49	3	899
Banten	788	233	51	1072
B a l i	892	54	15	961
Nusa Tenggara Barat	1145	90	6	1240
Nusa Tenggara Timur	859	301	59	1220
Kalimantan Barat	1626	97	30	1753
Kalimantan Tengah	1538	181	41	1760
Kalimantan Selatan	1261	86	24	1371
Kalimantan Timur	1080	279	52	1410
Sulawesi Utara	992	192	38	1222
Sulawesi Tengah	1332	65	22	1419
Sulawesi Selatan	1199	30	13	1242
Sulawesi Tenggara	1058	213	43	1314
Gorontalo	908	250	39	1197
Maluku	367	554	90	1011
Maluku Utara	795	428	77	1300
Papua Barat	381	578	89	1048
Indonesia	*917*	*146*	*28*	*1092*

The average water footprint in Indonesia is 1092 m^3/cap/yr. People in Kalimantan Tengah have the largest water footprint, 1760 m^3/cap/yr, and a person in Jakarta has the smallest water footprint, 841 m^3/cap/yr. A person in Jakarta also relies the most on external sources. The imported products come most of all from provinces with a large surplus. The virtual water content in those products is relatively low, because the crops are efficiently produced with a high yield. This is causing the relatively low water footprint. Lampung has the highest use of internal water resources (98%). Lampung can fulfill its own needs for almost every crop, only for groundnuts and soybeans it has a small deficit. The provinces have an average internal water use of 84%, for the other 16% they rely on other provinces or countries.

In figure 6.1 the water footprints and their distribution over Indonesia are visualized. The water footprints on Jawa are relatively low, Kalimantan has a relatively high water footprint. The factors that determine the water footprint in general are: volume of consumption, consumption patterns, climate and agricultural practice (Hoekstra and Chapagain, 2008). Because in this study the volume of consumption per capita and consumption patterns are the same for each province, the differences in water footprints are caused by climate and agricultural practice. Agricultural practice has influence on the yield and thus virtual water content. In Jawa the yields are high and the evapotranspiration rate is lower compared with other regions, this is causing the low water footprint in Jawa.

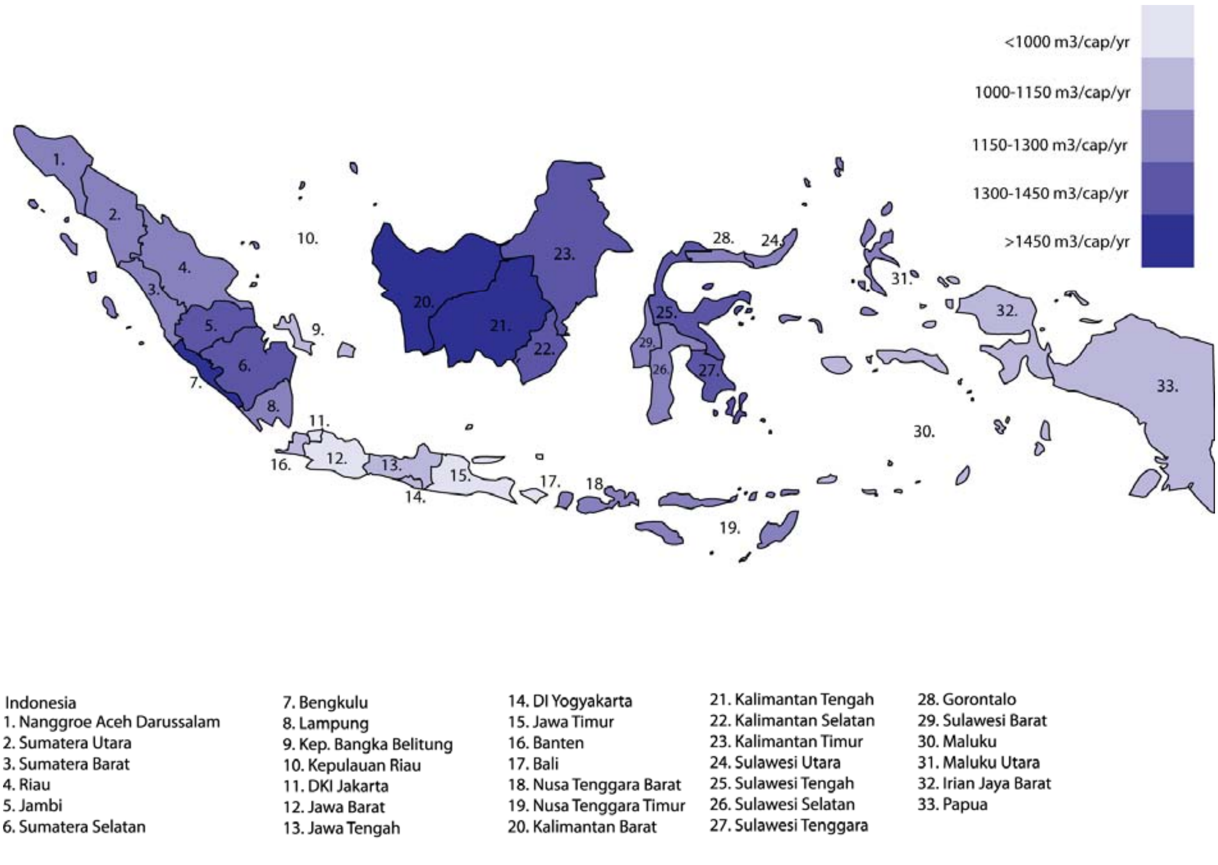

Figure 6.1: Water footprints and distribution over Indonesia

6.2 Contribution of crops to the water footprint

Each crop or product separately contributes to the water footprint of a person. This contribution is visualized in figure 6.2, in the figure the primary and processed products of the root crop are taken together.

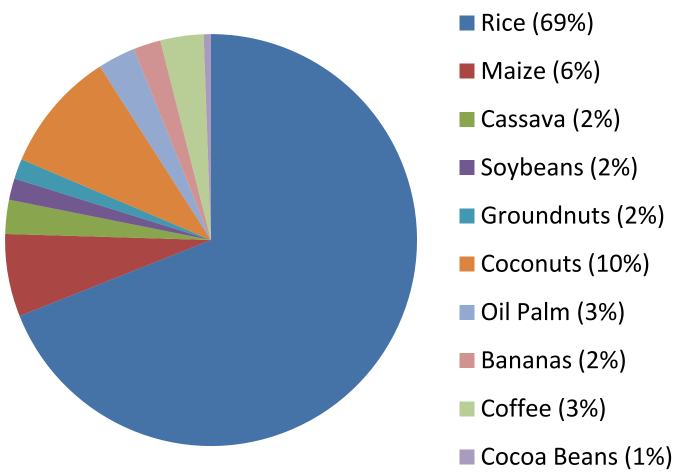

Figure 6.2: Contribution of crops to the water footprint

The figure points out that rice contributes most to the water footprint. This is caused by the high virtual water content of rice, but also the high consumption rate of rice in Indonesia. Coconut and coconut oil also have a notably large contribution.

The crops contribute differently to the water footprint in different island groups. This is presented in figure 6.3. The contribution of rice is the highest in Kalimantan and Sumatra, namely 72%, and in the Maluku it is only 62%. Other remarks can be made that the coffee contribution in Papua is 12% and in the Maluku coconuts contribute for 15% to the water footprint.

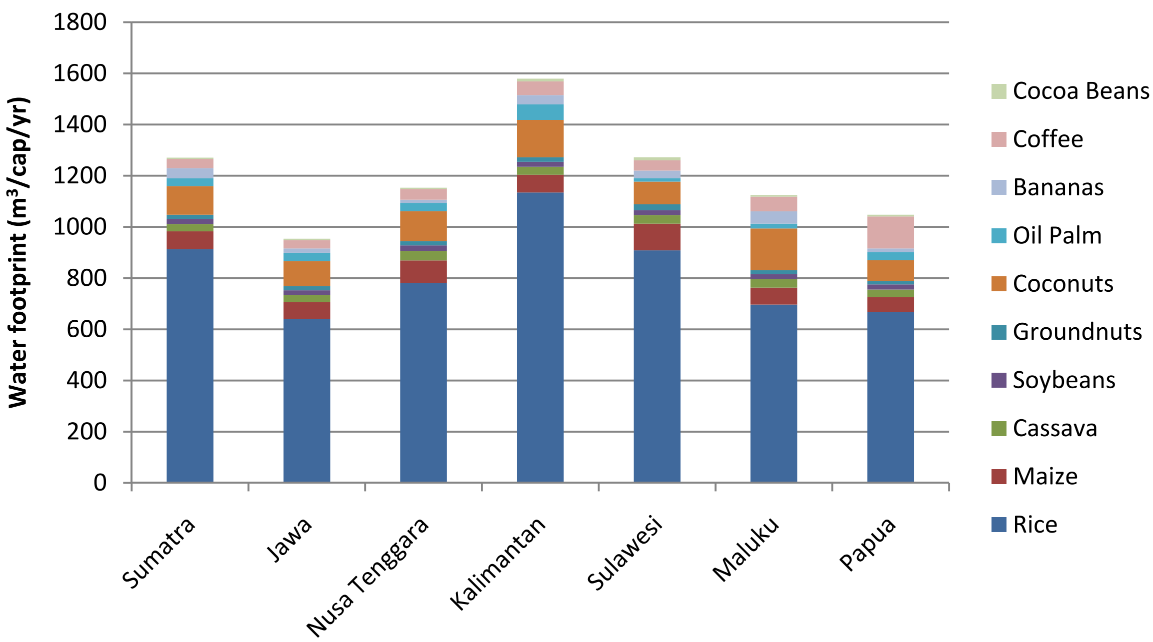

Figure 6.3: Water footprints and contribution of crops for island groups

6.3 Comparison with other studies

Previous studies also calculated the water footprint. These studies calculated the water footprint for Indonesia as a whole and not for each province separately. The results of this study will be compared with results from Chapagain and Hoekstra (2004). For the comparison the average Indonesian water footprint will be used. In table 6.2 the water footprint of both studies are shown.

Table 6.2: Water footprint of this research and Chapagain and Hoekstra (2004)

	This research	Chapagain and Hoekstra
	m^3/cap/yr	
Water footprint	1092	1317
Internal part of Agricultural goods	1063	1153
External part of Agricultural goods	28	127

Differences in results are caused by several reasons. First of all, this study is only taking agricultural goods into account. The study of Chapagain and Hoekstra is also taking domestic water and industrial goods into account. The water footprint of only agricultural goods is according to them 1280 m^3/cap/yr. Besides, this study is using a selection of crops and the other research has not made a selection and used every crop cultivated in Indonesia. Finally, only some of the selected crops are important import crops. Other important crops that are causing a large virtual water flow into the country are cloves and wheat, but these are not taken into account for this study. The reason for exclusion of these crops is the low production quantity in Indonesia. This is causing a lower external water footprint in this research. Reference here can be made to the research of Mees Beeker (2008) in which the external water footprint will be further researched and explained.

7 Discussion

In this chapter the limitation of this study will be discussed. Based on this discussion, some recommendations for improvements and for further research will be made. These recommendations will be discussed in section 8.2

A sensitive part of this study is the climatic data. In the database from CLIMWAT (FAO, 2008c) not enough weather stations are available to get the country completely covered. Additional data from BMG is used to get a complete coverage. The average evapotranspiration of CLIMWAT is lower than the evapotranspiration from the BMG data. This can be caused by the distribution of the weather stations over the country and the corresponding climatic differences, but there is a possibility that the sources use different assumptions for collecting and processing the data. This could affect the entire calculation. Besides this it is also uncertain that the calculated evapotranspiration represented the actual evapotranspiration in a province.

In this study the water footprint is determined by provinces, this is a relatively accurate level. But sometimes data was not available on this level, for example the consumption rate and fertilizer use in provinces. In the study the assumption is made that these parameters are equally distributed over the provinces, of course it is not realistic to assume that these rates are equal in every province. For example, in Papua the main food is not rice but sweet potatoes, so the consumption of rice per capita would be lower than the average consumption. It is also assumed that the crop calendar and crop coefficient are equal in Indonesia as a whole. To improve the calculation accurate data and parameters by province are necessary.

The virtual water content of crops varies between provinces. For some crops the differences between provinces are not large. But for some other crops the difference is conspicuous large. For instance, rice has a virtual water content of 2766 m^3/ton in Jawa and in Kalimantan the virtual water content is 4908 m^3/ton. The yield and climate differences between those two regions have an influence. Still it is a large difference for the main crop in Indonesia.

The differences between the water footprints are also large. On Jawa the water footprint is low compared with the other regions. The difference between the province with the lowest water footprint, Jakarta, and the highest, Kalimantan Tengah, is more than double. Jakarta is a developed city and has probably an high consumption rate per capita. But in this study the consumption rate is equal over Indonesia and only the yield and climate data have influence on the water footprint. That is a reason why Jakarta has the lowest water footprint. However the real water footprint of a person in Jakarta will be higher than in this report.

For the calculation some crops are selected, so not all crops are taken into account in this study. To improve the study other crops could also be taken into account. The import of virtual water is especially lower because of this selection, since evident imported crops as cloves, wheat and sugar cane are not taken into account. Reference here can be made to the work of Mees Beeker (2008) in which the external water footprint will be calculated more accurately.

The trade distribution within Indonesia is unknown. For this study the model from Ma et al (2006) is adapted and used. It is hard to describe trade in a model when no data about interprovincial trade is available, because in a free market trade depends on many factors. When using different models, it would be possible to see the change in flows and the difference in results.

Improvements in the calculations, data or models are possible. Still we think the study gives an accurate and reliable result about the water footprint of Indonesian provinces.

8 Conclusions and recommendations

8.1 Conclusions

The average water footprint of Indonesia is 1092 m^3/cap/yr, but there are large regional differences. The footprint in Jakarta is the lowest, namely 841 m^3/cap/yr, and the highest water footprint can be found in Kalimantan Tengah, 1760 m^3/cap/yr. The provinces have an average internal water use of 84%, for the other 16% they rely on other provinces or countries. The factors that determine the water footprint are: volume of consumption, consumption patterns, climate and agricultural practice (Hoekstra and Chapagain, 2008). Because the consumption volume and pattern are the same for every person in each province, the differences in water footprint are caused by climate and agricultural practice. The provinces are for a small part depending on external water resources. Only Jakarta is highly depending on external water resources. The provinces depend only for 16% on water resources of other provinces or countries. The biggest contribution to the water footprint is rice. This is caused by the high consumption rate and the high virtual water content of rice.

The virtual water content varies within the country, there are large differences between provinces. For instance, of all big rice producing provinces, the provinces on Jawa have the lowest virtual water content. The virtual water content of rice produced on Jawa is almost half the amount of virtual water of the rice produced on Sulawesi Selatan or Sumatra Utara .The green water component has the largest contribution. The blue water use is for most products less than 15% of the virtual water content, only for rice and soybeans the blue water contribution is higher. Blue water use is affecting the environment more than the green water use, because this component is originating from groundwater or surface water. However, to ensure high yields and food security, irrigation water is required. The gray component is relative low, it contribute to at most 6% of the virtual water content. If the use of fertilizers will increase, this component will become a more important factor in the total virtual water content.

The interprovincial water flows are primarily caused by the trade of rice. The products cassava, coconut, bananas and coffee have the largest interprovincial flow relative to the water use for production. Sulawesi Selatan has the largest contribution to the interprovincial trade. The flow out of this province exists primarily of virtual water from rice. Large importing provinces are Jakarta, Jawa Barat, Jawa Tengah, Riau, Jawa Timur and Banten. The largest flow of net virtual water is from Sumatra to Jawa. Sumatra also exports the most virtual water to other countries. The large flow of water out of Sumatra exists mainly of the products palm oil, coffee and coconut oil.

Provinces depend highly on internal water resources. On average 84% of the water footprint consists of internal water, the trade and flow of water between provinces are low. There is a large variance between the virtual water content of products in provinces. In some provinces the production will take less water than in other provinces, thus the production is more efficient in those provinces. When the pressure on the resources will increase and water will become scarcer, trade of virtual water can save water, drop the pressure on the water resources and assure a high degree of food self-sufficiency within Indonesia. But to achieve this the agricultural sector needs to be reformed on the basis of water efficiently production. This will cause more trade between provinces and could lead to a lower water footprint.

8.2 Recommendations

In this section some recommendations for improvements and further research will be made.

A sensitive point in the calculation is the weather data and the evapotranspiration. To get a more reliable evapotranspiration more weather stations with a more homogenous distribution over a province are needed. But it would be also possible to use satellite images and data about the climate.

Mom (2008) already included satellite data in his study about the virtual water content of rice. This method and data could ensure a more reliable and accurate result.

In the study consumption rate and pattern are equal over whole Indonesia, because no data was available per province. In general consumption rate and consumption pattern are related to income and wealth. If a model was available that uses those parameters, there would be variation in consumption rate between provinces. The water footprint would depend also on consumption rate and the result would be more realistic.

For the calculation it is assumed that the water comes either from rainfall or irrigation. But it might be possible that through capillary forces groundwater will become available for crops. The contribution of this process to the virtual water content could be further investigated.

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Appendix I Population by province in 2000

Province	Population
Nanggroe Aceh D.	3930905
Sumatera Utara	11649655
Sumatera Barat	4248931
R i a u	4957627
J a m b i	2413846
Sumatera Selatan	6899675
Bengkulu	1567432
Lampung	6741439
Bangka Belitung	900197
D.K.I. Jakarta	8389443
Jawa Barat	35729537
Jawa Tengah	31228940
D.I. Yogyakarta	3122268
Jawa Timur	34783640
Banten	8098780
B a l i	3151162
Nusa Tenggara Barat	4009261
Nusa Tenggara Timur	3952279
Kalimantan Barat	4034198
Kalimantan Tengah	1857000
Kalimantan Selatan	2985240
Kalimantan Timur	2455120
Sulawesi Utara	2012098
Sulawesi Tengah	2218435
Sulawesi Selatan	8059627
Sulawesi Tenggara	1821284
Gorontalo	835044
Maluku	1205539
Papua	2220934
Maluku Utara	785059
Total Indonesia	*206264595*

Appendix II Production, water use, production value and land use by crop

Crop	CC	Production	VWC	Water use		Poducer Price	Production value		Land use	
		1000 ton/yr	*m3/ton*	*M m3/yr*	*%*	*US$/ton*	*M US$/yr*	*%*	*1000 ha/yr*	*%*
Rice, paddy	CE	52015	2150	111832	43,48	138	7177	31,69	11643	40,21
Maize	CE	10158	1285	13053	5,07	132	1341	5,92	3326	11,48
Potatoes	RT	957	275	263	0,10	292	280	1,24	64	0,22
Sweet potatoes	RT	1848	409	756	0,29	82	152	0,67	187	0,65
Cassava	RT	17601	460	8096	3,15	58	1021	4,51	1276	4,41
Roots and Tubers Nec	RT	350	452	158	0,06	46	16	0,07	66	0,23
Sugar cane	SC	25173	164	4128	1,61	19	471	2,08	362	1,25
Sugar crops, nec	SC	205	2189	449	0,17	19	4	0,02	75	0,26
Beans, dry	PU	311	2992	931	0,36	133	42	0,18	325	1,12
Lentils	PU	0		0	0,00		0	0,00	0	0,00
Pulses, Nec	PU	1	6020	6	0,00	133	0	0,00	2	0,01
Cashew nuts, with shell	NU	106	26788	2838	1,10	729	77	0,34	260	0,90
Arecanuts	NU	43	24495	1060	0,41	380	16	0,07	105	0,36
Nuts, Nec	NU	84	19892	1666	0,65	380	32	0,14	101	0,35
Soybeans	OC	783	2030	1589	0,62	327	256	1,13	628	2,17
Groundnuts, with shell	OC	1329	2231	2964	1,15	356	473	2,09	678	2,34
Coconuts	OC	15796	2071	32714	12,72	58	921	4,07	2686	9,27
Oil palm fruit	OC	47256	635	30008	11,67	58	2743	12,11	2673	9,23
Seed cotton	OC	30	4453	133	0,05	79	2	0,01	22	0,08
Oilseeds, nec	OC	270		0	0,00	327	88	0,39	172	0,59
Cabbages and other brassicas	VE	1393	299	417	0,16	145	202	0,89	76	0,26
Spinach	VE	84	1318	110	0,04	256	21	0,09	32	0,11
Tomatoes	VE	587	339	199	0,08	231	136	0,60	48	0,16
Pumpkins, squash and gourds	VE	150	169	25	0,01	222	33	0,15	8	0,03
Cucumbers and gherkins	VE	451	324	146	0,06	274	123	0,54	48	0,17
Eggplants (aubergines)	VE	280	518	145	0,06	129	36	0,16	40	0,14
Chillies and peppers, green	VE	822	779	640	0,25	751	617	2,73	168	0,58
Onions, dry	VE	784	762	598	0,23	533	418	1,85	85	0,29
Garlic	VE	45	1210	54	0,02	662	30	0,13	8	0,03
Leeks, other alliaceous veg	VE	346	377	131	0,05	891	309	1,36	39	0,14
Beans, green	VE	719	423	304	0,12	153	110	0,49	145	0,50

Carrots and turnips	VE	338	238	80	0,03	151	51	0,23	21	0,07
Maize, green	VE	254	1344	341	0,13	252	64	0,28	83	0,29
Vegetables, nec	VE	485	398	193	0,07	166	80	0,35	50	0,17
Bananas	FR	4297	1074	4615	1,79	273	1172	5,18	281	0,97
Oranges	FR	1181	1521	1796	0,70	379	447	1,98	50	0,17
Strawberries	FR	0		0	0,00		0	0,00	0	0,00
Guavas, mangoes, mangosteens	FR	1233	2264	2792	1,09	401	494	2,18	189	0,65
Avocados	FR	201	2325	467	0,18	407	82	0,36	45	0,15
Pineapples	FR	567	518	294	0,11	129	73	0,32	61	0,21
Papayas	FR	579	721	417	0,16	168	97	0,43	18	0,06
Fruit, nec	FR	3546	1498	5312	2,07	337	1196	5,28	301	1,04
Cinnamon (canella)	SP	59	22273	1308	0,51	857	50	0,22	81	0,28
Tea	ST	164	3213	529	0,21	358	59	0,26	117	0,40
Coffee, green	ST	623	17665	11012	4,28	714	445	1,96	1326	4,58
Cocoa beans	ST	519	9959	5168	2,01	1001	520	2,29	484	1,67
Pepper (Piper spp.)	SP	85	5237	447	0,17	2342	200	0,88	91	0,31
Vanilla	SP	2	54363	124	0,05	1243	3	0,01	9	0,03
Cloves	SP	94	66387	6235	2,42	3168	298	1,31	346	1,19
Nutmeg, mace and cardamoms	SP	23	25432	596	0,23	664	16	0,07	40	0,14
Ginger	Sp	151	490	74	0,03	982	149	0,66	17	0,06
Spices, nec	SP	2	3816	8	0,00	441	1	0,00	2	0,01
Total		*194380*		*257218*	*100,00*	*22428*	*22644*	*100,00*	*28957*	*100,00*

Appendix III Province with the accompanying weather stations

	Province	Weather stations				
1	Nanggroe Aceh D.	Sabang	<u>Banda Aceh</u>			
2	Sumatera Utara	Medan	<u>Belawan</u>			
3	Sumatera Barat	Padang	Fort de Kock	<u>Padang</u>		
4	R i a u	<u>Pakanbaru</u>	<u>Tarempa</u>			
5	J a m b i					
6	Sumatera Selatan	Palembang				
7	Bengkulu	<u>Bengkulu</u>				
8	Lampung	<u>Menggala</u>	<u>Telukbetung</u>			
9	Bangka Belitung	Pangkalpinang	Buluh Tumbang			
10	Riau Kepulauan	<u>Batam</u>				
11	D.K.I. Jakarta	Jakarta				
12	Jawa Barat	Bandung	Bogor	Lembang	Rarahan	
		Tjipetir	Gunung-Rosa	Pangerango		
13	Jawa Tengah	Semarang	Magelang	<u>Tegal</u>	<u>Cilacap</u>	
14	D.I. Yogyakarta	<u>Jogjakarta</u>				
15	Jawa Timur	Surabaya	Djember	Karanganjar	Pasuruan	Sawahan
		Kawah-Idjen	Rogodjampi	Tosari	Tamansari	
16	Banten	Curung-Budiarto	<u>Serang</u>			
17	B a l i	Den-Pasar				
18	Nusa Tenggara Barat	Tambora	<u>Bima</u>			
19	Nusa Tenggara Timur	Kupang	Waingapu			
20	Kalimantan Barat	Pontianak	<u>Sintang</u>			
21	Kalimantan Tengah	<u>Palangkaraya</u>	<u>Pangkalan Bun</u>			
22	Kalimantan Selatan	Banjamarsin	<u>Banjarbaru</u>			
23	Kalimantan Timur	Balikpapan	Tarakan			
24	Sulawesi Utara	Manado	<u>Tahuna</u>			
25	Sulawesi Tengah	<u>Luwuk</u>				
26	Sulawesi Selatan	Ujung-Padang	<u>Masamba</u>			
27	Sulawesi Tenggara	<u>Kendari</u>	<u>Bau-bau</u>	<u>Poso</u>		
28	Gorontalo	<u>Gorontalo</u>				
29	Sulawesi Barat	<u>Majene</u>				
30	Maluku	Ambon	<u>Amahai</u>			
31	Maluku Utara	<u>Ternate</u>				
32	Papua Barat	Manokwari	Sorong	Kaimana		
33	Papua	Jayapura	Biak-Mokmer			

The underlined weather station are from BMG, the others are taken from CLIMWAT

Appendix IV Crop parameters

Crop	Season	Date		length of development stages (days)					Crop coefficient		
		Planted	*Harvested*	*I*	*CD*	*MS*	*LS*	*Total*	*Kc ini*	*Kc mid*	*Kc end*
Rice, paddy[1]	Wet	1-Nov	1-Apr	30	30	60	30	150	1,05	1,10	0,65
	Dry	10-Apr	10-Sep	30	30	60	30	150	1,05	1,12	0,67
Maize[2]	Wet	10-Oct	15-Feb	20	35	40	30	125	0,30	1,08	0,48
	Dry	10-Mar	15-Jul	20	35	40	30	125	0,30	1,10	0,50
Cassava[2]		1-Nov	1-Jun	20	40	90	60	210	0,30	0,99	0,39
Soybeans[3]	Dry	1-Aug	25-Oct	15	15	40	15	85	0,40	1,08	0,43
Groundnuts[4]	Wet	10-Mar	1-Aug	35	45	35	25	140	0,40	0,97	0,52
Coconuts		15-Feb		120	60	180	5	365	0,95	1,00	1,00
Oil palm fruit		15-Feb		120	60	180	5	365	0,80	0,81	0,81
Bananas		1-Feb		120	60	180	5	365	1,00	1,05	0,95
Coffee, green			1-Aug	120	60	180	5	365	0,80	0,82	0,82
Cocoa beans[5]			1-Nov	120	60	180	5	365	0,90	0,91	0,91

[1] IRRI (2008)
[2] Swastika et al (2004)
[3] FAO (2008d)
[4] Taufiq et al (2007)
[5] Wood and Lass (1989)

Appendix V Irrigated area fraction

Province	Wetland	Dryland	irrigated area fraction				
			Rice	Maize	Cassava	Soybeans	Groundnut
	ha	*ha*					
1. Nanggroe Aceh D.	367083	799003	0,99	0,20	0,20	0,20	0,20
2. Sumatera Utara	575249	812996	0,90	0,21	0,21	0,21	0,21
3. Sumatera Barat	237862	524900	0,98	0,06	0,06	0,06	0,06
4. R i a u	119555	708991	0,86	0,08	0,08	0,08	0,08
5. J a m b i	161213	733218	0,84	0,12	0,12	0,12	0,12
6. Sumatera Selatan	484207	661722	0,87	0,27	0,27	0,27	0,27
7. Bengkulu	77353	262748	0,83	0,11	0,11	0,11	0,11
8. Lampung	313317	786229	0,84	0,13	0,13	0,13	0,13
9. Bangka Belitung	4111	161028	0,37	0,02	0,02	0,02	0,02
10. Kepulauan Riau	692	78382	0,00	0,00	0,00	0,00	0,00
11. D.K.I. Jakarta	2244	2658	1,00	0,29	0,29	0,29	0,29
12. Jawa Barat	917725	808850	0,95	0,11	0,11	0,11	0,11
13. Jawa Tengah	967808	764248	0,96	0,21	0,21	0,21	0,21
14. D.I. Yogyakarta	57188	95896	0,73	0,10	0,10	0,10	0,10
15. Jawa Timur	1096077	1153277	0,94	0,21	0,21	0,21	0,21
16. Banten	194504	260052	0,91	0,13	0,13	0,13	0,13
17. B a l i	80211	133547	0,99	0,05	0,05	0,05	0,05
18. Nusa Tenggara Barat	225708	246328	0,87	0,28	0,28	0,28	0,28
19. Nusa Tenggara Timur	115596	738254	0,66	0,08	0,08	0,08	0,08
20. Kalimantan Barat	274662	846700	0,71	0,16	0,16	0,16	0,16
21. Kalimantan Tengah	163501	969870	0,58	0,10	0,10	0,10	0,10
22. Kalimantan Selatan	433864	383001	0,89	0,40	0,40	0,40	0,40
23. Kalimantan Timur	123892	456345	0,56	0,16	0,16	0,16	0,16
24. Sulawesi Utara	57969	358775	0,94	0,05	0,05	0,05	0,05
25. Sulawesi Tengah	117715	703427	0,97	0,04	0,04	0,04	0,04
26. Sulawesi Selatan	568748	624781	0,99	0,26	0,26	0,26	0,26
27. Sulawesi Tenggara	73312	300121	0,89	0,11	0,11	0,11	0,11
28. Gorontalo	27098	175489	0,97	0,05	0,05	0,05	0,05
29. Sulawesi Barat	47414	63308	0,00	0,00	0,00	0,00	0,00
30. Maluku			0,81				
31. North Maluku			0,86				
32. Irian Jaya			0,81				
33. West Papua			0,00				
Total	*7885878*	*14614144*					

Appendix VI Fertilizer use by crop

	Fertilized Area	Application of Nitrate
	%	*kgN/ha*
Rice	90	105
Maize	80	5
Cassava	40	65
Soybeans	0	0
Groundnut	0	0
Coconut	15	45
Oil Palm	80	95
Banana	0	0
Coffee	70	70
Cocoa	70	95

Appendix VII Production quantity in a province by product

	Rice	Maize	Cassava	Soybean	Groundnut
			1000 ton		
Nanggroe Aceh D.	1378	54	59	44	30
Sumatera Utara	3341	657	460	11	24
Sumatera Barat	1782	64	100	4	8
R i a u	414	40	58	2	3
J a m b i	558	26	54	4	2
Sumatera Selatan	1866	69	270	6	7
Bengkulu	383	48	83	2	6
Lampung	1964	1081	3741	11	11
Bangka Belitung	10	1	15	0	0
D.K.I. Jakarta	13	0	1		0
Jawa Barat	9483	414	1709	35	64
Jawa Tengah	8348	1675	3224	154	162
D.I. Yogyakarta	655	184	738	51	55
Jawa Timur	8904	3723	3836	330	185
Banten	1149	19	118	2	10
B a l i	805	91	146	11	17
Nusa Tenggara Barat	1435	60	93	54	33
Nusa Tenggara Timur	472	561	837	3	13
Kalimantan Barat	964	50	195	2	2
Kalimantan Tengah	402	9	99	3	2
Kalimantan Selatan	1374	34	105	7	17
Kalimantan Timur	410	12	98	2	2
Sulawesi Utara	385	159	37	4	6
Sulawesi Tengah	646	50	53	2	5
Sulawesi Selatan	3821	615	522	26	46
Sulawesi Tenggara	303	76	187	2	8
Gorontalo	117	82	8	1	2
Maluku	28	8	223	2	4
Papua	72	7	48	6	5
Maluku Utara	15	1	26	0	0
Total	*51497*	*9868*	*17145*	*781*	*731*

	Coconut	Oil Palm	Bananas	Coffee	Cocoa
			1000 ton		
Nanggroe Aceh D.	84	385	43	44	11
Sumatera Utara	118	2515	81	43	48
Sumatera Barat	72	458	51	20	7
R i a u	526	2248	41	2	2
J a m b i	123	657	16	5	0
Sumatera Selatan	31	844	85	141	0
Bengkulu	8	106	14	60	2
Lampung	139	166	197	121	11
Bangka Belitung	7	110	3	0	0
D.K.I. Jakarta		1	2		
Jawa Barat	99	13	1352	5	4
Jawa Tengah	215		497	15	2
D.I. Yogyakarta	47		41	0	0
Jawa Timur	255		753	44	15
Banten	57		155	2	1
B a l i	75		94	20	5
Nusa Tenggara Barat	49		119	4	1
Nusa Tenggara Timur	58		141	15	6
Kalimantan Barat	55	24	79	4	2
Kalimantan Tengah	56	553	16	2	0
Kalimantan Selatan	36	223	43	2	0
Kalimantan Timur	38	144	38	6	19
Sulawesi Utara	259		29	4	2
Sulawesi Tengah	188	114	43	6	73
Sulawesi Selatan	194	60	132	42	223
Sulawesi Tenggara	34	152	33	4	86
Gorontalo	59		2	0	1
Maluku	70		3	1	4
Papua	14	72	1049	4	15
Maluku Utara	173		39	1	12
Total	*3140*	*8866*	*5192*	*617*	*557*

Appendix VIII Production area in a province by product

	Rice	Maize	Cassava	Soybean	Groundnut
			ha		
Nanggroe Aceh D.	337142	22198	4889	33196	8920
Sumatera Utara	813200	208990	38078	10687	22870
Sumatera Barat	406465	24934	8168	3031	7687
R i a u	136260	18452	5273	2123	3866
J a m b i	163643	10640	4493	2932	2094
Sumatera Selatan	564820	27425	22940	4671	6104
Bengkulu	108992	25037	6841	2485	5918
Lampung	488323	355281	287148	10326	10242
Bangka Belitung	6066	691	1807	3	406
D.K.I. Jakarta	2781	33	91		24
Jawa Barat	1878279	121562	93765	26500	68832
Jawa Tengah	1629020	537519	224082	105178	146077
D.I. Yogyakarta	134701	66469	58419	42493	62550
Jawa Timur	1708325	1132131	248656	258898	167965
Banten	346612	9509	11856	2874	11830
B a l i	148218	32047	12310	8049	13790
Nusa Tenggara Barat	325533	30024	8151	65507	31038
Nusa Tenggara Timur	173572	258595	84153	3007	11932
Kalimantan Barat	357666	24451	14827	1550	1795
Kalimantan Tengah	178883	4487	9078	2432	2040
Kalimantan Selatan	432877	18644	7645	5550	14460
Kalimantan Timur	138836	6193	7392	2030	2447
Sulawesi Utara	90210	71333	4023	3327	5165
Sulawesi Tengah	175309	22010	4622	1942	5132
Sulawesi Selatan	816252	210010	40210	19328	39535
Sulawesi Tenggara	82533	35504	15498	2536	9457
Gorontalo	35667	49047	1043	1210	3223
Maluku	10900	5364	16816	1321	1672
Papua	23406	4405	4407	5385	5055
Maluku Utara	15813	2856	10261	518	2167
Total	*11730306*	*3335840*	*1256942*	*629088*	*674291*

	Coconut	Oil Palm	Bananas	Coffee	Cocoa
			ha		
Nanggroe Aceh D.	116001	164633	3608	98401	11117
Sumatera Utara	139704	558592	10048	66360	30886
Sumatera Barat	88623	184988	3370	45380	6751
R i a u	586347	885962	3535	10867	2375
J a m b i	133231	246479	1688	27731	1008
Sumatera Selatan	50429	329208	10124	282139	192
Bengkulu	19829	83471	2068	118924	7384
Lampung	155844	96225	28663	173067	11694
Bangka Belitung	15077	79096	1629	86	152
D.K.I. Jakarta			106		
Jawa Barat	188082	5335	67803	14575	5718
Jawa Tengah	283563		54800	40131	3395
D.I. Yogyakarta	40578		2750	1787	1517
Jawa Timur	282803		43816	93705	15233
Banten	101983	8340	13781	8792	2257
B a l i	72659		8917	38382	3677
Nusa Tenggara Barat	66546		3667	11884	1974
Nusa Tenggara Timur	162577	0	10239	66439	17746
Kalimantan Barat	108495	236807	4739	15858	4575
Kalimantan Tengah	68319	265559	1247	7138	494
Kalimantan Selatan	53908	114147	6176	6949	954
Kalimantan Timur	50474	113440	5979	16302	16806
Sulawesi Utara	255699		3367	8526	4081
Sulawesi Tengah	179301	31891	1378	19244	60263
Sulawesi Selatan	180754	9206	10424	94955	125359
Sulawesi Tenggara	51961	2715	1032	11496	68231
Gorontalo	59457	0	188	1127	2324
Maluku	93590		4762	5021	5501
Papua	35894	33752	2015	8565	13316
Maluku Utara	172514		2790	5008	14823
Total	*3814242*	*3449848*	*314708*	*1298837*	*439801*

Appendix IX Production and value fraction of crops

Root product	Processed product	Production fraction	Value fraction
		-	-
Rice	Rice (Milled Equivalent)	0,65	1
Maize	-	1,00	1
Cassava	-	1,00	1
Soybean	Soybean Cake	0,80	0,66
Soybean	Soybean Oil	0,18	0,34
Groundnut with shell	Groundnut shelled	0,68	1
Groundnut shelled	Groundnut Oil	0,52	0,78
Coconuts	Copra	0,20	1
Copra	Coconut Oil	0,54	0,63
Oil Palm Fruit	Palm Oil	0,20	0,93
Oil Palm Fruit	Palmkernels	0,05	0,07
Palmkernels	Palmkernel Oil	0,45	0,42
Bananas	-	1,00	1
Coffee	-	1,00	1
Cocoa Beans	-	1,00	1

Appendix X National Food Balance

Product	PR	IM	ST	EX	DO	FE	SE	FM	WA	OT	FO
					1000 tonnes						
Rice (Milled Equivalent)	34338	1375	108	7	*35814*	1376	307	0	2604	4	31524
Maize	9891	1237	0	42	*11085*	3250	96	0	625	30	7085
Cassava	17145	613	0	502	*17257*	343	0	0	2148	2459	12307
Soyabeans	797	1243	0	2	*2039*	0	45	0	97	0	1897
Groundnuts (Shelled Eq)	907	138	0	10	*1034*	0	19	62	90	0	863
Coconuts - Incl Copra	12090	39	0	283	*11846*	0	5	4751	1209	0	5881
Palmkernels	1942	1	15	6	*1951*	0	0	1951	0	0	0
Soyabean Oil	0	15	0	0	*15*	0	0	0	0	0	15
Groundnut Oil	28	0	0	0	*28*	0	0	0	0	0	28
Palmkernel Oil	868	3	0	640	*232*	0	0	0	0	0	232
Palm Oil	8450	31	-75	6037	*2369*	0	0	0	0	681	1689
Coconut Oil	789	2	-48	485	*258*	0	0	0	0	21	237
Bananas	4186	6	0	21	*4171*	0	0	0	419	0	3752
Coffee	650	11	0	328	*334*	0	0	0	26	0	308
Cocoa Beans	434	33	-6	401	*61*	0	0	0	0	0	61

PR = production quantity, IM = import quantity, ST= stock variation, EX= export quantity, DO= domestic supply (=PR+IM+ST-EX), FE= feed quantity, SE= seed quantity, FM= food manufacture, WA= waste quantity, OT= other uses quantity and FO= food quantity

Appendix XI Virtual water content of crops per provinces

	Rice				Maize				Cassava			
	GE	BL	GA	T	GE	BL	GA	T	GE	BL	GA	T
						m3/ton						
Nanggroe Aceh D.	2361	1385	225	3972	2626	155	15	2797	484	26	21	531
Sumatera Utara	2771	903	229	3903	2371	96	13	2479	458	36	21	516
Sumatera Barat	3054	143	213	3411	2720	3	13	2737	569	0	21	590
R i a u	3823	1501	305	5630	3579	83	18	3680	649	10	24	683
J a m b i	3558	727	275	4560	3176	52	16	3244	632	1	23	656
Sumatera Selatan	3423	351	274	4049	3005	26	16	3048	574	0	22	596
Bengkulu	3635	889	264	4789	4473	59	21	4553	662	7	23	692
Lampung	1733	1970	232	3935	1779	159	13	1951	409	22	19	450
Bangka Belitung	5612	71	398	6081	3007	0	15	3022	603	0	23	626
D.K.I. Jakarta	2210	722	201	3133	3832	148	22	4001	578	3	22	603
Jawa Barat	2126	115	187	2428	1811	1	11	1823	370	0	17	387
Jawa Tengah	2207	757	184	3148	2489	76	13	2578	513	0	18	531
D.I. Yogyakarta	2161	895	192	3248	2719	31	14	2764	619	0	20	640
Jawa Timur	1954	458	181	2593	2053	37	12	2102	416	0	17	433
Banten	1994	1332	205	3530	2618	112	15	2745	525	8	19	552
B a l i	2096	411	175	2683	2924	10	15	2949	623	1	22	646
Nusa Tenggara Barat	2778	640	213	3631	3972	113	19	4105	656	0	23	679
Nusa Tenggara Timur	2559	1802	336	4697	2431	112	18	2560	613	9	25	647
Kalimantan Barat	4879	392	344	5615	3426	19	16	3461	550	1	20	571
Kalimantan Tengah	4761	1005	384	6150	5046	86	26	5158	670	2	23	695
Kalimantan Selatan	3578	200	292	4070	3673	0	21	3694	480	0	20	501
Kalimantan Timur	4445	0	308	4753	4112	0	21	4132	516	0	20	536
Sulawesi Utara	3060	436	219	3714	3827	7	18	3852	712	0	25	738
Sulawesi Tengah	2512	1969	250	4732	3038	45	17	3100	549	8	23	581
Sulawesi Selatan	2525	1026	205	3756	2841	95	13	2950	579	9	20	608
Sulawesi Tenggara	2582	1639	254	4475	3368	101	19	3488	510	9	20	540
Gorontalo	1952	1920	214	4086	2418	47	14	2479	541	12	24	577
Maluku	3821	855	344	5020	4146	0	24	4170	502	0	22	524
Maluku Utara	2802	1546	267	4615	4233	0	26	4259	568	0	22	590
Papua	4312	16	315	4643	4942	0	26	4968	609	0	24	633

GE = green component, BL = blue component, GA = gray component, T = Total

	Soybeans				Groundnut				Coconut			
	GE	BL	GA	T	GE	BL	GA	T	GE	BL	GA	T
						m3/ton						
Nanggroe Aceh D.	2139	155	0	2294	1134	114	0	1248	3098	0	18	3117
Sumatera Utara	3238	15	0	3253	4236	115	0	4350	3117	0	16	3133
Sumatera Barat	2687	0	0	2687	3816	0	0	3817	3545	0	16	3561
R i a u	3150	63	0	3213	4900	166	0	5066	2963	0	15	2978
J a m b i	2495	74	0	2569	3824	91	0	3915	2834	0	14	2848
Sumatera Selatan	2130	152	0	2283	3288	46	0	3335	4140	0	22	4161
Bengkulu	3360	105	0	3465	4646	74	0	4720	7091	0	32	7123
Lampung	1471	425	0	1896	2302	282	0	2584	1734	0	15	1749
Bangka Belitung	2914	0	0	2914	4166	0	0	4166	5841	0	27	5868
D.K.I. Jakarta	0	0	0	0	878	69	0	946	0	0	0	0
Jawa Barat	2117	22	0	2139	2059	4	0	2062	3853	0	22	3874
Jawa Tengah	1349	315	0	1664	3000	230	0	3230	3127	0	17	3144
D.I. Yogyakarta	1515	110	0	1625	3167	108	0	3274	2144	0	12	2156
Jawa Timur	1381	262	0	1642	2587	128	0	2715	2090	0	13	2103
Banten	1111	279	0	1390	2685	190	0	2875	3430	0	23	3453
B a l i	1168	52	0	1221	2813	5	0	2819	2244	0	12	2256
Nusa Tenggara Barat	2198	712	0	2910	3430	169	0	3599	3435	0	18	3453
Nusa Tenggara Timur	188	302	0	490	1398	154	0	1552	3962	0	37	3998
Kalimantan Barat	2979	30	0	3009	4268	18	0	4286	5332	0	24	5356
Kalimantan Tengah	2171	173	0	2344	3628	96	0	3724	2886	0	15	2901
Kalimantan Selatan	1834	321	0	2155	3234	0	0	3234	3510	0	19	3529
Kalimantan Timur	3007	8	0	3015	4124	0	0	4124	3820	0	18	3837
Sulawesi Utara	2352	40	0	2392	4082	15	0	4096	2752	0	13	2765
Sulawesi Tengah	1603	100	0	1703	3847	19	0	3866	1913	0	13	1926
Sulawesi Selatan	1428	446	0	1874	3205	250	0	3454	2511	0	13	2525
Sulawesi Tenggara	2019	344	0	2363	4344	161	0	4505	3217	0	21	3238
Gorontalo	1288	144	0	1433	3171	78	0	3249	1874	0	13	1888
Maluku	2297	0	0	2297	1527	0	0	1527	2985	0	17	3002
Maluku Utara	2429	0	0	2429	2231	0	0	2231	2179	0	13	2192
Papua	2582	0	0	2582	4147	0	0	4147	7105	0	35	7140

GE = green component, BL = blue component, GA = gray component, T = Total

	Oil Palm				Banana				Coffee			
	GE	BL	GA	T	GE	BL	GA	T	GE	BL	GA	T
						m3/ton						
Nanggroe Aceh D.	776	0	57	832	874	0	0	874	24094	0	1139	25233
Sumatera Utara	485	0	30	516	1463	0	0	1463	18350	0	740	19089
Sumatera Barat	818	0	50	868	1098	0	0	1098	27309	0	1067	28376
R i a u	861	0	52	913	1185	0	0	1185	62231	0	2396	64628
J a m b i	790	0	49	839	1448	0	0	1448	63743	0	2536	66279
Sumatera Selatan	718	0	49	768	1531	0	0	1531	22315	0	982	23297
Bengkulu	1613	0	92	1705	1830	0	0	1830	26036	0	953	26989
Lampung	761	0	74	835	868	0	0	868	10844	0	677	11521
Bangka Belitung	890	0	56	945	3058	0	0	3058	38435	0	1534	39969
D.K.I. Jakarta	0	0	0	0	0	0	0	0	0	0	0	0
Jawa Barat	766	0	57	823	614	0	0	614	27016	0	1292	28308
Jawa Tengah	0	0	0	0	1271	0	0	1271	30244	0	1332	31576
D.I. Yogyakarta	0	0	0	0	796	0	0	796	50340	0	2295	52635
Jawa Timur	0	0	0	0	628	0	0	628	20611	0	1041	21652
Banten	625	0	51	676	667	0	0	667	36679	0	1906	38585
B a l i	0	0	0	0	1075	0	0	1075	21597	0	965	22563
Nusa Tenggara Barat	0	0	0	0	468	0	0	468	31717	0	1344	33060
Nusa Tenggara Timur	0	0	0	0	588	0	0	588	28440	0	2077	30518
Kalimantan Barat	991	0	58	1050	914	0	0	914	46886	0	1761	48646
Kalimantan Tengah	2035	0	131	2166	999	0	0	999	39184	0	1619	40802
Kalimantan Selatan	1304	0	95	1399	1620	0	0	1620	36604	0	1703	38307
Kalimantan Timur	1886	0	119	2006	1994	0	0	1994	34458	0	1391	35849
Sulawesi Utara	0	0	0	0	1472	0	0	1472	28154	0	1087	29241
Sulawesi Tengah	818	0	64	882	346	0	0	346	9778	0	490	10268
Sulawesi Selatan	154	0	10	164	923	0	0	923	28318	0	1169	29487
Sulawesi Tenggara	280	0	21	301	348	0	0	348	31599	0	1509	33107
Gorontalo	0	0	0	0	590	0	0	590	20255	0	1044	21299
Maluku	0	0	0	0	14782	0	0	14782	83426	0	3770	87196
Maluku Utara	0	0	0	0	742	0	0	742	80446	0	3556	84001
Papua	1006	0	67	1073	3242	0	0	3242	29554	0	1251	30805

GE = green component, BL = blue component, GA = gray component, T = Total

	Cocoa			
	GE	BL	GA	T
		m3/ton		
Nanggroe Aceh D.	10361	0	635	10996
Sumatera Utara	8242	0	426	8667
Sumatera Barat	13280	0	630	13910
R i a u	13760	0	690	14450
J a m b i	31248	0	1575	32823
Sumatera Selatan	19102	0	1045	20148
Bengkulu	37351	0	1735	39086
Lampung	7577	0	642	8219
Bangka Belitung	43712	0	2140	45852
D.K.I. Jakarta	0	0	0	0
Jawa Barat	14816	0	877	15693
Jawa Tengah	19493	0	1103	20596
D.I. Yogyakarta	53938	0	3180	57117
Jawa Timur	11792	0	753	12545
Banten	19979	0	1360	21339
B a l i	8015	0	456	8471
Nusa Tenggara Barat	19438	0	1039	20477
Nusa Tenggara Timur	15929	0	1503	17432
Kalimantan Barat	37939	0	1761	39701
Kalimantan Tengah	97377	0	5128	102505
Kalimantan Selatan	46711	0	2704	49414
Kalimantan Timur	11895	0	583	12478
Sulawesi Utara	21588	0	1051	22638
Sulawesi Tengah	6756	0	453	7209
Sulawesi Selatan	7418	0	399	7817
Sulawesi Tenggara	7975	0	508	8483
Gorontalo	13956	0	974	14930
Maluku	13255	0	765	14020
Maluku Utara	14244	0	824	15068
Papua	12227	0	633	12860

GE = green component, BL = blue component, GA = gray component, T = Total

Appendix XII Surplus and trade flow of a province by product

	Rice (milled eq)					Maize				
		EX		IM			EX		IM	
	S	IN	IP	IN	IP	S	IN	IP	IN	IP
			1000 ton					*1000 ton*		
Nanggroe Aceh D.	233	0	141	0	0	-85	0	0	-42	-43
Sumatera Utara	240	0	145	0	0	208	2	58	0	0
Sumatera Barat	428	1	259	0	0	-86	0	0	-42	-44
R i a u	-507	0	0	-193	-299	-134	0	0	-66	-68
J a m b i	-31	0	0	-12	-18	-59	0	0	-29	-30
Sumatera Selatan	74	0	45	0	0	-173	0	0	-85	-88
Bengkulu	-8	0	0	-3	-5	-9	0	0	-4	-5
Lampung	158	0	95	0	0	769	7	214	0	0
Bangka Belitung	-130	0	0	-49	-76	-30	0	0	-15	-15
D.K.I. Jakarta	-1274	0	0	-485	-751	-288	0	0	-141	-147
Jawa Barat	274	1	166	0	0	-844	0	0	-414	-430
Jawa Tengah	276	1	167	0	0	478	4	133	0	0
D.I. Yogyakarta	-81	0	0	-31	-48	63	1	18	0	0
Jawa Timur	69	0	42	0	0	2252	21	628	0	0
Banten	-312	0	0	-119	-184	-255	0	0	-125	-130
B a l i	5	0	3	0	0	-24	0	0	-12	-12
Nusa Tenggara Barat	255	0	154	0	0	-82	0	0	-40	-42
Nusa Tenggara Timur	-319	0	0	-121	-188	384	4	107	0	0
Kalimantan Barat	-33	0	0	-13	-20	-93	0	0	-45	-47
Kalimantan Tengah	-41	0	0	-15	-24	-56	0	0	-27	-28
Kalimantan Selatan	374	1	227	0	0	-71	0	0	-35	-36
Kalimantan Timur	-127	0	0	-48	-75	-73	0	0	-36	-37
Sulawesi Utara	-74	0	0	-28	-44	78	1	22	0	0
Sulawesi Tengah	51	0	31	0	0	-30	0	0	-15	-15
Sulawesi Selatan	1079	2	654	0	0	293	3	82	0	0
Sulawesi Tenggara	-95	0	0	-36	-56	8	0	2	0	0
Gorontalo	-33	0	0	-13	-20	72	1	20	0	0
Maluku	-167	0	0	-64	-99	-34	0	0	-17	-17
Maluku Utara	-296	0	0	-32	-49	-70	0	0	-12	-12
Papua	-84	0	0	-113	-174	-23	0	0	-34	-36
Total	*-96*	*7*	*2130*	*-1375*	*-2130*	*2086*	*42*	*1284*	*-1237*	*-1284*

S= surplus, EX= export, IM= import, IN= international, IP= interprovincial

	Cassava					Soybeans				
		EX		IM			EX		IM	
	S	IN	IP	IN	IP	S	IN	IP	IN	IP
	1000 ton					*1000 ton*				
Nanggroe Aceh D.	-183	0	0	-32	-151	0	0	0	0	0
Sumatera Utara	-295	0	0	-52	-244	-98	0	0	-96	-2
Sumatera Barat	-167	0	0	-29	-138	-36	0	0	-35	-1
R i a u	-245	0	0	-43	-202	-44	0	0	-43	-1
J a m b i	-98	0	0	-17	-80	-19	0	0	-19	0
Sumatera Selatan	-177	0	0	-31	-146	-59	0	0	-58	-1
Bengkulu	-22	0	0	-4	-18	-13	0	0	-12	0
Lampung	2847	230	1331	0	0	-53	0	0	-52	-1
Bangka Belitung	-36	0	0	-6	-30	-8	0	0	-8	0
D.K.I. Jakarta	-500	0	0	-87	-412	-77	0	0	-76	-1
Jawa Barat	-647	0	0	-113	-534	-299	0	0	-295	-5
Jawa Tengah	936	76	438	0	0	-158	0	0	-156	-3
D.I. Yogyakarta	455	37	213	0	0	14	1	13	0	0
Jawa Timur	1256	102	587	0	0	-43	0	0	-42	-1
Banten	-346	0	0	-60	-286	-72	0	0	-71	-1
B a l i	-61	0	0	-11	-51	-20	0	0	-19	0
Nusa Tenggara Barat	-158	0	0	-28	-131	8	1	7	0	0
Nusa Tenggara Timur	491	40	229	0	0	-34	0	0	-33	-1
Kalimantan Barat	-72	0	0	-13	-59	-36	0	0	-35	-1
Kalimantan Tengah	-25	0	0	-4	-20	-15	0	0	-14	0
Kalimantan Selatan	-87	0	0	-15	-72	-22	0	0	-21	0
Kalimantan Timur	-61	0	0	-11	-50	-21	0	0	-20	0
Sulawesi Utara	-88	0	0	-15	-72	-15	0	0	-15	0
Sulawesi Tengah	-86	0	0	-15	-71	-19	0	0	-18	0
Sulawesi Selatan	-28	0	0	-5	-23	-52	0	0	-51	-1
Sulawesi Tenggara	54	4	25	0	0	-15	0	0	-15	0
Gorontalo	-41	0	0	-7	-34	-6	0	0	-6	0
Maluku	122	10	57	0	0	-10	0	0	-10	0
Maluku Utara	-90	3	20	0	0	-15	0	0	-7	0
Papua	43	0	0	-16	-75	-7	0	0	-15	0
Total	*2690*	*502*	*2900*	*-613*	*-2900*	*-1241*	*2*	*20*	*-1243*	*-20*

S= surplus, EX= export, IM= import, IN= international, IP= interprovincial

	Groundnut (Shelled eq)					Coconut				
		EX		IM			EX		IM	
	S	IN	IP	IN	IP	S	IN	IP	IN	IP
			1000 ton					*1000 ton*		
Nanggroe Aceh D.	16	1	11	0	0	177	8	36	0	0
Sumatera Utara	-23	0	0	-12	-11	76	3	16	0	0
Sumatera Barat	-9	0	0	-4	-4	129	6	26	0	0
R i a u	-17	0	0	-9	-9	1679	75	342	0	0
J a m b i	-8	0	0	-4	-4	359	16	73	0	0
Sumatera Selatan	-21	0	0	-11	-11	-89	0	0	-3	-87
Bengkulu	0	0	0	0	0	-16	0	0	0	-16
Lampung	-16	0	0	-8	-8	289	13	59	0	0
Bangka Belitung	-3	0	0	-2	-2	-1	0	0	0	-1
D.K.I. Jakarta	-35	0	0	-18	-17	-239	0	0	-7	-232
Jawa Barat	-80	0	0	-40	-40	-675	0	0	-20	-656
Jawa Tengah	44	2	29	0	0	-147	0	0	-4	-142
D.I. Yogyakarta	47	2	30	0	0	74	3	15	0	0
Jawa Timur	55	3	36	0	0	-107	0	0	-3	-104
Banten	-20	0	0	-10	-10	-34	0	0	-1	-33
B a l i	5	0	3	0	0	171	8	35	0	0
Nusa Tenggara Barat	19	1	12	0	0	54	2	11	0	0
Nusa Tenggara Timur	-2	0	0	-1	-1	90	4	18	0	0
Kalimantan Barat	-15	0	0	-7	-7	77	3	16	0	0
Kalimantan Tengah	-5	0	0	-3	-3	140	6	29	0	0
Kalimantan Selatan	6	0	4	0	0	40	2	8	0	0
Kalimantan Timur	-8	0	0	-4	-4	63	3	13	0	0
Sulawesi Utara	-2	0	0	-1	-1	840	38	171	0	0
Sulawesi Tengah	-3	0	0	-2	-2	588	26	120	0	0
Sulawesi Selatan	16	1	11	0	0	442	20	90	0	0
Sulawesi Tenggara	1	0	1	0	0	65	3	13	0	0
Gorontalo	0	0	0	0	0	179	8	36	0	0
Maluku	0	0	0	0	0	210	9	43	0	0
Maluku Utara	-4	0	0	-1	-1	-16	26	117	0	0
Papua	-1	0	0	-2	-2	577	0	0	0	-16
Total	*-65*	*10*	*136*	*-138*	*-136*	*4995*	*283*	*1286*	*-39*	*-1286*

S= surplus, EX= export, IM= import, IN= international, IP= interprovincial

	Groundnut Oil					Palmkernel Oil				
		EX		IM			EX		IM	
	S	IN	IP	IN	IP	S	IN	IP	IN	IP
	1000 ton					*1000 ton*				
Nanggroe Aceh D.	1	0	1	0	0	33	27	6	0	0
Sumatera Utara	-1	0	0	0	-1	233	189	44	0	0
Sumatera Barat	0	0	0	0	0	40	32	8	0	0
R i a u	-1	0	0	0	-1	215	174	41	0	0
J a m b i	0	0	0	0	0	62	50	12	0	0
Sumatera Selatan	-1	0	0	0	-1	75	61	14	0	0
Bengkulu	0	0	0	0	0	9	7	2	0	0
Lampung	0	0	0	0	0	9	7	2	0	0
Bangka Belitung	0	0	0	0	0	10	8	2	0	0
D.K.I. Jakarta	-1	0	0	0	-1	-9	0	0	0	-9
Jawa Barat	-2	0	0	0	-2	-39	0	0	-1	-38
Jawa Tengah	2	0	2	0	0	-35	0	0	-1	-34
D.I. Yogyakarta	2	0	2	0	0	-4	0	0	0	-3
Jawa Timur	2	0	2	0	0	-39	0	0	-1	-38
Banten	-1	0	0	0	-1	-7	0	0	0	-7
B a l i	0	0	0	0	0	-4	0	0	0	-3
Nusa Tenggara Barat	1	0	1	0	0	-5	0	0	0	-4
Nusa Tenggara Timur	0	0	0	0	0	-4	0	0	0	-4
Kalimantan Barat	0	0	0	0	0	50	40	9	0	0
Kalimantan Tengah	0	0	0	0	0	20	16	4	0	0
Kalimantan Selatan	0	0	0	0	0	11	9	2	0	0
Kalimantan Timur	0	0	0	0	0	8	7	2	0	0
Sulawesi Utara	0	0	0	0	0	-2	0	0	0	-2
Sulawesi Tengah	0	0	0	0	0	3	3	1	0	0
Sulawesi Selatan	1	0	1	0	0	6	5	1	0	0
Sulawesi Tenggara	0	0	0	0	0	0	0	0	0	0
Gorontalo	0	0	0	0	0	-1	0	0	0	-1
Maluku	0	0	0	0	0	-1	0	0	0	-1
Maluku Utara	0	0	0	0	0	-2	5	1	0	0
Papua	0	0	0	0	0	6	0	0	0	-2
Total	*0*	*0*	*8*	*0*	*-8*	*637*	*640*	*149*	*-3*	*-149*

S= surplus, EX= export, IM= import, IN= international, IP= interprovincial

	Palm Oil					Coconut Oil				
		EX		IM			EX		IM	
	S	**IN**	**IP**	**IN**	**IP**	**S**	**IN**	**IP**	**IN**	**IP**
		1000 ton					*1000 ton*			
Nanggroe Aceh D.	335	257	46	0	0	16	14	1	0	0
Sumatera Utara	2302	1768	313	0	0	16	14	1	0	0
Sumatera Barat	402	308	55	0	0	13	11	1	0	0
R i a u	2102	1614	286	0	0	126	106	5	0	0
J a m b i	607	466	83	0	0	28	24	1	0	0
Sumatera Selatan	748	574	102	0	0	0	0	0	0	0
Bengkulu	88	68	12	0	0	0	0	0	0	0
Lampung	103	79	14	0	0	27	23	1	0	0
Bangka Belitung	97	75	13	0	0	1	1	0	0	0
D.K.I. Jakarta	-69	0	0	-2	-67	-10	0	0	1	9
Jawa Barat	-280	0	0	-8	-272	-16	0	0	1	15
Jawa Tengah	-256	0	0	-7	-249	18	15	1	0	0
D.I. Yogyakarta	-26	0	0	-1	-25	8	7	0	0	0
Jawa Timur	-285	0	0	-8	-277	24	20	1	0	0
Banten	-43	0	0	-1	-42	5	4	0	0	0
B a l i	-26	0	0	-1	-25	15	13	1	0	0
Nusa Tenggara Barat	-33	0	0	-1	-32	8	6	0	0	0
Nusa Tenggara Timur	-32	0	0	-1	-31	10	9	0	0	0
Kalimantan Barat	494	380	67	0	0	9	8	0	0	0
Kalimantan Tengah	198	152	29	0	0	12	10	0	0	0
Kalimantan Selatan	113	87	15	0	0	6	5	0	0	0
Kalimantan Timur	89	68	12	0	0	7	6	0	0	0
Sulawesi Utara	-16	0	0	0	-16	63	53	3	0	0
Sulawesi Tengah	39	30	5	0	0	45	38	2	0	0
Sulawesi Selatan	79	60	11	0	0	39	33	2	0	0
Sulawesi Tenggara	4	3	1	0	0	6	5	0	0	0
Gorontalo	-7	0	0	0	-7	14	12	1	0	0
Maluku	-10	0	0	0	-10	16	14	1	0	0
Maluku Utara	-18	48	8	0	0	1	36	2	0	0
Papua	62	0	0	-1	-18	43	1	0	0	0
Total	*6761*	*6037*	*1072*	*-31*	*-1070*	*551*	*485*	*24*	*2*	*24*

S= surplus, EX= export, IM= import, IN= international, IP= interprovincial

	Bananas					Coffee				
		EX		IM			EX		IM	
	S	IN	IP	IN	IP	S	IN	IP	IN	IP
	1000 ton					*1000 ton*				
Nanggroe Aceh D.	-41	0	0	0	41	38	28	10	0	0
Sumatera Utara	-154	0	0	1	153	26	19	7	0	0
Sumatera Barat	-41	0	0	0	41	14	10	4	0	0
R i a u	-61	0	0	0	61	-5	0	0	0	5
J a m b i	-33	0	0	0	32	2	1	0	0	0
Sumatera Selatan	-65	0	0	0	64	132	97	35	0	0
Bengkulu	-19	0	0	0	18	59	43	16	0	0
Lampung	19	0	18	0	0	112	83	30	0	0
Bangka Belitung	-13	0	0	0	13	-1	0	0	0	1
D.K.I. Jakarta	-151	0	0	1	150	-13	0	0	1	11
Jawa Barat	319	6	313	0	0	-48	0	0	4	44
Jawa Tengah	-212	0	0	1	211	-32	0	0	3	29
D.I. Yogyakarta	-27	0	0	0	27	-4	0	0	0	4
Jawa Timur	-93	0	0	1	93	-7	0	0	1	7
Banten	0	0	0	0	0	-10	0	0	1	9
B a l i	10	0	10	0	0	15	11	4	0	0
Nusa Tenggara Barat	12	0	12	0	0	-2	0	0	0	1
Nusa Tenggara Timur	29	1	29	0	0	9	7	2	0	0
Kalimantan Barat	-17	0	0	0	17	-1	0	0	0	1
Kalimantan Tengah	-22	0	0	0	22	-1	0	0	0	1
Kalimantan Selatan	-24	0	0	0	24	-2	0	0	0	2
Kalimantan Timur	-17	0	0	0	17	2	2	1	0	0
Sulawesi Utara	-16	0	0	0	15	1	1	0	0	0
Sulawesi Tengah	-10	0	0	0	10	3	2	1	0	0
Sulawesi Selatan	-52	0	0	0	51	31	23	8	0	0
Sulawesi Tenggara	-10	0	0	0	10	1	1	0	0	0
Gorontalo	-13	0	0	0	13	-1	0	0	0	1
Maluku	-20	0	0	0	19	-1	0	0	0	1
Maluku Utara	711	0	23	0	0	0	0	0	0	0
Papua	23	13	698	0	0	0	0	0	0	0
Total	*15*	*21*	*1102*	*6*	*1102*	*316*	*328*	*118*	*11*	*118*

S= surplus, EX= export, IM= import, IN= international, IP= interprovincial

	Cocoa				
		EX		IM	
	S	IN	IP	IN	IP
	1000 ton				
Nanggroe Aceh D.	8	8	0	0	0
Sumatera Utara	34	35	-1	0	0
Sumatera Barat	4	4	0	0	0
R i a u	0	0	0	0	0
J a m b i	0	0	0	0	0
Sumatera Selatan	-2	0	0	3	-1
Bengkulu	1	1	0	0	0
Lampung	6	7	0	0	0
Bangka Belitung	0	0	0	0	0
D.K.I. Jakarta	-2	0	0	3	-1
Jawa Barat	-7	0	0	10	-3
Jawa Tengah	-8	0	0	11	-3
D.I. Yogyakarta	-1	0	0	1	0
Jawa Timur	2	2	0	0	0
Banten	-2	0	0	2	-1
B a l i	3	3	0	0	0
Nusa Tenggara Barat	0	0	0	0	0
Nusa Tenggara Timur	4	4	0	0	0
Kalimantan Barat	0	0	0	0	0
Kalimantan Tengah	-1	0	0	1	0
Kalimantan Selatan	-1	0	0	1	0
Kalimantan Timur	14	14	0	0	0
Sulawesi Utara	1	1	0	0	0
Sulawesi Tengah	57	57	-1	0	0
Sulawesi Selatan	172	173	-4	0	0
Sulawesi Tenggara	67	67	-2	0	0
Gorontalo	1	1	0	0	0
Maluku	3	3	0	0	0
Maluku Utara	11	9	0	0	0
Papua	9	11	0	0	0
Total	*373*	*401*	*-9*	*33*	*-9*

S= surplus, EX= export, IM= import, IN= international, IP= interprovincial

Appendix XIII Virtual water flow between provinces in million m^3

Importing province	Exporting province	Nanggroe Aceh D.	Sumatera Utara	Sumatera Barat	R i a u	J a m b i	Sumatera Selatan	Bengkulu	Lampung	Bangka Belitung	D.K.I. Jakarta	Jawa Barat	Jawa Tengah	D.I. Yogyakarta	Jawa Timur	Banten	B a l i	Nusa Tenggara Barat	Nusa Tenggara Timur
Sumatra	Nanggroe Aceh D.		21	0	0	1	2	0	131	1	0	0	1	0	2	0	1	0	3
	Sumatera Utara	4		0	0	3	10	0	115	3	0	1	7	7	6	0	4	12	3
	Sumatera Barat	1	22		0	0	1	0	126	0	0	0	3	2	4	0	1	4	3
	R i a u	391	420	599		1	161	20	458	0	0	0	5	5	7	0	2	8	4
	J a m b i	24	38	37	0		8	0	96	0	0	0	2	2	3	0	1	4	2
	Sumatera Selatan	21	51	15	161	33		0	210	0	0	0	6	6	9	0	2	10	5
	Bengkulu	9	9	12	29	6	2		22	0	0	0	0	0	0	0	0	1	1
	Lampung	3	0	0	0	1	2	0		0	0	0	4	4	4	0	1	7	0
	Bangka Belitung	100	106	153	2	1	41	5	104		0	0	1	1	1	0	0	2	1
Jawa	D.K.I. Jakarta	234	252	320	276	65	161	48	175	4		534	786	85	485	2	27	10	25
	Jawa Barat	203	284	149	844	205	408	186	198	16	0		343	161	892	3	77	25	70
	Jawa Tengah	118	224	90	401	108	292	128	108	14	0	84		8	0	0	29	5	25
	D.I. Yogyakarta	24	34	26	30	9	40	16	20	1	0	41	39		8	0	3	0	2
	Jawa Timur	71	219	74	408	106	147	51	42	16	0	37	0	4		0	12	4	11
	Banten	72	86	87	74	21	92	37	60	2	0	116	273	54	321		8	1	7
Nusa Tenggara	B a l i	4	19	6	30	8	9	2	1	1	0	0	0	0	0	0		2	64
	Nusa Tenggara Barat	6	24	7	39	10	12	3	2	2	0	0	0	0	0	0	21		209
	Nusa Tenggara Timur	17	35	25	38	10	15	3	9	2	0	0	0	0	0	0	13	869	
Kalimantan	Kalimantan Barat	3	1	1	0	0	8	4	22	0	0	0	10	5	28	0	2	6	32
	Kalimantan Tengah	2	1	1	0	0	5	3	9	0	0	0	5	2	16	0	1	2	19
	Kalimantan Selatan	4	2	2	0	1	14	7	29	0	0	0	5	1	19	0	2	1	27
	Kalimantan Timur	0	0	0	0	0	0	0	16	0	0	0	7	3	21	0	1	3	25
Sulawesi	Sulawesi Utara	1	3	1	5	1	2	0	21	0	0	0	0	0	0	0	0	1	5
	Sulawesi Tengah	0	0	0	0	0	0	0	20	0	0	8	11	3	0	2	0	1	4
	Sulawesi Selatan	0	0	0	0	0	0	0	6	0	0	23	32	8	0	7	1	2	3
	Sulawesi Tenggara	0	0	0	0	0	0	0	0	0	0	9	12	3	0	3	0	1	0
	Gorontalo	0	1	0	2	1	1	0	10	0	0	0	0	0	0	0	0	0	2
Maluku	Maluku	39	39	60	1	1	20	4	28	0	0	0	3	1	9	0	1	0	10
	Maluku Utara	19	19	30	0	0	9	1	13	0	0	1	4	1	7	0	0	1	7
Papua	Papua	70	80	108	33	8	28	2	70	1	0	1	8	3	20	0	1	3	27
	Total	*1441*	*1994*	*1801*	*2374*	*599*	*1487*	*519*	*2123*	*66*	*0*	*857*	*1567*	*369*	*1862*	*18*	*210*	*985*	*596*

Importing province	Exporting province	Kalimantan Barat	Kalimantan Tengah	Kalimantan Selatan	Kalimantan Timur	Sulawesi Utara	Sulawesi Tengah	Sulawesi Selatan	Sulawesi Tenggara	Gorontalo	Maluku	Maluku Utara	Papua	**Total**
Sumatra	Nanggroe Aceh D.	0	0	0	0	1	0	3	0	1	0	0	117	*284*
	Sumatera Utara	0	0	0	0	0	0	6	0	0	0	0	440	*622*
	Sumatera Barat	0	0	0	0	1	0	5	0	1	0	0	117	*292*
	R i a u	0	0	0	0	2	0	9	1	1	0	0	174	*2266*
	J a m b i	0	0	0	0	1	0	4	0	0	0	0	94	*315*
	Sumatera Selatan	0	0	0	0	2	0	11	1	1	0	0	185	*730*
	Bengkulu	0	0	0	0	0	0	0	0	0	0	0	53	*146*
	Lampung	0	0	0	0	0	0	4	0	0	0	0	0	*31*
	Bangka Belitung	0	0	0	0	0	0	2	0	0	0	0	38	*558*
Jawa	D.K.I. Jakarta	43	39	342	19	109	144	1585	11	16	29	59	158	*6043*
	Jawa Barat	143	129	46	62	291	143	230	30	42	78	157	2	*5417*
	Jawa Tengah	91	82	28	34	59	30	86	8	8	15	31	221	*2328*
	D.I. Yogyakarta	8	7	23	3	0	6	103	0	0	0	0	28	*475*
	Jawa Timur	98	87	30	35	42	21	34	4	6	11	23	98	*1690*
	Banten	16	14	85	6	14	29	393	2	2	4	7	0	*1884*
Nusa Tenggara	B a l i	8	7	3	3	0	0	0	0	0	0	0	0	*169*
	Nusa Tenggara Barat	10	9	3	4	0	0	0	0	0	0	0	0	*359*
	Nusa Tenggara Timur	10	9	25	4	0	6	99	0	0	0	0	0	*1189*
Kalimantan	Kalimantan Barat		0	130	6	15	0	48	2	9	4	2	50	*390*
	Kalimantan Tengah	0		153	4	9	0	28	1	5	1	1	67	*336*
	Kalimantan Selatan	0	0		10	12	0	37	1	7	5	2	71	*257*
	Kalimantan Timur	0	14	482		12	0	35	1	7	3	1	51	*685*
Sulawesi	Sulawesi Utara	1	1	0	0		31	252	6	0	4	2	46	*386*
	Sulawesi Tengah	0	1	1	0	10		35	6	6	4	2	29	*143*
	Sulawesi Selatan	0	3	2	0	0	0		2	0	1	1	155	*246*
	Sulawesi Tenggara	0	1	1	0	0	19	310		0	0	0	29	*387*
	Gorontalo	1	1	0	0	1	14	129	3		2	1	39	*208*
Maluku	Maluku	0	0	70	0	5	19	337	1	3		14	0	*667*
	Maluku Utara	0	0	35	0	4	10	172	0	2	0		0	*336*
Papua	Papua	7	6	125	3	18	37	602	2	8	7	5		*1283*
	Total	*438*	*413*	*1585*	*193*	*606*	*508*	*4559*	*83*	*125*	*170*	*308*	*2266*	

Appendix XIV Water footprint of provinces

	Domestic	Interprovincial	International	Total water use
		million m^3		
Nanggroe Aceh D.	4701	284	16	5001
Sumatera Utara	14062	622	247	14930
Sumatera Barat	4602	292	100	4995
R i a u	3262	2266	399	5927
J a m b i	3087	315	84	3486
Sumatera Selatan	8133	730	217	9080
Bengkulu	2496	146	32	2674
Lampung	7813	31	130	7974
Bangka Belitung	317	558	98	973
D.K.I. Jakarta	39	6043	972	7054
Jawa Barat	24484	5417	1036	30937
Jawa Tengah	31689	2328	522	34538
D.I. Yogyakarta	2804	475	60	3338
Jawa Timur	29467	1690	97	31254
Banten	6379	1884	416	8678
B a l i	2812	169	46	3027
Nusa Tenggara Barat	4590	359	23	4972
Nusa Tenggara Timur	3397	1189	235	4821
Kalimantan Barat	6560	390	123	7073
Kalimantan Tengah	2856	336	77	3269
Kalimantan Selatan	3764	257	72	4093
Kalimantan Timur	2651	685	127	3462
Sulawesi Utara	1996	386	77	2459
Sulawesi Tengah	2954	143	50	3147
Sulawesi Selatan	9660	246	108	10014
Sulawesi Tenggara	1927	387	79	2394
Gorontalo	758	208	33	1000
Maluku	442	667	109	1219
Maluku Utara	624	336	61	1020
Papua Barat	846	1283	198	2327
Indonesia	*189172*	*30123*	*5843*	*225138*