Virtual water

What is virtual water

- The water consumed in the production process of an agricultural or industrial product has been called the 'virtual water' contained in the product (Allan, 1998).
- If one country exports a water intensive product to another country, it exports water in virtual form.
  - For example, to produce one kilogram of wheat we need about 1000 litres of water. For meat we need about five to ten times as much!
  - If every human being adopted a Western-style diet, some 75 percent more water would be needed for food production! (Zimmer and Renault, 2003)

Virtual water has not attracted much research so far.

- (i) what volumes of water are involved;
- (ii) whether they represent a significant part of the blue or of the green water;
- (iii) the countries exporting and importing most of the virtual water;
- (iv) the products responsible for the most important transfers;
- (v) trends and developments on the virtual water market and
- (vi) the impacts of possible virtual water trade actions.

The origin of the concept of Virtual Water

- The concept of Virtual Water was coined in London in about late 1994 some years after finding that the term 'embedded water' did not have much impact. The idea is derived from Israeli analysis by Gideon Fishelson et al in the late 1980s which pointed out that exporting Israeli water in water intensive crops did not make much sense.

- **Virtual water content for selected products** [m3/ton]
- (Zimmer D.,and D. Renault 2003)
- Wheat 1,160
- Rice 1,400
- Soybean 2,750
- Beef 13,500
- Pork 4,600
- Poultry 4,100
- Eggs 2,700
- Milk 790

Products	Specific Water Demand (m3/T)
Cottonseed	1145
Coconut oil	5500
Palm oil	5500
Palmkernel oil	5500
Sesame seed oil	5500
Groundnut oil	8713
Sunflower seed oil	7550
Rape and Mustard oil	3500
Soybean oil	5405
Cottonseed oil	5500
Olive oil	11350
Bovine, mutton, goat meat	13500
Pig meat	4600[2]
Poultry meat	4100
Other meat	13500
Eggs	2700
Milk	790
Butter + Fat	18000
Sugar	1929
Sweeteners	2731

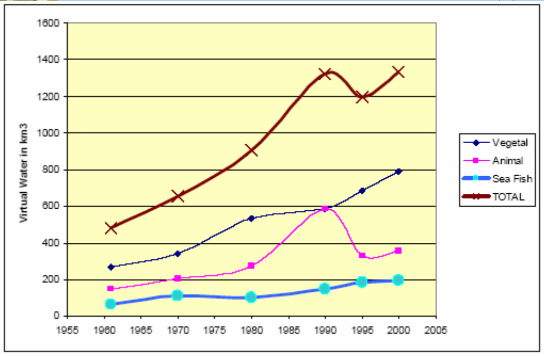
The principle of calculation of water productivity is rather simple: crop water requirements ETa (m^3/ha) are calculated from the climatic demand (ET) adjusted with crop coefficients. Software like CROPWAT (FAO,1992) can be used for this purpose. Water productivity is then obtained by dividing the crop yield Y (kg/ha) by these crop water requirements. Virtual water value, the inverse of water productivity is then given by the following equation:

$$VWV = \frac{ETa}{Y} \quad (1)$$

in km^3

Table A3. Water consumed for crop production and virtual water traded year 1999, assuming an annual increase of 1% in water productivity. Valu

Country	Water for crop production	Virtual Water imported	Virtual water exported	Net virtual water balance
Argentina	114	3	69	-66
Australia	64	3	85	-82
Brazil	251	19	75	-57
Canada	93	19	62	-43
China	624	75	19	56
Colombia	23	8	4	4
Egypt	32	22	1	21
Ethiopia	11	1	0.04	1
France	103	43	91	-48
Germany	75	64	63	1
India	423	31	8	23
Indonesia	422	36	8	27
Mexico	47	54	5	49
Nigeria	47	8	0.3	7
Pakistan	56	15	4	11
Russian Federation	93	49	4	45
UK	35	43	22	21
USA	502	65	234	-169



gure 8. Virtual water in food trade between countries since 1961 considering an increase of water productivity of 1% per year.

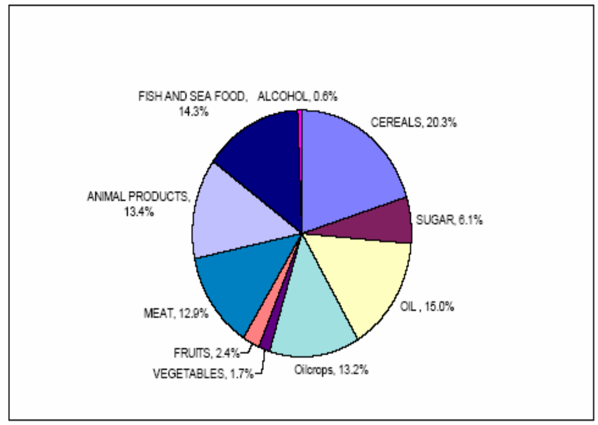


Figure 6. Global virtual water food trade in 2000 (1 340 km3).

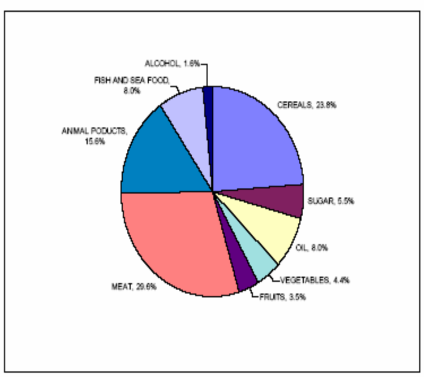
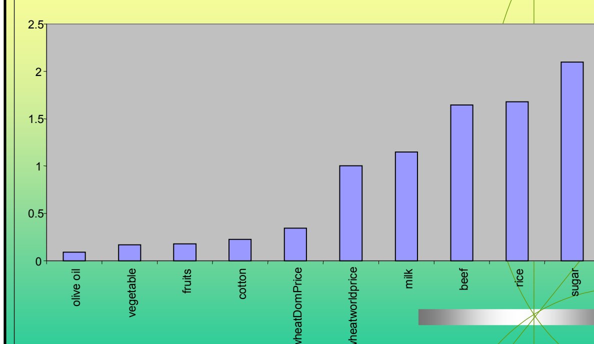


Figure 3. Distribution of global water embedded in food products in 2000 (5 200 Km3).

Relative Cost of Water Transformation, adjusting water use by product prices in world markets (index wheat at world prices=1.0)



Virtual water content of diets [m3/person/day]

• Diet 0 (reference USA)	5.4
• Diet 1 25% reduction animal product	4.6
• Diet 2 poultry replaces 50% beef	4.8
• Diet 3 vegetal products replaces 50% red meat	4.4
• Diet 4 50% reduction of animal products	3.4
• Diet 5 vegetarian	2.6
• Diet 6 Survival	1.0

The significance of virtual water trade

- The estimates on present annual Virtual Water Trade range from 1,040 – 1,340 km3 depending on the perspective taken as water saver/importer or producer/exporter (Hoekstra ed., 2003).
- The total annual freshwater withdrawals (blue water) amount some 3.800 km3
  - 2000 km3 are for agriculture
  - 1.750 km3 for consumption (Cosgrove and Rijsberman, 2000).
- This means that an amount of 50-70% of the total consumed blue water is traded.

  (This does not include green water)

- Trade in cereals and other crops amount to some 60% - 67%,
- animal products 23%– 26% and others 10-14%
- Jordan is for 80-90 % dependent on virtual water imports.
- Net export of virtual water from the USA amounts to one third of the total water withdrawal in the country.

Environmental impacts of virtual water

- Many experts are concerned that by exporting rice means , exporting a lot of virtual water, they had rather this water be put to more productive uses, such as industrial production.
- However, in practice, in humid monsoon countries, most rice is produced in the rainy season, where one has rather too much water than not enough. Reducing rice areas would lead to more flood damages

Employment - poverty

- Making water available for different purposes by reducing local food production and Importing virtual water through food imports may result in loss of employment in agriculture and the quality of livelihoods.

- One of the consequence of application of the virtual water trade concept could be that more profitable, economic crops will get higher levels of water security at the cost of high water consuming-low price crops.
- For example the cultivation of sugar cane: this needs huge quantities of water, and even in places where there is rainfall for only 3 months of the year.
- The well-off farmers who usually have the political and financial clout to divert the water resources to their fields prefer sugar cultivation.
- This may lead to a very inequitable situation for water sharing - the sugar cane producers get relatively more, and the poor subsistence farmers are left to fend for themselves.

Food security

- Food security is the capability of a nation to provide access to everyone in the country to adequate, nutritious and safe food now and in the future.
  - This can be achieved by striving for food self-sufficiency where all food is grown domestically or a combination of domestic production and food imports. Especially the more populous countries like China, India and Indonesia would like to be self-sufficient in food.
- Countries depending on food imports as part of their food security strategy are concerned about the access to this market and the generation of exchange to pay for the imports.
- Safety of foods

- Many poor countries lack the necessary financial ability to either develop irrigated agriculture or purchase food from the international market, improving food security in these countries lies largely in rainfed agriculture.
  - Therefore, greater efforts should be devoted to the development of rainfed agriculture and the overall rural economy.

Virtual Water –Policy decisions

- Can we import instead of creating infrastructure like irrigation etc?
- How reliable are global producers, the international food market and the access to this market? What are the risks food importing countries take related to dependence on producing and exporting countries? How can these risks be minimised?
- To what extend is food security through local production at the cost of the environment justifiable?
- What are the food safety risks as an importer especially looking at the use of agro-chemicals and genetically modified crop varieties?

Investments in infrastructure or VW imports

- Virtual water trade between or within nations can be seen as an alternative to inter-basin water transfers especially when land is not a limiting factor for food production.
- This is for instance very relevant for China and India, where major real water transfer schemes (from the south to the north of China) are being considered. Also in the Southern African region, virtual water trade is a realistic, sustainable and more environmentally friendly alternative to real water transfer schemes

The methodology needs to be further developed in the following areas:

- Validity of computations and data – the methodology on computations of virtual water content need to be standardised regarding what is and is not included:
  - only real water consumed, with transpiration only or with evapotranspiration? And what standard parameters/formulas are used?
- Water used in the production process: irrigation supplies and irrigation inefficiencies?
- Inclusion of loss of water due to quality degradation

- the geographic location of the so called Virtual Water the location of production - in the exporting country:
- Calculating all crop VW contents based on evapotranspiration in production countries and, then `globalized' to derive VW trade movements. This approach creates enormous bias because it does not incorporate irrigation intensity and cropping intensity.
- the location of consumption – in the importing country also named "shadow water" being the indigenous water resources that are needed to produce the imported commodities.

- The inclusion of soil moisture (green water) as an integral component of the virtual water balance as that is responsible for the support of rain-fed agriculture and of natural pastures be counted as a component of the available water stock.
- the methodology used for indirect inclusion of virtual water in meat and derivatives of animal products in particular related to grazing animals (green water) and household backyard pigs which are fed mainly with leftovers rubbish (vegetables and others) from the household.

- The differentiation between irrigated and rainfed agriculture green and blue water for which there is alternative use or not.
- Just taking the rainfed cereals such as wheat out of the computation may result in a totally different VW export balance and the net flows may lead to more insightful policy recommendations

Indicators

- The virtual water content of a product tells something about the environmental impact of consuming this product
- The sum of national water use and net virtual water import is defined as the ‘water footprint’ of a country. The water footprint can be a strong tool to show people their impact on the natural resources. Awareness of one’s individual water footprint would stimulate a more careful use of water.

- Such footprint could be differentiated into a "blue water foot print" which can be used for short and long term water resources planning and allocation,
- Green water footprint which is to be included for long term land-use aspects of water resource planning and management.

Other indicators

- water scarcity or water stress
- the need to provide for environmental flows through water availability per unit of exported product
- water storage capacity per unit of exported product
- the percentage of agricultural unemployment to total unemployment,
- the extend to which an economy is diversified,
- relationship between implementing authority and the farming sector and/or rural dwellers,
- the current percentage of food requirements produced domestically,
- the degree to which the implementing authority encourages/discourages stakeholder representation.

Example Dairy

What is a typical daily water requirement for range livestock?

- Size and type of animal
- Physiological state (pregnant, lactating, growing) - lactating cows require about an extra 0.86 kg of water for every kg of milk produced, and water intake during the latter stages of pregnancy can be 30-50% higher than normal

- Activity level –
  - more active animals consume more water
- Type and amount of diet –
  - animals fed on dry feed will require more voluntary water than those fed on silage or lush grass
- Weather conditions –
  - water consumption increases as air temperature increases
- Water quality –
  - more palatable water or greater total salt intake will result in increased water consumption
- Ease of access –
  - animals will consume less water if they have to travel further to the source, or if access to the source is awkward and uncomfortable.

Type of Livestock	Winter		Summer	
	Imp. Gal./day	L/day	Imp. Gal./day	L/day
Milking Cows	17	77	21	95
Cow-calf Pairs	11	50	15	68
Dry Cows	8	36	12	55
Calves	5	23	8	36
Growing Cattle (400-800 lb. or 180-360 kg.)	5-8	23-36	8-12	36-55
Finishing Cattle (600-1200 lb. or 270-540 kg.)	12	55	19	86
Bulls	8	36	12	55
Horses	8	36	12	55
Sheep	0.8	3.6	3	14

Source - The Stockman's Guide to Range Livestock Watering From Surface Water Sources

Gujarat Example

Water use in Milk production and milk water productivity (Per day/animal)

Details	South and central Gujarat		Saurashtra region		North Gujarat	
Water consumed	Buf	CB cow	Buf	CB cow	Buf	CB cow
green fodder(cum)	2.01	1.76	2.67	2.62	7.41	7.52
Dry fodder(cum)	1.45	1.52	0.84	0.86	1.65	1.51
Concentrate(cum)	2.51	2.2	4.22	5.31	2.7	2.54
Drinking water(cum)	0.04	0.03	0.04	0.03	0.05	0.05
Total water used(cum)	6.01	5.51	7.77	8.82	11.81	11.62
Milk production (LPD)	1.87	2.9	3.82	5.14	2.56	3.95
Water productivity (LM/cum)	0.31	0.53	0.49	0.58	0.22	0.34
Water used for liter milk production(liters)	3213.90	1900.00	2034.03	1715.95	4613.28	2941.77