Synthesis
WWC Publication No. 2

E-Conference Synthesis:

Virtual Water Trade - Conscious Choices

March 2004



Edited by the World Water Council

World Water Council
4th World Water Forum

Dialogue
on Water, Food and Environment

ISBN: 92-95017-10-2

To order: wwc@worldwatercouncil.org

This report can be cited as follows:

World Water Council. 2004. E-Conference Synthesis: Virtual Water Trade - Conscious Choices, March 2004.

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This E-conference is a contribution of the World Water Council to the Dialogue on Water, Food and Environment.

World Water Council
4th World Water Forum

Foreword

The World Water Council is engaged in stimulating debate and research on the implications of using virtual water trade as a strategic instrument in water policy. The session on Virtual Water – Trade and Geopolitics on March 17th, 2003,during the 3rd World Water Forum, was the first major activity and attracted much attention from many different groups of society. However, the limited time available did not allow for extensive debate on the many issues and impacts of virtual water trade that were brought up during the session. The World Water Council considered the issues of such relevance that it committed itself to organise an e-mail conference to continue the unfinished discussions started during the forum, and to enhance the understanding of different viewpoints on the potential and impacts of virtual water trade.

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. I decided to avoid putting a lot of effort into developing a quantified version of the concept. I had learned that an equivalent effort to quantify the energy content of commodities in the oil-shocked world of the 1970s ended in confusion. On the assumption that the oil/energy analysis would be based on tougher data than could ever be devised for water and agriculture as well as on the work of a much bigger community of better funded economists I left the concept as a metaphor, albeit a powerful metaphor.

Tony Allen, 2003

Over 300 persons subscribed to the virtual water e-conference, which was held from September to November 2003 and almost one hundred comments were received from some 60 persons who participated actively in the debate and posted on the website.

The E-conference was organised along four questions and for each of the questions a discussion note was prepared. The conference questions were:

> **Question1**: Does Virtual Water Trade contribute in the improvement of water availability and by that to local food security, livelihoods, environment and local economy and in which conditions should virtual water trade be encouraged?
>
> **Question 2**: Does virtual water contribute to conflict resolution or will it increase tensions and conflict potentials for those countries relying on trade and what Governance structures would be necessary to enable a fair virtual water trade?
>
> **Question 3**: How can the concepts of virtual water and water footprints help in creating awareness on water consumption and saving water by modification of diets?
>
> **Question 4**: What is required from whom to progress on the appropriate and fair introduction and use of the virtual water concept?

A synthesis of the results of the inputs and debates in the e-conference along the lines of the four conference questions was presented to all participants for comments. Their comments have been incorporated in this final report of the E-conference on Virtual Water Trade and Geo-Politics.

Acknowledgements

The World Water Council would like to express its gratitude to all who have contributed to the preparation, implementation and synthesis of the E-conference. First of all to the staff of the WWC Headquarters Marie LAGIER and Stephanie PORRO who prepared and managed the e-communications; Arjen HOEKSTRA of UNESCO-IHE who prepared one of the discussion notes; Tony ALLAN, Ramon LLAMAS, Domitille VALLEE for their review and comments on the final synthesis report and of course the active participation of Mohamed Nasr ALLAM, Cairo University, Egypt; Tony ALLAN, SOAS, United Kingdom; David BARKIN, Universidad Autonoma Metropolitana-Xochimilco, Mexico; Bhavanishankar BENKIPUR, SAHAYOGA, India; Ashok K. CHAPAGAIN, UNESCO-IHE, The Netherlands; Enrique CHAVES, National Water Agency, Brazil ; Edna CHUKWURA, Nnamdi Azikiwe University, Nigeria ; Katherine CINQ-MARS, McGill University, Canada; Cor DIETVORST, IRC International Water and Sanitation Centre, The Netherlands; Thierry FACON, FAO - Regional Office for Asia and the Pacific, Thailand ; Debi GOENKA, Bombay Environmental Action Group, India; Munther HADDADIN, University of Oklahoma and Oregon State University Former Minister of Water and irrigation, Jordan; David HAMLET, Queensland Government, Australia; Don HEAD, USA; Sarah HENDRY, University of Abertay Dundee, United Kingdom; Theodore HERMAN, World Bank - Indonesia's current water resources & irrigation reform program, Israel; Arjen HOEKSTRA, UNESCO-IHE Institute for Water Education, The Netherlands; Chris HOSKINS, Georgia State College and University, USA; Vijay K. LABHSETWAR, International Commission on Irrigation and Drainage, India; Junguo LIU, Swiss Federal Institute for Environmental Science and Technology, Switzerland; Ramon LLAMAS, Spain's Royal Academy of Sciences, Complutense University, Madrid, Spain; Olga LUCIANO, Ministry of the Environment, Dominican Republic ; Janot-Reine MENDLER, Centre for Developing Areas Research, Dept. of Geography, Royal Holloway, University of London, United Kingdom; Gareth MORGAN, Environmental Change Institute, Oxford, United Kingdom ; Leo MUKARO, Leadership For Environment And Sustainable Development (LEAD), Zimbabwe; Yves NARDINI, Switzerland; Kallirroi NICOLIS, Social Aid of Hellas, Greece; Onur ÖKTEM, Hacettepe University of Ankara, Turkey; Salvador PENICHE, University of Guadalajara - Economics Department, Mexico, Usha P. RAGHUPATHI, National Institute of Urban Affairs, New Delhi, India; Daniel RENAULT, FAO - Land and Water Development Division, Italy; Claudia RINGLER, International Food Policy Research Institute , USA; Sahana SINGH, Asian Water, Singapore; Andrew SPEERS, International Water Association, United Kingdom; Dev TEWARI, University of Natal - Division of Economics, South Africa; Khalil Tian SHAHYD, Tuskegee University - Agricultural and Resource Economics, USA; Frank VAN BERKOM, International Institute for Land Reclamation and Improvement, Alterra, The Netherlands ; Batir WARDAM, World Conservation Union (IUCN) - West Asia North Africa Water Programme, Jordan; Budi WIGNYOSUKARTO, Gadjah Mada University Yogyakarta - Department of Civil Engineering, Indonesia; Hong YANG, Swiss Federal Institute for Environmental Science and Technology , Switzerland and all the other persons that subscribed to this conference.

Marseille, April 22, 2004

Paul van Hofwegen

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1 The Concept

The principle of virtual water is really simple. Water is required for the production of food such as cereals, vegetables, meat and dairy products. The amount of water consumed in the production process of a product is called the 'virtual water' contained in the product (Allan, 1998). 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)

This explains why food production uses about 70 percent of the fresh water withdrawals and that diets and their evolution do have a great impact on water resources. Changing our diets could make much water available for other purposes. But virtual water is not only about diets. It is also about trade – virtual water is what really makes water a global issue.

1.1 The potential of the concept

Virtual water trade as such is not new; it is as old as there is exchange of food. With the trade of goods, especially food, there is a virtual flow of water from commodity exporting countries (food and manufactured goods) to the countries that import those commodities. Instead of producing these goods themselves, the importing country can utilise this water for other purposes that else would have been necessary for its production. A water-scarce country can import products that require a lot of water for their production rather than producing them domestically. This results in real water savings relieving the pressure on water resources.

Importing countries need not be water poor or water short to be receiver of this virtual flow. For example, bananas and citrus are imported by Canada - a water-rich country and down-streamer on the virtual flow of water that originates in Central America. In the global environment of world trade, virtually all countries are down-streamers of virtual flow of water, and a great many of them are up-streamers, even those of high water shortage like Jordan or Gaza of which both also export food commodities (citrus, vegetables). With virtual water trade optimisation of the use of water as a scarce commodity in terms of environmental, social and economic value becomes possible.

Reversibly, water-rich countries could profit from their abundance of water resources by producing water-intensive products for export. Virtual water trade between nations and even continents could thus ideally be used as an instrument to improve global water use efficiency, to achieve water security in water-poor regions of the world and to alleviate the constraints on environment by using best-suited production sites. (Turton, 2000)

Virtual water content for selected products

[m³/ton]

(Zimmer D., and D. Renault, 2003)

Beef	13 500
Pork	4 600
Poultry	4 100
Soybean	2 750
Eggs	2 700
Rice	1 400
Wheat	1 160
Milk	790

Virtual water content of diets

[m3/person/day]

(D. Renault, W.W. Wallender, 2000)

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

Allan (2003) depicts virtual water as a remedy to large water deficits associated with insufficient water for crop production (figure 1). In this conceptual diagram he explains the level of dependency (D) on fresh surface and groundwater (sometimes referred to as blue water) and soil water (sometimes referred to as green water) and the possibility to meet the deficits of small quantities by manufactured desalination processes or for large quantities by virtual water through imports of for example food crops.

A number of arid countries – such as Jordan and Israel - have consciously formulated policies to enable water saving by reducing export of water-intensive products, notably crops. The remaining virtual water export is largely related to crops that yield relatively high income per cubic metre of water consumed.

Hoekstra et al (2003) made a preliminary estimate of the flow of virtual water as a consequence of food trade. This indicates a major export from the Americas, South- East Asia and Oceania and major imports in North Africa, Western Europe, and Central and South Asia (figure 2). The scale of virtual water flows – the flows of water virtually embodied in food products – have been assessed at 700 –1100 km^3 /year. Possible liberalisation of trade might cause this flow to more than double. (Rodgers, 2003) A preliminary estimate of Oki et al (2003) indicates that presently on global level some 455 km^3 of water is saved annually due to virtual water trade[1].

[1] The debate on the quantification of virtual water content and flows is still ongoing. Various estimates have been made based on different assumptions (Oki 2002, Zimmer and Renault 2003, Rodgers 2003). There is general agreement that in order to make the concept practical, a unified procedure has to be developed

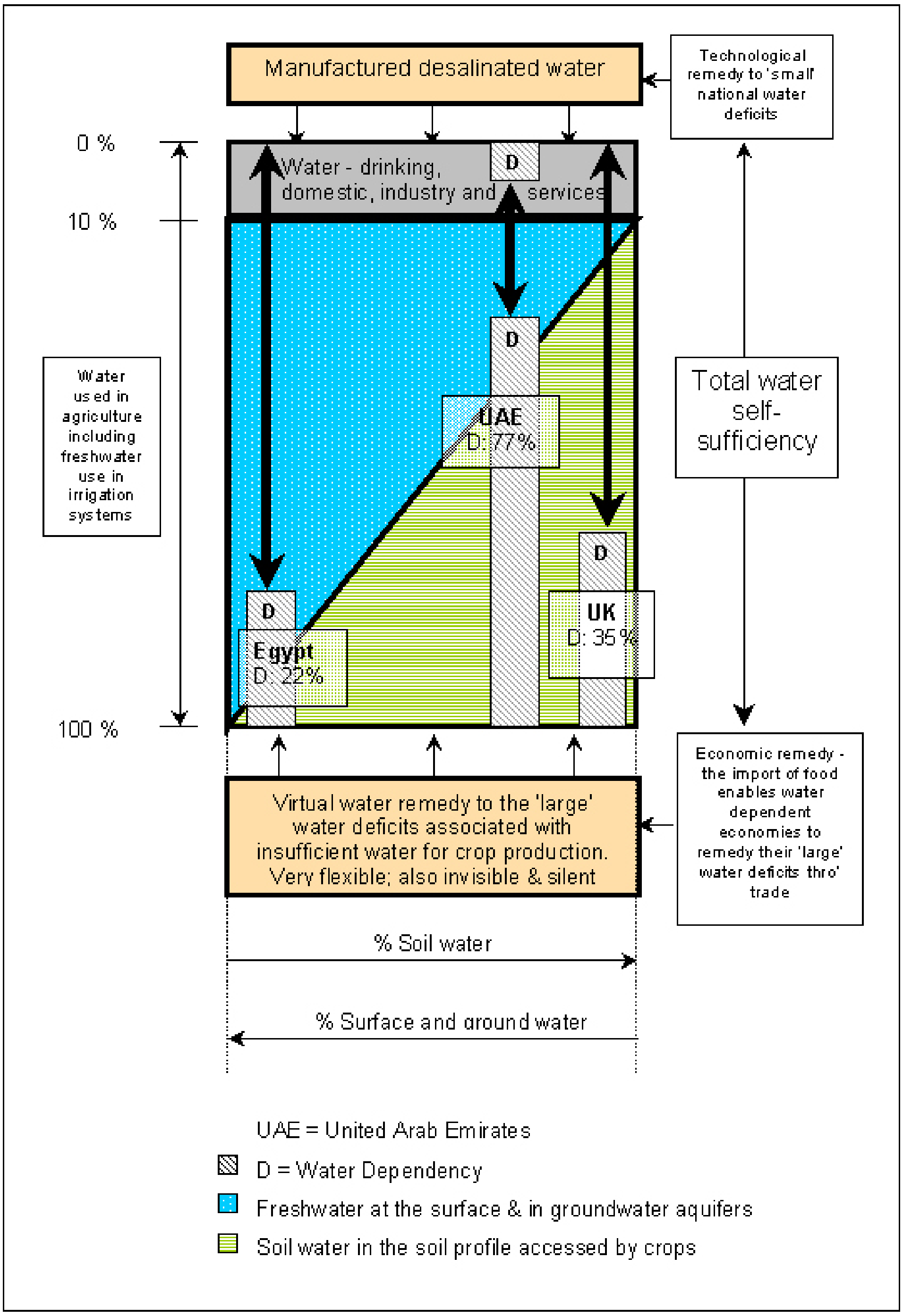

Figure 1. Showing (1) The extent of the water dependency (D) of different water deficit economies (Hoekstra & Hung 2002 p55-59); (2) How local water can come from freshwater sources and soil water sources; (3) How manufactured water and virtual water can remedy the water deficits. (Used with the permission of Tony Allan).

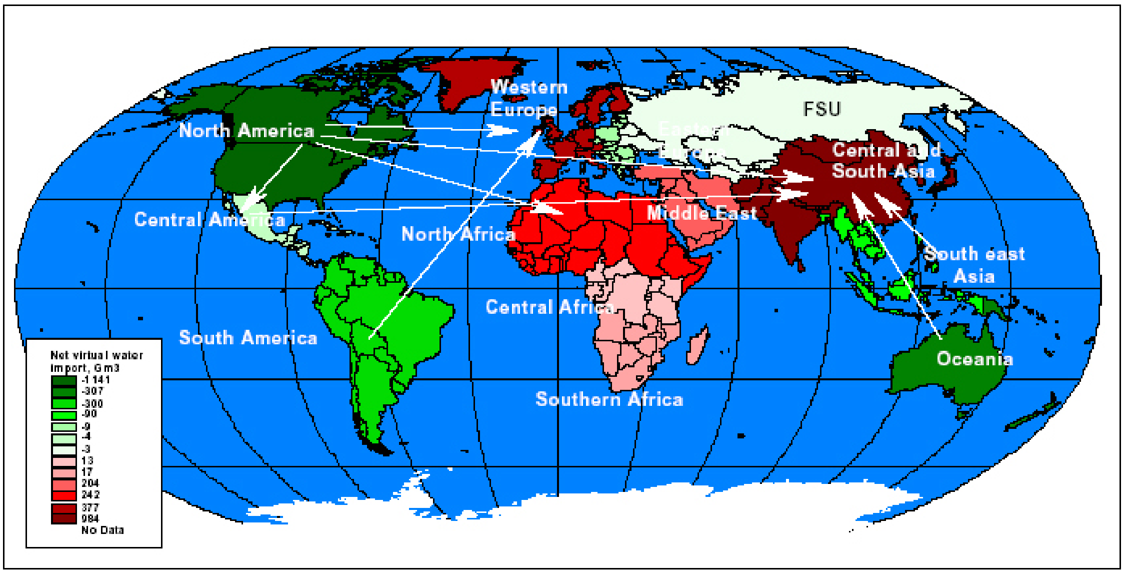

Figure 2. Major virtual water flows as a consequence of food trade for the period 1995-1999 - arrows show net volumes > 100 Gm^3. (Hoekstra et al, 2003)

1.2 Virtual Water Trade – applicability of the concept

The underlying foundation of trade is the notion of comparative advantages. The concept of virtual water import originated from empirical observations that food imports, especially cereal imports, have played a crucial role in compensating for the water deficit in water scarce countries. For these countries, the underlying motivation of importing food (virtual water) is hardly a pursuit of comparative advantage, but to fill the domestic shortfall of food supply and to maintain social stability. It is in these situations that the imperative rather than comparative advantage drives the virtual water trade import in these countries.

> *One can only speak of virtual water trade if conscious choices are made in water and environmental management policies whether or not to make water available or to release pressure on the domestic water resources by importing goods that else would have consumed much of the domestic water resources available.*

To make conscious choices, the elements of choice and the players involved in virtual water trade have to be made visible. Allan (2001) states that virtual water trade is so successful because it is invisible and is applied beyond the general political debate. However, invisibility may lead to postponement of necessary reforms by politicians as imports can be regarded as 'secret reserves' that might bail out in the short run (Warner, 2003).

The growing global interest and attention to the virtual water issue is at least partly because of its increasing importance for food security in many countries where water is becoming scarcer with the continuous expansion of population. The stake is heightened further by the fact that only a few countries are net cereal exporters in the world. A majority of countries are indeed net food importers. In addressing the policy relevance of virtual water trade, therefore, water scarcity-induced imperative of food imports must be given appropriate attention. Neglecting this point in the discussion on virtual water makes it of little relevance to policy makers in the countries where water scarcity is becoming a looming threat to their food security.

Virtual water trade can also be implemented beside the world market on local or river basin level. Poor water-scarce countries rely very much on the subsistence farming systems. In case of any drought or flood, food shortages occur which are replenished by imports (or food-aid), otherwise famines occur. For such countries the challenge is to stimulate and direct the investments in the agricultural sector to enable activities beyond subsistence farming – probably the only way out of poverty. This requires management of water resources where optimum economic returns can be pursued and markets can be physically accessed to generate the financial means for financing the purchase of food.

This is not necessarily the ‘world market’ but can be the local market or even a regional barter market not requiring foreign exchange.

The concept of virtual water is relevant to most of the developed, developing and least developed countries Local planning and regional collaboration incorporating the notion of virtual water trade could result in exchange of goods, diversification of crops, diet awareness creation or crop replacement actions for any country. For countries like India and China with low and low-middle GNP it is not the problem of affordability, but more the problem of priority and independency related to food security. This drives the efforts to invest enormous amounts of money into the development of infrastructure for growth in local food production what if looked from only an economic point of view would hardly be justifiable. The virtual water concept provides an alternative to such investments and if applied it can result in either incorporating food imports as part of the water and environmental policies or it can be rejected for geo-political reasons, local political interests or certain lobby groups defending present interests.

The significance of virtual water trade

The estimates on present annual Virtual Water Trade range from 1,040 – 1,340 km^3 depending on the perspective taken as water saver/importer or producer/exporter (Hoekstra ed., 2003). To put this in perspective, the total annual freshwater withdrawals (blue water) amount some 3,800 km^3 of which 2000 km^3 are consumed or for agriculture these values are respectively 2,500 km^3 for withdrawals and 1,750 km^3 for consumption (Cosgrove and Rijsberman, 2000). This means that an amount of 50-70% of the total consumed blue water is traded. However, a great amount of virtual water is green water. So, if we include the soil water (green water), then the virtual water trade amounts some 15% of the total water use on earth, including rain-fed agriculture.

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.

Beside the direct financial cost, other costs to be considered related to imports by water deficit countries to solve food deficiency are: (i) increased dependency on main exporting countries; (ii) if not able to compete or adapt, local agriculture may be damaged, because of importing food; (iii) the exporting country may start interfering in internal affairs of importing country; and (iv) imports may result in foreign reserve depletion if there is no export compensation of less water intensive or higher value commodities.

1.3 Water Footprint

The virtual water content of a product tells something about the environmental impact of consuming this product. Knowing the virtual water content of products creates awareness of the water volumes needed to produce the various goods, thus providing an idea of which goods impact most on the water system and where water savings best could be made. Hoekstra and Hung (2002) have introduced the concept of the *water footprint*. The total use of local water resources within a country is not the right measure of a nation’s actual appropriation of the global water resources. If there is ‘virtual water’ import into a country, this ‘virtual water’ volume should be added to the total water use of a country in order to get a picture of a nation’s real call on the global water resources. Similarly, export of ‘virtual water’ should be subtracted from the volume of the country’s water use. 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, and a “green water footprint”, which is to be included more involving more the long term land-use aspects of water resource planning and management.

These water footprints could also be focussed on basins, industries and individuals. Conscious people might vote for more environment friendly imports good and services. It would be interesting for a start to take a few countries where good data on trade is available, as case studies for the water footprint.

Each case study should be chosen on criteria such as dependence on imports or exports, availability of water resources, water resource management policies, food security problems, etc.

1.4 'Blue' and 'green' water and land use.

A differentiation of the origin of virtual water can be made in blue and green water. Blue water (groundwater, surface water) generally has many alternatives for its development and use because of the flexible access and its transportability. This is much less for green water (soil moisture in the unsaturated zone), which can only be taken up by local vegetation.

> *Whatever the origin, the virtual water discussion should focus on water for which there is an alternative use and water for which there is not*.

Where the alternative uses for blue water are obvious and manageable (domestic water supply-agriculture-industry-environment), the possibilities for alternative uses for green water are not always that obvious. However, also green water has alternative uses (rain-fed natural cover or any rain-fed cultivated crop). This requires changes in crops or land use and will usually not importantly change the water balance in quantitative sense but could make important differences in qualitative sense.

In many countries, pasture is not natural but the result of encroachment of population and farming systems on forest. The alternative for such pasture could be forest or plantation, which produces some other values - not necessarily food but conservation of bio-diversity, erosion control, or even commercial forest exploitation. There are cases though for which use there is no alternative, like a study made by FAO in Mauritania (Renault, this conference), showing that this arid country is exporting virtual water through the trade of goats, which are produced almost in a desert land taking advantage of little rain and small water streams on huge areas. Here there is apparently no alternative for this water use other than feeding goats.

Feedlots and growing alfalfa, lucerne and corn for dairy cattle is a virtual water issue. About 1/3 of the cereal production worldwide is for feed (684 millions tons out of 1900 millions produced). This represents about 3kg of grain per kg of meat. Land and water devoted to this feed production whether irrigated or not, have in many cases some alternatives for use that could be weighed in terms of plus and minus again cereals production. The alternative could be forestry, or environmental and/or recreational parks, etc.

The virtual water content of for example timber, coffee, tea, rubber, oil palm etc. comes from rain. The economic benefits for these regions up in the hills are very important. This cannot be considered as a waste of water given their value added (especially when processed) and foreign exchange contribution, not to mention economic support of many thousands of families. Unlike deforestation, the change of this forest land into plantations will not have much effect on the water balance of the region - no water will be saved for other purposes elsewhere – but more on the environmental and economic situation of the region. It must not be forgotten that in the absence of these cultivations, the regions would have been covered with natural forests having rich biodiversity

For almost all agricultural activities there are some agro-ecological alternatives or other land uses possible, and this must be considered particularly if there is an urgent local need of water or land, which cannot be satisfied. One cannot expect to have, for example, irrigated or rain-fed maize land being turned into timber production or just afforested unless income and farming systems adjustment solutions for the farming population on these lands are available. One of the major driving forces in this process will be rural income and farming systems. Many aspects have to be weighed locally when it comes to decide about land use looking at economical, social issues, environment and natural resources management. Decision-making will be about economic and financial gain the social factor, the role and rights of the local farmers against environmental protection and conservation of biodiversity and the role virtual water imports could play. This balancing of interests is exactly the heart of the virtual water trade discussion.

1.5 Regional context

Virtual water trade can improve the water availability and can be used to building a regional economical solidarity, and fuel the agriculture sector. The up-scaling effect from local to regional trade is very important to consider.

Low cost transport is often a key factor. Transport of real water is obviously facing some limitations, economical and physical. But the same is experienced for virtual water. The lack of transportation infrastructure in for example Southern Africa is an important constraint to virtual water trade, therefore what was theoretically possible in terms of virtual water transfer between the wet north and the dry south, did not materialize because of transportation cost. It is much cheaper to import cereals from anyplace of the world by sea than get it from the inland on trucks.

In South Africa it looks like there is a jump from local to global, without the intermediate step (regional) and that can be one of the adverse effects of virtual water trade on regional development and livelihoods.

1.6 Virtual Water Trade: Conscious Choices, Common Sense or both?

The Virtual Water concept is a tool that can help in developing alternatives in water, food and environmental policies. Inclusion of the possibility of virtual water trade, especially food imports, allows a wider spectrum of alternatives in water and environmental management policies.

The strength of the virtual water concept is that it embraces the whole water management in a country or basin and allows for a deeper understanding of water use through for example diet description or broader optimisation of water allocation between different water uses by incorporating access to external water resources through virtual water trade. This makes the concept a practical policy tool that can be extended to detailed analysis of water resources management, environmental policies, irrigation policy and international trade issues. Until now many of these policy issues have been solved empirically by common sense food policies and strategies in many semi-arid Middle Eastern countries. Some of these countries like Israel and Jordan have made policy choices to reduce or abandon exports or local production of water intensive crops and replace them by imports or higher return crops to allow optimisation of water use. These are the conscious choices related to what might appear as a common sense strategy.

2 Issues

Virtual water trade as a policy option requires a thorough understanding of its impacts not only related to international trade regimes and dependencies but also on the local, social, environmental, economic and cultural situation. Moreover, it should contribute to local, national and regional food security requiring appropriate trade agreements which respect nation's right to decide on their way to achieve food security but also local distribution mechanisms ensuring access to food.

2.1 Food security, food self-sufficiency, food safety and food sovereignty

Each country is sovereign in the decision of how to realise its 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. Food security is necessary for planning the future of a country and it involves larger policy decisions that the country takes in the context of infrastructure development and international relations. Especially the more populous countries like China, India and Indonesia would like to be self-sufficient in food. This means that all food is produced domestically to prevent dependence on foreign entities for their staple food supplies.

Larger food markets like those of Europe, USA and Japan are more and more concerned about the safety of food imported. The quality of the produce, their production processes and their safety for public health, become more and more constraining factors for exporting developing countries. Countries depending on food imports as part of their food security strategy are concerned about the access to this market for their exports necessary for the generation of exchange to pay for the imports.

While water scarcity is a constraint to food production, the level of income primarily determines food security. A large part of the developing world's cereal production is for home subsistence consumption. Many poor countries lack the necessary financial ability to either develop infrastructure for irrigated agriculture or purchase food from the international market. Improving food security in these countries lies largely in rain-fed agriculture in combination with low cost groundwater irrigation and as recent developments show at the detriment of the groundwater reserves. Therefore, greater efforts should be devoted to the development of rain-fed agriculture and the overall rural economy.

The above-mentioned issues makes the virtual water discussion of relevance to four questions related to this complex issue that policy and decision makers are facing:

- Are investments in development of infrastructure (irrigation, drainage, flood protection, transport etc.) necessary and justified to obtain food self-sufficiency or could these investments be used for other sectors while importing the food required?
- How reliable (in terms of food security) 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 extent can local food production be justified at the cost of the environment to achieve food security?
- As an importing country, what are the food safety risks related to the use of agro-chemicals and genetically modified crop varieties?

Food security, environmental health and social equity are the rationale for encouraging virtual water trade as a water policy instrument. Countries might be better off using their scarce water resources for economic activities that bring higher economic returns and buy food instead of growing it themselves. However, countries would be wary of becoming too dependent on external sources for such a basic commodity as food. One factor that might alleviate the fear of dependency might be if there are multiple sources of food from which to import and that the development of quasi-monopolies is prevented. The water situation in some countries is so dire that these countries do not have a choice but to import some food items. However, some countries have a choice and have opted to import food items instead of producing them (Malaysia, Jordan, Egypt and others).

Food security is politically a very sensitive subject and virtual water trade can show a path for sustainable future. Shopping for some food in the world is a matter of risk analysis, and costing, to decide what your policy should be short and long term and what type of investments and how much would be required.

2.2 Environment

Poverty is the root of many environmental problems. Many developing countries need to encourage economic growth to provide even a basic quality of life for its citizens and that provision of more than minimal environmental flows may be a luxury in this context if this water otherwise could have been used for food production.

The acceptance of a "hidden and silent" concept may find difficulties where water decision makers ignore the role of groundwater in water resources policy. This attitude has induced the silent revolution of the intensive use of groundwater. Millions of modest farmers in arid and semi-arid regions have drilled millions of wells to abstract groundwater for irrigation. The driving force for this revolution is economic. Usually the cost of abstracting groundwater for irrigation represents only a small fraction of the value of the crop, which is guaranteed by the aquifer development. This is a revolution achieved during the last half century.

Today in Spain more than 50 percent of the total economic value of irrigated agriculture is almost for sure obtained with groundwater irrigation. The revolution is silent because it has been done outside of the conventional water administrators. The farmers have directly financed and operated their water wells. The lack of governmental planning and control has induced problems in a few regions. Usually to solve these problems the decision makers, instead of controlling the groundwater abstractions, try to build more dams to do water inter-basin transfers or artificial recharge. Social conflicts arise related to the designed water transfers that are opposed by hundreds of thousands of Spanish citizens. The basic cause of these conflicts is the chaos in groundwater administration. It seems that in other countries now similar situations exists. This situation is usually caused by a blend of ignorance (lack of knowledge), arrogance (professional bias), neglect (institutional inertia) and corruption (vested interests).

Environmental impacts of virtual water in Thailand

In Thailand, a number of experts are concerned that Thailand, through its rice exports, is exporting a lot of virtual water, they had rather this water be put to more productive uses, such as industrial production. Now, in practice, for Thailand, as well as other 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, reduced groundwater recharge, etc. There is more tension on water resources in the dry season, but allocation rules ensure that agriculture is the last served, after other sectors. So, even if a large proportion of water resources is virtually exported, should we think that something should be done about it? Just looking at the virtual water trade figures, which aggregate quantities of very different types of virtual water, may be quite misleading.

Thierry Facon

The ethical issues embedded in virtual water and in the silent revolution of the intensive use of groundwater are almost the same because of the similarities between the new concepts of virtual water and the silent groundwater revolution that now is being transformed into clamorous social conflicts. (Hernandez Mora et al, 2001; Llamas et al. 2003)

Any economist will agree that it is profitable to a water-abundant region to use its comparative advantage in crop production. But virtual water export can have negative impacts as well. For example, in the USA, 1/15 of the available water resources are used for producing crops for export. In Thailand, this is even one quarter! The development of the Ogallala aquifer in the USA (500.000 km^2 in surface) is one of the most mentioned examples of groundwater mining, i.e. the abstraction of groundwater higher than the average inter-annual recharge. Of course, the USA and Thailand have profited from this export, but partly at the cost of their environment.

In cutting agricultural subsidies in the rich world, there is a danger that developing countries, both water-rich and water-poor will try to capitalise on this opening on the international market by increasing their agricultural output, which for water-poor countries may be unsustainable. For example, the structural change in Mexican agriculture, due to the opening of the trade barriers has generated in Mexican agriculture a dramatic shift since the enforcement of NAFTA, from corn based smallholder farming to agribusiness in non-traditional products. These occupy only 3% of the harvested land but contribute for almost all the exports. Some of these products are a typical example of virtual water trade effects. In Mexico water is free for agriculture so virtual water signifies an environmental subsidy. Consequently the Chapala Lake, the biggest lake in Mexico has dropped its levels to less than 15% since 1994 due to water diversion for agriculture.

2.3 Employment and 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 consequences 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.

If low value crops such as wheat and maize are to be scaled back in production, there is the possibility that farmers will substitute to less water intensive or higher value crops. In many countries farmers change crops when economy and water scarcity demand it. For instance, in water scarce areas of Spain groundwater irrigation farmers have changed from alfalfa and corn to less water consuming and higher return cash crops as grapes and olives. The regional market of the European union was an important stimulant for this development. This indicates that if the transition is made successfully, there may not be much effect on employment in the targeted sector.

If such transitions are not possible, farm labour unemployment is likely to increase. In a country like South Africa, which suffers from upwards of 30% unemployment, and where the majority of farm labour has little or no schooling at all there, there is little prospect of this group finding alternative employment. The livelihoods of these people would be seriously compromised unless the implementing authorities could adequately cater for them. The same counts for the international community with its subsidies and tariffs in agricultural products and trade, which are a serious obstacle to initiate the crop change to overcome poverty in some poor countries.

However, the loss of employment has to be considered within the general trend of enlargement of scale in agriculture, urbanisation and increased off-farm employment. For instance, in Mexico only half a century ago the rural population was almost 50 percent of the total population. Today it is about 22 percent and continues to decrease. In the USA today 2-3 of its population is able to feed the 98-97 percent of their fellow citizens and they dominate the staple food market (and consequently the virtual water trade) with their crops. In other words, although the social changes due to virtual water should be carefully studied mainly in the poorest countries, it might be a fatal error to extrapolate this potential problem to every country.

Groundwater development in India

There are about 16 million ha of groundwater irrigation in India alone (about equal to the area irrigated by surface sources) and a similar size of groundwater irrigated area in Pakistan (mainly in the Indus basin). Groundwater irrigation grew exponentially in the 1980s and 1990s as a result of Federal and State subsidies that made it very attractive for farmers outside large irrigation commands to invest in an electrified pump to grow profitable crops and/or to sell water to their neighbours. Populist State policies stipulate that rural electricity for irrigation is free (e.g. Tamil Nadu and Punjab) or sold at a pittance. Many aquifers are being unsustainably over-pumped and groundwater tables are falling and are now threatening the future of the new groundwater-fed economic boom to farmers. The numbers of wells are so numerous, that no State Groundwater Board can afford the transactions cost of well licensing, groundwater monitoring and its management. In fact, although there is a model Groundwater Law formulated by the Central Water Commission, no State (except possibly Gujarat) has adopted it, as it is unworkable in their staff and budget reality. Thus groundwater is unsustainably used and not always for the most economically or VW efficient crops (e.g. rice or sugar cane), while a very large adverse and unaffordable economic, social and environmental opportunity cost is being created.

One could have at least related connection to the rural electricity grid to aquifer status through a licensing approach but no one saw, or wanted to see, the connection between pumping development and rural power subsidies. At the same time, it should be mentioned that many shallow tubewells of large diameter wells in large irrigated commands do serve canal mid-reach and tail-end farmers who receive inadequate water, while many such wells in the head reaches serve as a form of drainage and delay waterlogging and salinity. The issues of efficient and economic canal irrigation management are well known but conservative irrigation agency bureaucracy and political expediency drive out common sense policy.

A lot of this VW energy is also used in villages and commerce but everyone "turns the Nelson eye" as they say in India. The first immediate result was a major drain on the financial viability of the State Electricity Boards who were driven further into bankruptcy by the expanding pumping load. World Bank staff tried to link new irrigation and rural water supply loans to a higher rural electricity pricing loan condition but could not overcome the "we will continue free rural electricity" mantra of the populist political parties (who always have their eye on a State or National election - one or the other occurs every 2-3 years).

Teddy Herman

3 Geo-politics

Virtual water trade as a component of water policies is contingent to the rules of the international market that the WTO today is trying to establish. Current trade climates and conditions are not very supportive for enhancing virtual water trade as option in water policies for especially the poorest countries. Trade arrangements, access to markets, finance and foreign exchange, must all be taken into account.

The agricultural subsidy systems and import quota and tariffs of especially USA, Japan and the European Union, are the biggest obstacles to free trade and constrain the development of the virtual water market considerably. The magnitude of the agricultural subsidies from OECD countries is huge (about 1 billion US$ per day), has a major impact on the prices of agricultural products in developing countries and on the economic returns from farming to the detriment of producers in developing countries.

At the global level, virtual water trade has geopolitical implications: it induces dependencies between countries; it is influenced by and has implications on the world food prices as well as on the global trade negotiations and agreements on tariffs and trade. Indeed the issue of virtual water is related to that of globalisation, which raises a concern among many politicians and the general public. This can be understood from the fact that increasing global trade implies increased interdependence of nations. This can be regarded either as a stimulant for co-operation or as a reason for potential conflict. Alternatives to the current trends and directions of economic globalisation must be developed, tested and supported. Regional approaches are worthwhile to stimulate. Many obstacles in the virtual water trade could be removed by developing a political willingness that allows special trade agreements among regions, common market countries, and even between countries of different commercial blocks (e.g. Mercosur & European Union). This requires mutual interest, trust and political stability.

In virtual water trade one has to consider the food import requirements of the water scarce countries and the willingness of water abundant countries to produce these products, if soil and climatic conditions permit, at a price that is acceptable and affordable for the importing countries. Therefore, even if countries face water scarcity, they may consider the needs to produce the basic crops themselves priority, if they cannot afford to import products.

The tension in the food trade debate relates to the fact that the game of global competition is played with rules that many see as unfair. Countries with large virtual water exports, which contribute to the water budgets of other countries, are unfortunately also the countries that are accused of nefarious food trade practices for other reasons. Centralised imports of cereals may create a food ‘reservoir’ giving the state a monopoly on the food market, allowing it to create a client base in the major cities, distributing food in exchange for political allegiance. Such allegiance brings a degree of political dependency (Warner, 2003). Unless a set of norms, principles, rules, and decision making systems are carefully designed and successfully converged upon, it would lead to even more conflicting situations in the rapidly changing global trading systems (Mori, 2003). These implications are politically sensitive especially since the current low food prices of the global market are closely related to the high level of subsidies in many exporting countries and since they have a detrimental effect on the agriculture development of the countries importing food products.

3.1 Geopolitics

The virtual water concept could mitigate (and possibly solve) some of the international water scarcity problems. However, technical, economical and political issues have to be discussed accordingly, if success is desired.

If water-poor countries are encouraged to import food instead of using scarce water resources to grow their own, international demand for food will increase giving water-rich countries an economic incentive to expand their agricultural output. In the case of international river basins, an upstream (relatively) water-rich country may want to capitalise on the increased demand for food on the international market. In increasing its agricultural output, its water consumption and virtual water exports will go up, which may, depending on the specific hydrological features of the basin, leave less water to flow into downstream countries. Downstream countries would not only receive less water (and thus have a reduced capacity for food self-sufficiency), but would have to purchase food at a higher price (than the price before virtual water trade was encouraged and demand went up).

To work in a regional context is a very attractive concept. Countries in the Middle East could well be hiding to military conflicts due to water shortages. Virtual water could be an interesting tool to minimize the dangers of water wars.

International Relations in The Aral Sea basin – room for a virtual water trading council?

Relations between Central Asian states located in the Amu Darya and Syr Darya River basins (or Aral sea basin) shows us a clear inter-dependency and power politics over the natural resources which was provided in the period of Soviet patronage.

Countries like Uzbekistan and Turkmenistan, relatively more powerful from the others when you compare their abilities, continue to apply water management projects (like irrigation channels in Turkmenistan) which are not sustainable and holistically also damage the environment.

The degradation of soil and water resources of Aral Sea is a dramatic example to this case. Central Asian states draw upon water as a trump card, so water has become a resource to drive power politics among others. Like oil and natural gas. That kind of politics is not going to let water being used as a constructive natural resource in these water basins.

Soviet traditions about planning and taking advantage of these rivers have been priority since the Union collapsed.

The States of Central Asia are trying to be independent and they want to prove themselves in the international arena as sovereign nation especially related to the politics of natural resources. So a proposal like Virtual Water Trading Council to solve water related conflicts relevance with virtual water metaphor must take these power relations between states into account.

Onur Öktem

3.2 Pricing and subsidies

Various countries have overall cost structures that give them competitive advantages over other countries in all sorts of areas. Sectoral policies, such as agricultural taxation and input and output price policy profoundly influence farmer decisions regarding cropping decisions and associated water use. Subsidies on inputs other than water can also profoundly influence the utilization and quality of water. In addition to highly subsidized irrigation water, farmers benefited from cheap fertilizers, pesticides and credit, for example. Input subsidies that keep input prices low directly affect crop management practices at the farm level; they reduce farmer incentives for improving input use efficiency. In much of Asia, for example, government interventions in cereal markets through crop price support and input subsidies provided farmers incentives to produce water-intensive rice at the expense of other, less water-intensive commodities. Reduction in crop price supports and input subsidies could significantly influence trade in virtual water. Increases in virtual water trade could therefore provide significant benefits by reducing the negative environmental consequence of distorted agricultural policies.

Increased water price may have considerable effects on irrigated agriculture. Yang and Zehnder (2001) find that the share of irrigation costs in the total production input cost (excluding labour) is about 10 percent for wheat and over 10 percent for corn in the North China plain provinces. By comparison, the proportion of irrigation cost is less than 2 percent in the United States, the European Union, Canada, and Australia.

Obviously, increasing the price of irrigation water may further disadvantage grain farmers in North China but reinforces the ongoing trend of substituting high-value cash crops for grain because of higher marginal returns to water from cash crops. In fact, in the past two years, Beijing has removed more than 10,000 ha of rice fields of the total 23,300 ha and plans to eliminate all rice from the fields by 2007 (China Daily, 2002)."

3.3 Investments in infrastructure or virtual water 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 (Earle and Turton, 2003; Meissner, 2003). With two Asian examples, Nakayama (in Hoekstra, 2003) points out that application of the idea of virtual water trade could seriously impact on the management practice of international river basins.

Water Diversion from South to North China

While medium-distance transfers from the Yellow River to large cities have been carried out as shorter-term projects, the Chinese government is about to start a massive water transfer from South to North as a longer-term strategic project. This project is composed of eastern, central, and western routes and is designed to divert water separately from the upper, middle, and lower reaches of the Yangtze River to meet the needs of North and Northwest China. The 500 billion Yuan (US$ 60 billion) project will divert 38-48 billion m3 of water, 5 percent of the Yangtze annual flow (China Daily, 2001d). Construction is planned to begin in 2002 on the 715-mile eastern route and 774-mile central route, and it is expected to be completed by 2010 at an approximate cost of 180 billion Yuan (US$ 22 billion), which will divert 16 billion m3 or more (MacLeod, 2001). The western route, the most costly leg, still remains on the drawing board. World Bank (2000a) estimates the investment, operation, and maintenance cost roughly at 2 yuan/m3 on average in 2000 prices. The central government will share 60 percent of the total investment, and local authorities that will benefit from the project will pay the rest. To raise part of the investment, local governments will gradually increase present water-use charges, and the price for water will vary from region to region. The water price for residents in Beijing is expected to increase from 2 Yuan in 2001 to 6 Yuan per m3 in 2005 (China Daily, 2001f). While irrigated farming can be quite profitable near large cities if high-valued fruits and vegetables are grown, average returns of irrigation water are as low as 2 yuan/m3 (World Bank, 1997d). Raising prices is an incentive for people to conserve water, but some users, particularly farmers, may not be able to afford the water supplied by the project and instead will rely on pumping groundwater. Nevertheless, farmers will benefit indirectly since the shares for irrigation water from local sources will be preserved and there will be greater supplies of treated sewage water available for irrigation.

Don Head

One of the aspects of the Virtual Water Concept implies that importing food grains is cheaper than investing in large-scale water transfers or reservoirs. In other words grow food, where water is abundant, and transport food to water scarce regions, where food is required. However, because of long-term food security reasons and prevention of geo-political dependency, countries with large populations and which do have the means, are embarking on large-scale infra-structural development to enable growth in food production. India is an example of a large and mostly poorer country, which is embarking on a project to move massive quantities of water over huge distances at tremendous cost as a consequence of their food self-sufficiency policy. For the same reason China is also investing heavily in inter-basin transfers.

4 Diets

A vegetarian diet requires less water for its production than a meat-based diet due to the food chain effect. As societies develop, and their buying power goes up they tend to switch to a more meat-based diet. The higher up the food chain i.e. from vegetarian food to non-vegetarian food, the more water will be required to produce that food. (See box on China). Another important aspect is that with reducing especially feedlot meat production, pollution could be reduced considerably, making more water available for reuse.

Not all peoples on this planet are geared to a vegetarian diet. World population will always have mixed food habits for various reasons. Coastal populations around the world heavily depend on fish (sea food). Asking or even suggesting to not eat fish may be absurd therefore mix food habits will continue. It is not realistic, nor desirable to give up meat in our diets, but at least a beginning can be made to create a realisation what implications meat based diets and the increase in the amount of meat consumed will have on our water resources.

Changing Diets in China

Changes in diet and urbanization are the major driving forces for the restructuring of China's agriculture. Food preferences in China have rapidly changed to a more diverse diet-not only are Chinese eating more meat, but they are also increasing their consumption of vegetables, fruit, alcohol, sugar, eggs, and dairy products.

Feilig (1999) points out that diet changes have affected agriculture in two ways: (1) conversion of land usage from grain production to production for vegetables, tobacco, orchards, or fish ponds; and (2) a massive expansion of feed grain cultivation to meet the increase in meat consumption.

Because of the low energy efficiency of cycling grain through animals, more cropland is needed to support a meat-based diet than one based on grain."

Don Head

Increasing awareness is important and the following activities could be undertaken:

- The media should be used to popularise the concept of virtual water and to make it clear to people that eating lower down the food chain helps to save water.
- Hotels, airlines, conference organisers etc should present some vegetarian choices on food menus and make a variety of vegetarian dishes available to people so that at least some people start developing a taste for vegetarian food.
- Chefs around the world need to exchange vegetarian recipes and make them available. For instance, there are thousands of palatable vegetarian dishes that people living outside South Asia (a predominantly vegetarian population) have not heard about.

By modificating our diet habits the quality of future generations' health and life conditions can be preserved. The concepts of virtual water will lead to some new concepts and knowledge on world food trade and its analysis.

Virtual water content and Food production methods

An effective intervention to reduce nutrient (as well as chemical, endocrine, sediment, etc.) pollution of fresh water resources worldwide may be through changes in agricultural practices induced by a global transition to eating lower on the food chain. With a reduction of the amount of meat consumed, the total demand for grains would decrease as the fodder crops being currently raised for livestock could then be diverted or replaced by crops for human consumption. As a consequence pressure on water resources will be released and water quality will improve as the livestock population is contributing tremendously to water pollution.

To reduce virtual water flows from export agriculture (in particular meat industry) related to a focus at the livestock/crop nexus the following is proposed:

Eating meat is not always a bad thing for the environment

In Quebec (Canada), caribou hunting decreased in the 1960s due in part to government regulation intended to protect the specie. As a result of this (and other environmental factors), the population of some herds increased dramatically. Now, we are faced with a situation where the population of caribous is too high and there is not enough food in the natural habitat to sustain them all. Females feeding their newborns have exhausted their fat reserves after the first month. Admittedly, eating caribou meat hunted in the wild is not a solution accessible to all non-vegetarians around the world, but this is just to show that we cannot always take humans/predators out of the natural cycle without some consequences.

Katherine Cinq-Mars

In Switzerland, the high development of human settlement and activities in mountains has pushed the great predators out of the place (such as lynx, bear, wolf or eagle). Thus, the herbivores species have increased dramatically. However, the problem is not about food missing, but about the important grazing induced by this important herbivore population. This grazing has a direct and reducing impact on the forest and its renewability. In the mountains, forest is the only protection for human beings against many natural hazards (soil erosion, high-amplitude flooding, mud and debris flows, avalanches, etc.). In this case, hunting seems to be one solution to conserve the protective forests; the other solution is the re-introduction of the great predators.

Yves Nardini

5 Methodologies

5.1 Assessment of Virtual Water and Virtual Water Trade

For a comprehensive assessment of water management in agriculture and to better understand its future, it is necessary to analyse the recent tendencies in food trade and in virtual water trade. However, we should avoid developing an academic discussion on what the virtual water content is and what should or should not be included. What is more important is how can we make effective use of this concept to convince policy and decision makers of its potential and its opportunities while making them aware of the threats and problems it might create for the environment and local socio-economic development. In doing so, they need to be provided with tools that can be used efficiently, giving information on (i) what volumes of water are involved and what economic value they represent; (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.

Information on these issues is developing. Country and regional studies, global estimates on virtual water trade volumes and maps depicting these virtual water flows have been produced recently. However, these are only first approximations and there is no standard methodology yet to evaluate the virtual water contents especially of food products.

Hoekstra (2003), Oki (2002), Zimmer and Renault (2003), and Hung (2002) are now developing different methods for the quantification of virtual water. Due to the great spatial and temporal variability of water productivity the amount of virtual water embedded in a product can already be viewed from different perspectives (Renault, 2002): the producers perspective looking at the real amount of water used to produce the good or the importers perspective looking at the amount of water required if the good was produced domestically. Also the level of inclusion of embedded water in the production process should be clarified and agreed upon. There are limits to be set and these are not yet clear.

5.2 Methodology

It is obvious that the rigor of the virtual water concept as a practical policy tool can be extended to detailed analysis of irrigation policy and international trade issues. At the same time, the policy issues related needs to be strengthened. The methodology needs to be further developed in the following areas:

1. Methodology for determining the virtual water content regarding what is and is not included has to be standardised for a good validity and reliability of computations and data:
    a. Only real water consumed? Is that transpiration or evapo-transpiration? What standard parameters/formulas are used?
    b. Water used in the production process: irrigation supplies and irrigation inefficiencies?
    c. Inclusion of water loss due to quality degradation?

2. Determination of the virtual water content according to the geographic location of production or consumption of the virtual water:
    a. Calculating all crop virtual water content based on evapo-transpiration in production countries and derive virtual water trade movements after its aggregation.
    b. From the importing country point of view, calculating the indigenous water resources that would be needed to produce the imported commodities locally..
    c. Both approaches should allow for incorporation of a differentiation along the lines of green or blue water, irrigation intensity, cropping intensity and water quality degradation.
3. The inclusion of soil moisture (green water) as an integral component of the virtual water balance as it supports rain-fed agriculture and natural pastures.
4. 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.
5. The differentiation between irrigated and rain-fed agriculture green and blue water for which there is alternative use or not. If it were possible to segregate irrigated crop exports from rain-fed exports, then more valid policy analyses could be conducted in relation to water availability and costly irrigation (70-90% of water use in many countries –even monsoon Indonesia). Just taking the rain-fed cereals such as wheat out of the computation may result in a totally different virtual water export balance and the net flows may lead to more insightful policy recommendations.
6. Looking at already existing methodologies for accounting the environmental burdens of products and processes such as the life-cycle assessment (ISO 14040) may be interesting to help define a common methodology for the assessment of virtual water content.

5.3 Indicators

Virtual water trade can improve availability of water, food security, livelihoods, environment and local economies. As a way forward, besides the water footprint, other baseline performance indicators should be developed taking into consideration the country's socio-economic and climatic conditions, water consumption and the country's water yield potential. Such indicators could include:

- The scarcity or water stress;
- The need to provide for environmental flows through water availability per unit of exported product;
- The water storage capacity per unit of exported product;
- The percentage of agricultural unemployment to total unemployment;
- The extent to which an economy is diversified;
- The 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.

Conclusions

Including virtual water as a policy option requires thorough understanding of the impact and interactions of virtual water trade on the local social, economic, environmental and cultural situation. Import of virtual water can relieve the pressure on a nation's own water resources and environment. At the same time, countries can in some cases damage their environment by exporting virtual water. Further research should be carried out on the natural, social, economic, environmental and political implications of using virtual water trade as a strategic instrument in water policy. This includes an analysis of the geo-political importance of virtual water, the opportunities and threats involved and the associated political processes underlying decision making on application of this concept. Tools are to be developed for analysing the impact of 'virtual water' on local socio-economic and cultural conditions.

Governments and international organisations should include 'virtual water' accounts as an instrument in any national or regional water and agricultural policy analysis. Common procedures and standards for virtual water accounting should be developed and disseminated. To enable introduction of virtual water as an instrument, virtual water accounts and associated accounting procedures should be developed to support any national or regional water and agricultural policy analysis. A first attempt could be made in the EU where 15 countries are exchanging goods without tariff and tax constraints.

Reduction of virtual water in our diets may also contribute significantly to water savings. Showing people this virtual water content through water footprints will increase water awareness and may lead to water saving consumption patterns. The implications of changing diets on water resources have to be addressed through education. Trading and manufacturing companies could help to enhance awareness by publicising the virtual water content the virtual water concept by mentioning the virtual water content of their products.

A joint effort by governments, international finance institutions and research institutes is needed to analyse the geo-political importance of 'virtual water': This should include the opportunities and threats involved and the associated political processes underlying decision-making on application of this concept.

There is a very real need for more research to work on the prescriptive potential of the virtual water theory and on the potential of virtual water trade to relieve pressure on the globe's water resources and to achieve food security in the world's water-scarce regions. To make the concept of virtual water helpful in policy making, the concept itself needs to be further clarified and the difference with common food trade must be made more explicit.

It is necessary and urgent to understand and develop solidarity mechanisms related to virtual water trade. How can we ensure food security and economic development in water poor countries?

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ISBN: 92-95017-10-2

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