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Review

Conceptual explanation of virtual water trade and lessons for Africa

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Overtime, some African countries have experienced a scarcity of water resources due to changing climatic conditions. Thus, there is a dire need for the sustainable and integrated management of these resources. Against this background, this article aims to evaluate the applicability of the virtual water trade in analysing the water situations in developing countries, given their relations within the global trading system. The paper argues that the future of Sahelian and North African countries lies in the better understanding and applicability of the concept of virtual water trade as a water resources management technique. It notes that the concept is of dire need in Sahelian Africa as it faces dwindling water resources, within the highly competitive agricultural trading terrain.

Key words: Virtual water, trade, Africa, developing countries.

INTRODUCTION AND STUDY BACKGROUND

Ironically, Africa's annual renewable water resources are estimated at a staggering 5,400 billion m^3 per year, of which roughly 15% is ground water (African News Update, 2004). This translates to per capita water availability of about 6,800 m^3 per annum. These water resources are characterized by 'extreme temporal and spatial variability, with relatively greater availability along the equatorial region and scarcity in the Sahelian Belt, North Africa and the Horn, with high incidences of floods and droughts. According to the African Development Bank (AfDB), the level of exploitation of African water resources is low with only about 150 billion m^3 or 3% of the total amount withdrawn for water supply, agriculture and industrial use each year. Less than 30% of the estimated potential of 45 million hectares or about 6% of the total cultivated area in Africa is under irrigation, whereas, a study has revealed that irrigation could contribute to the 3.3% increase in food production, which is needed to achieve food security by 2025 (African News Update, 2004). Further, since water remains a key resource for sustainable development and as part of efforts geared towards the attainment of the Millennium Development Goals (MDGs) and African Water Vision targets, the AfDB Group has been focusing on water resources management issues through major initiatives which are designed to tackle the challenges of providing basic water needs and services. In addition, AfDB support notable water initiatives, such as the African Water Vision and Framework for Action, the development of the Rural Water Supply and Sanitation Initiative (RWSSI), the African Water Facility and its lead role in the preparation and implementation of the New Partnership for Africa's Development Programme (NEPAD) Water Infrastructure Programme.

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 resources management 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 the global society. This led to the AfDB Water Week on the 1st - 3rd July, 2004, which was titled "Building Partnership for Water in Africa" which aims: To promote water resources development in Africa to meet the MDGs by fostering partnerships around major initiatives of the African Development Bank; and to provide a venue for the exchange of ideas, experiences and best practices for attaining the MDG targets. In view of this, this article explores the applicability of Virtual Water Trade in fostering sustainable water resources management in Africa.

THE STATEMENT PROBLEM

With only 62% of its population having access to improved water supply (as against a global average of 82%) and 60% access to improved sanitation, Africa has the lowest coverage of water supply and sanitation services in the world. About Four hundred million people do not have access to adequate water and sanitation services. This situation contributes to the poor health statistics in the continent, with 50% of Africans suffering from one of six water-related diseases. African women and children spend inordinate amounts of time fetching water instead of engaging in income generating activities or attending school.

Water resources development and utilization to meet social, economic and environmental needs is very low in Africa with only one quarter of the irrigation potential being utilized and most of the hydropower potential remains unexplored. In addition, there is very limited scope for private sector participation in water sector activities.

In the developing countries, water development has itself not produced much value added for the present economy although it is in these communities that this resource is in very high demand. The immediate needs of water, especially, in tropical Africa's rural communities, are chiefly in agriculture. It is also in these communities that the low-yielding subsistence farming can hardly pay the cost per acre-foot of irrigated water. The problem of demand and supply is, therefore, intimately connected with the problem of raising agricultural yields per acre-foot of water and per man-hour of labour inputs, thus increasing the economic value of water.

At present, the irrigated land area in Egypt is estimated to be less than 50.0% of this acreage. The same picture is true of other great rivers of Africa such as the Senegal, the Niger, the Benue, the Congo, the Zambezi, and the Orange. The seriousness of the water problem in Africa is very grave especially in the arid and semi-arid Sahelian zones of the continent. For example, in the Magreb countries of North Africa such as Tunisia, Algeria, and Morocco, there is not enough water in the region north of the Sahara to irrigate more than 3.5 million acres of land that has an estimated population of 26 million in the three countries, and this is likely to double in the nearest future. The dry land farming of this and other Sahelian zones is highly susceptible to the vagaries of weather, most especially drought.

The question may be asked: how can Tropical Africa cope with this water problem, bearing in mind the severity of the food insecurity in the region? The first and most effective solution is the development of irrigation coupled with an improvement of the present rather low efficiency of water use. This can be achieved through effective research in Virtual Water Trade (VWT).

THE SIGNIFICANCE OF VIRTUAL WATER TRADE

The virtual water concept is a tool that can improve the development of alternatives in water, food and environmental policies. In other words, it links water, food and trade. It aims at achieving water security through the optimal management of water resources. In fact, it appears to be the only efficient way through which water deficit economies can remedy their inadequacies. It is pertinent to state that the virtual-water content of a product consists of three components - green, blue, and grey. The green virtual-water content of a product is the volume of rainwater that evaporated during the production process. It is mainly relevant for agricultural products, where it refers to the total rainwater evaporation from the field during the growing period of the crop (including transpiration by the plants and other forms of evaporation). The blue virtual-water content of a product is the volume of surface water or groundwater that evaporated as a result of the production of the production of the product. For instance, the crop production, the blue water content of a crop is defined as the sum of the evaporation of irrigation water from the field and the evaporation of water from irrigation canals and artificial storage reservoirs. The grey content of a product is the volume of water that becomes polluted during its production.

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. 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. The inclusion of the possibility of virtual water trade, especially food imports, allows a wider spectrum of alternatives in water and environmental management policies. 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. Allan (2001) states that virtual water trade is so successful because it is invisible and is applied beyond the general political debate.

Furthermore, 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 the rest of the countries is 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 this paper 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 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 either replenished by imports (or food-aid). 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 independence 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 that if looked from only an economic point of view would hardly be justifiable.

In addition, 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 because of geo-political reasons or some local, political interests.
Water is perhaps the most important resource any rural development process. This importance arises from the fact that substantial amount, about 10 tons of living tissue, is required each year by human beings and domestic animals. Rural industrialization will require substantial quantities of water, ranging from 2 tons per ton of manufactured bricks to 250 tons per ton of paper and 600 tons per ton of nitrate fertilizer.

With respect to the water requirements of agriculture, it is estimated that to grow a ton of sugar or maize under irrigation will require about 1,000 tons of water. Rice and cotton fiber will respectively require about 4,000 and 10,000 tons of irrigated water per ton of crop.

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.

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 rainfed agriculture. Trade in cereals and other crops amount to some 60 - 67%, animal products 23 - 26% and others 10 - 14%.

VIRTUAL WATER TRADE: STYLISED FACTS

Empirical studies reveal that regions with substantial net virtual water export are North America, South America, Oceanic and South East Asia. North America (United States and Canada) is by far the biggest exporter of virtual water in the world. Net exports of virtual water from the United States amount to one third of the total water withdrawal in the country. The regions with a significant net virtual water import are: Central and South Asia, Western Europe, North Africa, and Middle East.

A general methodology has been developed to assess the virtual water content of crops, livestock and livestock products and to quantify the virtual water trade flows between nations related to the international trade of these products. The virtual water trade flows are calculated as the trade volume of the product (ton/yr) times its virtual water content (m^3/ton). As the virtual water content of a product varies spatially and temporally, virtual water content of products has been estimated for five different years (1995 - 1999) and for each country separately. This calculation is in relation to the definition of the virtual water content of a product as the amount of water that was required to produce the product in the place of its origin.

Crop water requirements for different crops have been calculated using the CROPWAT model of FAO. The virtual water content of a crop (m^3/ton) is the ratio of the crop water requirement (m^3/ha) and the specific yield (ton/ha) of respective crops. The virtual water content of a livestock product is calculated in two steps. First the virtual water content of the live animal is calculated based on its diet (crop composition) and total drinking and servicing water consumption during its entire life span. The virtual water content of a live animal is distributed over the different products produced from that animal.

The global volume of virtual water trade is estimated to be 940 Gm^3/yr (695 Gm^3/yr from the trade in crops and 245 Gm^3/yr from trade in livestock and livestock products). The virtual water trade related to trade of crops and livestock products is 15 - 20 % of the total world water use for agricultural production. Table 1 show the virtual water trade and the Netherlands. The list of top-12 net exporters and top-12 of net importers are presented in the table.

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Table 1. Top 10 virtual exporting/importing countries (1995-1999)

Top 10 virtual exporting countries (1995 - 1999)	
Country	**Net export volume (109 m^3)**
USA	758.3
Canada	272.5
Thailand	233.3
Argentina	226.3
India	161.1
Australia	145.6
Vietnam	90.2
France	88.4
Guatemala	71.7
Brazil	45.0

Top 10 virtual importing countries (1995 - 1999)	
Country	**Net import volume (109 m^3)**
Sri Lanka	428.5
Japan	297.4
Netherlands	147.7
Korea Rep.	112.6
China	101.9
Indonesia	101.7
Spain	82.5
Egypt	80.2
Germany	67.9
Italy	64.3

Source: A.Y. Hoekstra, P.Q. Hung. virtual water trade - A quantification of virtual water flows between nations in relation to international crop trade.

see here that North America is by far the largest net virtual water exporter in the world; Oceania and South America are the next large exporters. By far the largest importing region is Central and South Asia (particularly because of imports to Japan and Sri Lanka). Some regions that are net exporter in relation to crop trade while some are net importer in relation to the trade of livestock products. For example, South East Asia has net export of 27 Gm^3/yr from crop trade whereas it has net import of 9 Gm^3/yr in the form of livestock trade. The Former Soviet Union and Central America, net exporters in relation to crop trade have nearly a trade balance if we take into account trade related to livestock and livestock products as well.

Though the bulk of food trade is in the form of trade of cereals, the virtual water trade related to the trade of livestock and livestock products is quite significant. The reason is that the virtual water content of livestock products is very high compared to the virtual water content of crops. Change in dietary habits of people can significantly change the virtual trade balances. For example, if Chinese people change their dietary habits to that of an average citizen of the United States, the virtual water trade balance of Central and South Asia, which is already a net importer of virtual water, may escalate severely.

In addition, the sum of national water use and net virtual water import can be seen as a kind of 'water footprint' of a country, on the analogy of the 'ecological footprint' of a nation. The water footprint of a nation is related to dietary habits of people. High consumption of meat brings along a large water footprint. Also the more food originates from irrigated land, the larger is the water footprint.

Nations in warm climate zones have relatively high water consumption for their domestic food production resulting in a larger water footprint, especially in Africa. The importance of virtual water at global level is likely to increase dramatically as population will increase and cropping patterns will change. Therefore the transfer of virtual water is becoming an important component of water management on global as well as regional level. Virtual water import can ease the water scarcity problems of water deficit African economies. The analysis made strongly depends on statistics on water requirements, yields and trade. Also a number of assumptions had to be made with respect to the calculation of virtual water content of products.

Trade in virtual water has steadily increased over the last forty years: about 15% of the water used in the world is for export, in virtual form. Since, at the global level, agriculture is the largest economic sector in terms of water use, trade in agricultural products is the main component of trade in virtual water. According to A.Y. Hoekstra, an expert from the UNESCO-IHE Institute: 67% of the global virtual water trade is related to international trade of crops; 23% is related to trade of livestock and livestock products; 10% is related to trade of industrial products. Wheat represented 30% of the total volume of crop-related virtual water trade between nations in the period 1995-1999, followed by soybean (17%) and rice (15%) (Tables 2 and 3). The trade of beef is also important to global virtual trade. Some experts argue that the importing of virtual water (via food or industrial products) can be a valuable solution to water scarcity, especially for arid countries that depend on irrigation to grow low-value food with high water needs.

Conclusion

Virtual water trade has proved adequate in the integrated management of water resources in many water poor regions. It is very crucial to note that while virtual water calculations are an essential planning tool, and can be useful in determining how seasonal water can be used most efficiently to provide more food at the right times, they are dependent on all other factors (political, economic and natural) being equal - which is seldom the case in sub-Saharan Africa. Nevertheless, the awareness of how water is an invisible part of the food economy is

Table 2. Global virtual water trade between nations: top 10 crop products (1995-1999).

Product	% of the virtual water trade
Wheat	30.20
Soybean	17.07
Rice	15.36
Maize	8.85
raw sugar	7.20
Barley	4.88
Sunflower	2.71
Sorghum	2.01
Bananas	1.97
Bananas	1.86

Source: A.Y. Hoekstra; P.Q. Hung. virtual water trade - a quantification of virtual water flows between nations in relation to international crop trade

Table 3. Water requirement equivalent of main food products

Product	Unit	Equivalent water (m^3 per unit)
Cattle	head	4,000
Sheep and goats	head	500
Fresh beef	kg	15
Fresh poultry	kg	6
Cereals	kg	1.5
Citrus fruits	kg	1
Palm oil	kg	2
Pulses, roots and rubber	kg	1

Source: FAO, 1997. published in the UN world water development report.

already a bold and positive step. Once states, farmers, citizens and aid agencies have more accurate information about the virtual water that is involved in their numerous transactions, they will be better able to decide on their own course of action.

However, what are the lessons that water deficit African countries can learn from the virtual water concept? The answer perhaps lies in the fact that emphasis should be laid on integrated water resources management, which is more embracing, and encompassing. Hence, the definition of integrated water resources management can be stated as a process, which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP Technical Advisory Committee, 2000).

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

In essence, this implies that virtual water trade will find relevance in the seed bed situations of African countries as they actively participate in the global trading competition. It becomes more applicable to their growth dynamism in the evolving inter-regional integration.

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