GLOBAL AND REGIONAL FRESHWATER RESOURCES

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Summary

The management of global and regional freshwater resources has changed significantly over the past few decades, in many countries of the developed North and developing South. This is exemplified by the changing water paradigm that brought about a change in our perception of water resources and the life support systems it sustains. Two perspectives in current thinking about global and regional water resources that manifest the changing water paradigm is virtual water and blue and green water. These views are radical departures from the traditional outlook humans had of water. Virtual water and blue and green water also contain elements of the quantity and distribution of the globe's freshwater resources. The quantity, quality and distribution of the world's freshwater resources are some of the most important aspects regarding the management of water resources on a world-wide scale. How much water there is, the quality of it and where and when it is in abundance and/or scarce at the present moment will depend large on how we will use water in future. The most important drivers in this equation regarding future water needs are population growth and economic development. These two factors will have an impact on future global and regional freshwater management. Yet, not all regions and states will use water in the future in the same manner. The two variables will have different effects on global and regional freshwater utilisation.

1. Introduction

Sustainable economic development hinges on the availability of water resources, especially in the developing world. Where the industrial sector is not well developed, or weak, water consumption in it can be as high as 80 %. This offers support to the socio-political importance of water in the economic development of many regions around the world. The importance of water to these regions is reflected in the vision of the water sector within some regions. For instance, the water vision of the Southern African Development Community (SADC) states that SADC attempts to "attain the sustainable, integrated planning, development, utilisation and management of water resources that contribute to the attainment of SADC's overall objective of an integrated regional economy on the basis of balance, equity and mutual benefit for all member states". Within this vision water is directly linked to the economic development of all SADC member states, which is a good indication of the socio-economic and political importance of water. In other parts of the developing south, it is estimated that more than 1.7 billion people, spread over 80 countries, are suffering from water shortages which further signify the importance of water to humans and the societies they live in. Basic human consumption, survival and economic well-being of a large part of the population residing within developing and developed regions rests on this scarce resource. This suggests that there should be enough water to cater to the needs of society and that the water resources should also be of a good quality.

As one of the most important resources available to all life support systems, and constituting such a system itself, water resources are becoming more and more exploited while the quantity and quality thereof is becoming inextricably limited. This is due to the fact that a number of constraints and limiting factors, such as population growth, industrialization and urbanization, is taxing global and regional water resources to their limits. If this sounds very pessimistic, there is however room for optimism. This idealism lies in the fact that there are different perspectives regarding the global water balance and regional water resources. These perspectives can offer practical solutions to our water problems and can become one of the major practices of future generations to develop and use the water in the hydrologic cycle in a more sustainable manner. In this article the different perspectives of the global water balance and regional water resources will be discussed.

Any discussion of future water needs must acknowledge that while it is possible to sketch a picture of the global future, water use is a local activity that affects individuals and small communities as much as it does sovereign states and large commercial enterprises. Global averages are only useful when they allow a better understanding of individual and community use of water. That water is unevenly available is a principle that will guide this analysis of future water needs. One community may have more water than it can use while another may have so little water that its survival is at stake. While humans and ecosystems can tolerate and sometimes depend on an uneven supply of water, there is generally a continuous and growing demand for water. It can be said that the flow of water through the biosphere is like the flow of blood through a body. The relationship between the constant demand for water and the uneven supply is crucial. If well-managed, it can help society in its search for a better life. If water needs are not carefully matched to the supply, disaster becomes unavoidable. Need and demand must conform to supply and access.

In this topic some of these issues will be discussed in more detail. The topic starts of with a look at the changing water paradigm, which has had, and is still having a large impact on the way humans perceive water and how it is utilised. Two perspective of global and regional freshwater resources will be discussed in the second part of the topic: virtual water and blue and green water. These perspectives are part of the changing water paradigm. In the third section of the topic global freshwater quantity, quality and distribution will come under the magnifying glass. In the last part, the future needs of the earth's population for freshwater will be discussed.

2. A Change in the Perception of Water

From the onset it is important to note that water scarcities are a local, or river basin, phenomenon. The importance of this is quite extreme regarding strategic decision-making, for it allows for a conceptual difference to be developed between water scarcity at a local level, and the search for a solution at the regional or global level. Although there is enough water on earth, the distribution thereof is of such a nature that it is in abundance in some places and in others it can be extremely scarce. Water is therefore both scarce and bountiful over space. Not only that, it can also be limited or ample over time. Some regions of the world might experience periods of adequate rainfall while at others droughts can persist for some time. For instance, due to the El Niño/Southern Oscillation (ENSO) effect (see article The Impact Of El Niño On Water Resources) Southern Africa have seen over the past 20 years periods of drought (1981-1985 and 1990-1995) with intervals of sufficient rainfall that provided for most of the water requirements for the economic activities of the region. During such periods of drought many rivers will not be able to supply water to large urban, industrial and agricultural communities. In fact, during the severe drought of the 1930s in South Africa many of the large and important rivers, like the Orange and Vaal Rivers, stopped flowing. Rivers are therefore an important part of the hydrologic cycle and an important source of water for humans.

A fundamental characteristic of traditional water resources planning, is that it has regularly and persistently concluded that future water demands will exceed actual water supplies, mainly due to the unchecked advancement of the three drivers. This will be called supply sided management (SSM). In terms of current social science theory, this form of management tends to focus on what has been defined as a first order resource scarcity - i.e. the scarcity of a natural resource such as water. Supply Sided Management was the dominant mode of water development and management in the United States of America (USA) prior to the 1980's, with the Bureau of Reclamation (BoR) and Army Corps of Engineers (ACoE) being the main instruments. Significantly, these organizations spawned a global paradigm due to the fact that they trained many of the hydraulic engineers who subsequently went on to construct the world's largest dams.

The main concern wit respect to change in thinking about water resources development is that of sustainable water use. The scale of water mobilization has thus altered from modest scale water management construction endeavours to sustain local and relatively small populations to larger and grander projects for huge (in terms of population and economic productivity) societies.

Yet, during the last part of the twentieth century another change in the thinking about freshwater resources management and the human needs for water has taken place - the so-called changing water paradigm. Conventional planning and management system and approaches and a dependence on physical solutions continue to dominate the water discourse in many states and regions around the world. However, new methods are in the process of being developed in order to use the current infrastructure available to meet the demands of growing populations and economies without the construction of major water resource management projects (WRMPs). The improvement of the efficient use of water, demand management and the reallocation of water resources between different users are now being considered at an increasing rate by water planners and managers. The new change in the thinking about water resources management has not been easy to say the least. Old habits die hard. There has been strong opposition between and inside organizations responsible for water resources management. For instance, during the 1990s the Namibian government started with plans to pipe water from the Okavango River to supply water to its urban and industrial centres in the central regions of the country. These plans were feverishly opposed by environmental interest groups, concerned about the ecological integrity of the Okavango Delta. These non-state entities even came up with alternative plans to augment Namibia's water supply. One of these plans was the implementation of water demand management (WDM) across the entire country. Yet, the strategies of the interest groups were countered by the Namibian government, invoking the sovereign right of a state to develop its water resources as it sees fit. Furthermore the methods mentioned are not yet globally accepted practices and they may not be a permanent solution to our water problems.

Notwithstanding these barriers, the new water paradigm is here to remain in addressing unresolved water problems. States have already started with the implementation of some of these measures and interest groups are already advocating the implementation of some of these actions such as in the case of Namibia. For instance, WDM has been initiated by a number of states in the Southern African region. Most notable of these are Botswana and South Africa. In South Africa the working for water programme (WWP) is but one of these actions with respect to the change in thinking about water resources management. The WWP is an initiative build on the approach of the eradication of alien plant species within individual river basins. These plants use a lot of water and by getting ride of them can improve the run-off of rivers and streams. In Botswana the Water Master Plan (WMP) proposes that WDM should be initiated alongside expanding water supply sources. This is a departure from earlier approaches that concentrated on water supply management (WSM). These changes in the thinking about water resources management represents a change in the paradigm of human water use. Many environmental interest groups have adopted the promotion of such measures as a central feature of their policy and influencing endeavours, in order to bring about more sustainable water planning efforts on the part of governments around the world. Currently the World Conservation Union (IUCN) in Southern Africa has, over the past two years, running a project on the implementation of WDM in the region, and are now looking at the constraints that can affect this water management strategy.

The traditional water paradigm, with its emphasis on water supply measures to address the water problems of regions, regions within states and individual river basins emerged from the conservative view that the global water balance has enough water to meet the water needs of humans in the foreseeable future. For instance, for decades and even millennia it was thought that every drop of water within the global hydrologic cycle that runs-off from rivers into the sea was a wasted drop of water. The global water balance was therefore seen as huge reservoir that should be tapped at the expensive of other life support systems in order to furnish the needs of humans. Yet, with the new water paradigm, with its emphasis on sustainable water resources development, already being paramount in the thinking about water needs came innovative perspectives about the global water balance and the inventory of regional water resources. Some of the most notable of these are virtual water and the notion of blue and green water. These two perspectives about the global water balance and regional water resources embodies the notion of sustainable development of water resources. In the next section these perspectives will come under closer scrutiny.

3. Perspectives of Global and Regional Freshwater Resources

3.1 Virtual Water

A potential solution to the water problems on a global and regional scale is provided by the perspective of virtual water. The concept of virtual water was developed by Prof. Tony Allan at the School of Oriental and African Studies (SOAS) at the University of London, after an economist by the name of Fishelson, indicated that the export of citrus fruit produced in Israel was no longer in the national interest of that state. The exporting of citrus fruit, in the case of Israel, or any other water intensive commodity forms an arid or semi-arid region to one that is water abundant, like North America, constitutes the international trade in water. This made Allan realise that water policy planners and makers within water scarce economies needed to become aware of the interrelationship between natural resources (water) and sustainable development of such a resource.

Virtual water is the volume of water needed to produce a commodity or service. In the international political economy (IPE) vast quantities of water are present in the international cereal market. For instance, it takes approximately 1 000 tonnes of water to grow one tonne of grain. This figure presents the virtual water value (VWV) of grain. Similarly it takes approximately 2 000 tonnes of water to produce one tonne of rice and 1 000 tonnes of water to grow one tonne of wheat. To produce nine tonnes of sugar cane requires 1 000 tonnes of water. From one tonne of sugar cane about 700 kilograms of juice (sap) can be extracted. This 700 kilograms of juice represents the VWV of sugar cane. Also, approximately 1 200 tonnes of water are needed to produce one tonne of maize.

All countries have to trade in foodstuffs, commodities and services. This means virtual water embedded in food is crossing borders every day, which makes virtual water such an important aspect of a country’s food security. An analysis of the global economy of water indicates that vast quantities of water are present in the international cereal market. This implies that as country’s trade in commodities, they are actually importing and exporting water in a virtual sense. An example from the Middle East will suffice. Prof. Tony Allan notes that as much water that enters the Middle East region as virtual water in the form of subsidised grain purchases as flows down the Nile annually. He also concludes that hydrological systems are therefore subordinate to the IPE of which they are a part. Global food trade has the capacity to augment water supplies on the scale needed to meet the growing demands of the rising population of semi-arid and arid regions. The trade in virtual water can therefore be seen as a WDM strategy, to supplement water resources where they are scarce.

Virtual water is not only present on the world food market. Regional markets are also an important source of food commodities. Intra-regional trade in food is a very important aspect of regional trade within the Southern African Development Community (SADC) region. Countries in SADC region trade with each other not only as regards to foodstuffs or virtual water, but they also trade with other countries in the global economy. This infers a duality when it comes to trade in virtual water. On a regional scale the proposed SADC Free Trade Area (FTA) is an example of globalisation on a regional scale, where countries are interdependent on each other concerning their food trade and food security. The SADC FTA is a typical example of trade integration. As trade integration grows, so does interdependence. Because the countries in SADC are predominantly developing countries, with the agricultural sector dominating economics in certain member states, virtual water is also of great importance to trade on a regional scale. It can be expected that as trade integration in SADC grows, so will the interdependence of the member states of the SADC region regarding agricultural commodities and virtual water. The importance of virtual water, as a consequential aspect of political economy, can be narrowed down still further to the national level.

Trade in agricultural commodities is important to a state in two respects: it allows for the importation of virtual water and it permits the generation of foreign currency to balance out virtual water costs. On a national level in economies such as those found in Canada, the USA and countries of Central Europe there is an abundance of viable, mainly rainfed agricultural production. The governments of these grain-producing states often subsidise their farmers, which infers that the virtual water content of that grain is both high in volume, and cheap in price. The water budget of a country can be balanced in the following ways:

- By purchasing water-intensive agricultural commodities from states with a natural surplus.
- By re-directing the water-short economy away from a policy of food self-sufficiency towards one of food security.

The world food market is an important source of food supply for many developing countries, especially those states where output is constrained by natural and other factors. Developing countries' dependence on trade is growing. Over the period 1970-90, food consumption grew 10 % faster than production in the developing world. With respect to cereals, imports accounted for some 14 % of the domestic consumption of developing states in 1994, up from less than 10 % 20 years earlier. To import a commodity generally means that it can be procured more cheaply than it can be produced domestically, give or take a few export subsidies and protectionist policies. Some countries will aim at food self-sufficiency for specific reasons. It makes better sense to follow a more flexible policy of food self-reliance coupled with that of food self-sufficiency where possible. This implies that developing states' reliance on trade in foodstuffs on the global market will, in the future, increase exponentially with that of socio-economic development and political stability.

The perspective of virtual water sheds light on 'alternative' water resources in that it place emphasis on the international trade of commodities, especially, but not exclusively, on food stuffs. Another perspective regarding visible water resources is that of blue water and green water. Here the significance is the interaction humans have with nature and the ecological processes within life support systems.

3.2 Blue and Green Water

In the recent past as well as at present the approach to freshwater resources has centred only on specific aspects, while overlooking others which are equally, or more important, for human development. For instance, the quality problem with respect to freshwater looked only at the pollution problem. There is thus an invisibility regarding freshwater and the water related ecosystem services that is quite important with respect to direct freshwater services. Water is invisible as green water. This freshwater resources that is concealed in the soil and involved in the production of plants where it establish a green water vapour flow (evapotranspiration) back to the atmosphere. Yet, water is also discernible as blue water which occurs in rivers and streams, lakes, wetlands, bogs, and also partially in acquifers which trickle back into terrestrial water bodies via springs and wells. The hydrologic cycle is therefore separated into these types of water. Both green water and blue water makes up large components of the hydrologic system and interacts in such a manner that the one cannot exist without the other, with ecosystems also highly dependent on these type of water resources.

The concept of green water was introduced at an informal workshop organised by the Food and Agricultural Organization (FAO) in 1993 in order to reduce the invisibility of freshwater aspects contained in the water discourse literature. Most literature on desertification and the interdependence on soil and water ignores the special attention that is paid to invisible water resources and tend more to focus on the visible aspects of soil and water. The definition of green water originally referred to soil moisture needed for the production of plants. Blue water, on the other hand, concerned the water that passed trough acquifers and rivers. In other words, water seen in the traditional sense. The FAO accepted the venture in order to shed light on the conventional land/water dichotomy to change it towards the acceptance that land is a system which is transmitted by water and that the use of land is both dependent and impacted by water. The concepts was slightly modified by the FAO and was used to refer to the vertical and horizontal tributaries in the water balance. Green water was therefore referred to as vertical water and blue water as horizontal water. Green water was seen as the fragment of water that evaporated. This subsequently was defined as the water supply for all non-irrigated plants, including forests and woodlands, grasslands and rain-fed crops.

The green water section of the flow of global and regional water resources can be summarised as follows. The earth's surface is wetted by precipitation. The water that falls on the landscape replies with two main water flows which is produced through the apportionment of the falling precipitation at ground level. The vertical water vapour flows along the green water branch and involves the production of plants. Water is sucked up by the roots of plants and is channelled throughout the entire organism. Of all the water that is taken up by plants, only a small amount is consolidated as raw material in the plant production process and changed into plant matter (fibre) and oxygen. The rest of the water balance is released back into the atmosphere through the process of evapotranspiration when stomata unclose to take in other raw material like carbon dioxide (a greenhouse gas; see topic The Impact Of Climate Change On Water Resources: An Overview) from the air. Yet, green water does not only involve the evaporation of water via plants. Water can also evaporate from wet surfaces such as rivers, lakes and human made reservoirs. This is the non-productive component of green water. There is also a productive constituent attached to the green water equation, which involves plant production. This component is vital for the production of, for instance, agricultural commodities and timber. However, the non-productive route is involved in a number of eco-system services which can also be productive, but in an abstract sense only. This involves the economic valuation, of sort, of some aquatic eco-systems such as wetlands and marches.

The blue water, or horizontal, branch is composed of the water that flows under the earth's surface via acquifers and above the ground through the rivers flowing through the landscape. These flows are driven by gravity which moves the water to lower levels in the landscape and eventually (but not in all cases such as the Okavango River basin in Southern Africa) into seas and oceans. There is therefore two routes that are taken by the blue water branch: ground water and terrestrial water flows. This branch of (blue) water flows is very important, especially when considering the hydrological based projections of water needs to a growing world population (see article on the impact of demographics and water resources), food production (see article on the impact of El Niño on water resources) and other water related services such as navigation and hydro-power generation (see article on the impact of climate change on freshwater resources, flooding and drought). The flows of blue water resources represents the availability of water for use to satisfy the needs for socio-economic development in human societies. These flows constitute about 40 000 cubic kilometres per year (km^3/yr) which have been subject to manipulations, by humans and other living organisms such as beavers, to make water available where and when it is in demand. These controls of blue water are in the form of dams, reservoirs, canals, pipelines, irrigation systems, water purification plants, etc. and constitute a large component of human water services across the entire globe.

In spite of the staggering increase in blue water, through large dams and reservoirs, the volume of readily accessible blue water is much less than the green water. In fact, it is estimated that the global green water flow is about twice as large as the gross blue water flow i.e. around 125 000 km^3/yr. Whereas blue water flows are manipulated and mobilised in a more or less direct fashion, green water flows are indirectly exploited through a number of landscape activities like urbanization, reforestation, deforestation, crop production, influencing the division between blue and green water through infiltration and the uptake of water via plant roots. It should be noted that green water should not be confused with virtual water. Whereas virtual water accounts for water used in the production of all commodities, green water has to do with the evaporation of water from plants, such as grain, maize, sugar cane timber and a host of other economically and non-economically usable plant species.

The access to safe water, to aquatic ecosystem services including food production (food stuffs and fish) and to economic generation (industrial production etc.) are some of the

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Bibliography

Adams W.M. (1998). *Wasting the Rain: Rivers, People and Planning in Africa.* London: Earthscan Publications. [Practical examples of water projects are discussed critically ; River development plans are evaluated.]

Allan, T. (2001). The Middle East Water Question: Hydropolitics and the Global Economy, 382 pp. London: I.B. Tauris Publishers. [This book provides and in-depth look at the role of water in the economies of the states of the Middle East and North Africa region.]

Falkenmark, M. Gordon, L and Folke, C. (1999). Water in the Landscape - Functions and Values, 34 pp (Chapter 2). Food and Agricultural Organization: Geneva. [This chapter takes a closer look at the concepts of blue and green water and the interaction between the two regarding a number of interrelated aquatic and economic functions and values in society.]

Gleick P.H. (1998). The World's Water, 1998-1999: The Biennial Report on Freshwater Resources, 307 pp. Washington, D.C., Covelo, California: Island Press. [This report on freshwater resources across the globe, which is published every second year, gives a comprehensive study on different aspects of freshwater resources across the globe.]

Lundqvist J. *et al.* (1999). *Adapting to Growing Water Scarcity: Ecological and Social Challenges.* Report prepared for the Food and Agricultural Organisation. [This suggests a new way of thinking about water supplies, classifies water and identifies challenges for future water needs.]

Ponting C. (1998). Progress and Barbarism: The World in the Twentieth Century, 561 pp. London, Sydney, Auckland, Parktown: Chatto & Windus. [This book outlines the history of the twentieth century by looking at the various processes, dimensions and the problems associated with human live on our planet during this period.]

Rosegrant M.W. (1997). Water Resources in the Twenty-First Century: Challenges and Implications for Action, 27 pp. Washington D.C.: International Food Policy Research Institute. [This book provides useful information on the problems facing the water sector and the economic sectors dependent on this precious resource.]

Turton A.R. (1999). *Water Scarcity and Social Adaptive Capacity: Towards an understanding of the social dynamics of water demand management in developing countries.* London: School of African and Oriental Studies; MEWREW Occasional Paper No. 9. [A paper discussing how societies cope with water scarcity.]

Turton A.R., Goldblatt M., Moodley M., and Meissner R. (2000). An Analysis of the Role of "Virtual Water" in Southern Africa in Meeting Water Scarcity : An Applied Research and Capacity Building Project, 160 pp. Johannesburg: Group for Environmental Monitoring. [This report gives and outline of the impact of water scarcities on agriculture in selected Southern African countries and likelihood of off-setting these impacts by the importation of virtual water.]

Van Hofwegen P. and Svendsen M. (2000). A Vision of Water for Food and Rural Development. The Hague: World Water Forum. [This books outlines the different aspects of water use in societies with specific reference to food security and rural development.]

Biographical Sketch

Richard Meissner received his training as a political scientist at the Rand Afrikaans University (RAU) in Johannesburg. He obtained a Magister Artium (M.A.) degree in Political Studies from the same university in 1999 and is currently busy with a D.Phil. in International Relations at the University of Pretoria (UP). He was one of the first students in South Africa to complete a Master's thesis on water politics.

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