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VIRTUAL WATER FLOW AND WATER FOOTPRINT FOR SUSTAINABLE WATER USES AT NATIONAL AND INTERNATIONAL LEVEL

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By:

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Abstract

Just a few years ago, concept of virtual water in economics and environmental subjects has entered in developing countries like Pakistan. But it has been contemplated in the policies of developed nations for about 3 decades. The Virtual water is amount of water which refers to the water used for production of all the goods and services for consumers around the world.

This paper aims to identify the aspects and impacts of practices regarding water usage by the developed and developing countries that will bridge the gaps and further strengthening of global economies and environmental management.

We discussed about the concept of virtual water, types of required water and its connection with importing and exporting countries. We discussed about importance of virtual water trade. Where we focus on point that, water should be treated as an economic good. It is suggested that, achieving water security of water scarce countries by importing water intensive products instead of producing water demanding goods. Also described that how countries with rich water resources can get benefit from this situation. Which eventually refines global water use efficiency.

Then we have elaborated about water foot print and how it's helping to improve the water usage efficiency. We have described the classifications of water footprint (WF), water foot print assessment and manual approach of assessment of WF along with hotspot mapping of earth. Which overlays the water consumptions with local water stress data. The identified factors are highlighted and compared, with intention to help overcome the strains on economy and environment due to this extensive and imbalanced water usage.

Introduction

In about 1993 the term "virtual water" was coined at a seminar at SAOS. Before 1993 the term Embedded water was used by the authors, which did not capture the attention of water managing community (Allan 1993;1994)In recent years, virtual water concept has been extended to refer to the type of water that is required for the production of industrial goods as well as agricultural commodities. (Hoekstra and Hung, 2003).

Building upon the virtual water accounting in the literature, this study attempts to provide an assessment of water use efficiency embodied in the virtual water trade with respect to

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water saving, opportunity costs of the use of green and blue water, and environmental impacts. The assessment is made on two dimensions: the global and country levels, and the exporting and importing countries. With the focus of this study on the water use efficiency, we would, however, like to acknowledge that the virtual water trade issue is more complicated because of the sensitive political and social conditions, which also merit careful analyses

About 1000 cubic meter of water is required to produce a one ton of grain. If a political economy short of freshwater/soil water is conveyed a ton of grain, then that economy is spared the economic and importantly , the political stress of mobilizing 1000 cubic meter of water.

Globally, the volume of virtual water flow in commodities is 1,625 billion cubic meters a year, which accounts for about 40% of total water consumption. And 80% virtual water flow is related to agricultural products trade and rest is related to industrial products trade. Increasing demand for animal feed is also a current pressure on water resources. Meat production takes 8-10 times more water than cereal production. (UNESCO; 2020 WWAP)

Soil water is major input to productive sector of agriculture. The author emphasizes to support the natural vegetation environment by keeping an eye on the role of soil water (Falkenmark, 2000). However, water professionals and policy makers who know there is much at stake rejected the idea (Allan, 2001 a).Nevertheless, virtual water issues have primarily focused on food commodities due to their large share in total water usage. As water scarcity is continuously intensifying in many areas of the globe. So, balancing the local water budget by virtual water trade is expected an increase (Yang et al., 2003).

Water footprint is separated into classifications of net water consumption, there are three types of classifications, which is blue water, green water and grey water.

Grey water is a waste water. It includes waste water from all the streams except from fecal contaminations. It is generated from housing, corporate buildings, Schools etc. Grey water is also known as sullage and foul water. From the period of 1996-2005, the water foot print of crop production was 7404 Gm3 yr-1 (78% green, 12% blue, and 10% grey). The crops that require nitrogen fertilizers for cultivation have large grey water footprint. It was 733 Gm3 yr-1. For Wheat it wad (123 Gm3 yr-1), for maize it was (122 Gm3 yr-1) and for rice it was (111 Gm3 yr-1). Altogether it is 56% of global grey water footprint. But in most of the crops, the green water footprint contributes more than 80% of water footprint toward the total consumptive water footprint (Blue and Green). As it is blue water footprint account for 45% of the global water footprint. Large water footprints are found in the Ganges and Indus river basins (India, Pakistan and Bangladesh), in eastern China and in the Mississippi river. **(Mekonnen and Hoekstra)**.

Green water generally refers to the water stored in unsaturated soil (Savenije, 2000).Green water refers to the source of rain fed agriculture. Blue water is the water in the rivers, lakes, reservoirs, aquifers and ponds (Rockstrom et al., 1999). Blue water is typically used in agricultural practices as a supplement to rainfall. Blue and green water are the major classifications of water footprint and both of them have different characteristics in many aspects. Use of these waters also have different opportunity

cost. This paper conducts a partitioning to quantify the contribution of both waters in international food trade, the cost associated with trade of two types (Blue and Green) of virtual water is also addressed.

In contrast, there are many functions of blue water. Irrigation often yields lowest economic benefits among all other functions (Zehnder et al., 2003). Irrigation water has high opportunity cost. Meanwhile, facilities require for distribution and storage of blue water so, it can be delivered to the users. The supply of water involves cost. Moreover excessive irrigation cause water logging, salinization and soil degradation, which are obvious in many areas around the globe (Postel, 1999). From the viewpoint of the use of water resources and their opportunity cost, trading green virtual water is more efficient than trading blue virtual water, holding other factors constant.

The Hotspot Mapping is used to elaborate the blue, green, grey and total water footprint of per country consumption in the period of 1996-2005 (cubic meter/year/capita). The water footprint of national consumption for countries with a population larger than 5-million is shown in the maps provided below.

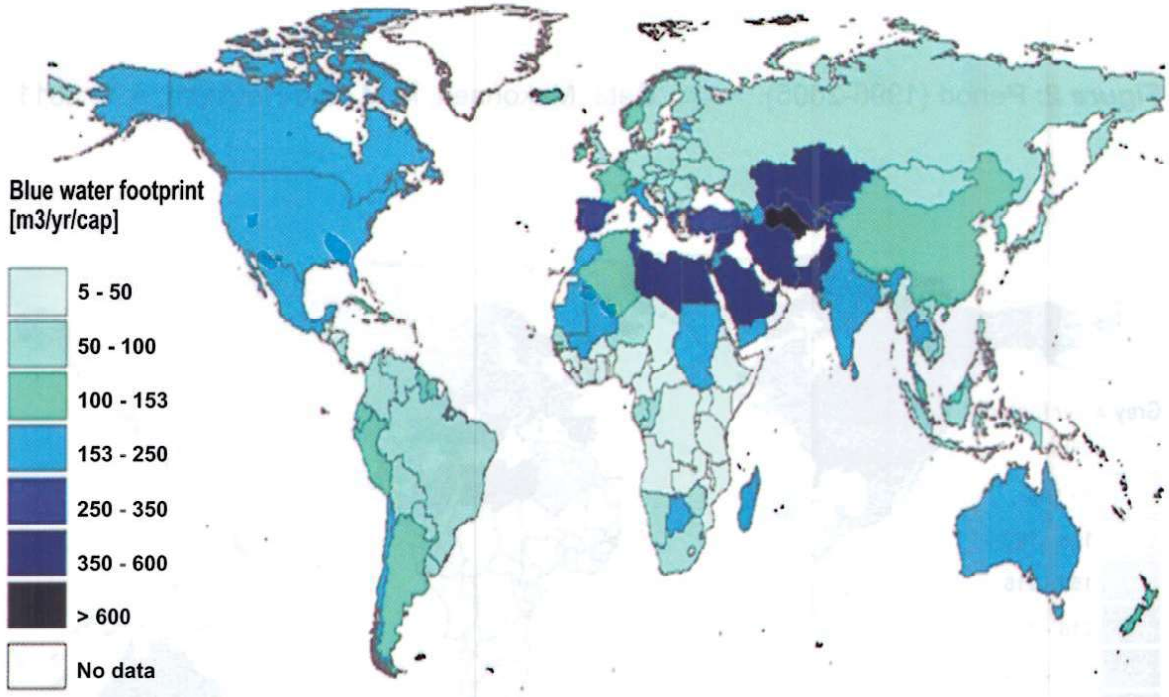


Figure 1: Period (1996-2005) Data: Makonnen, M.M. and Hoekstra, A.Y. 2011

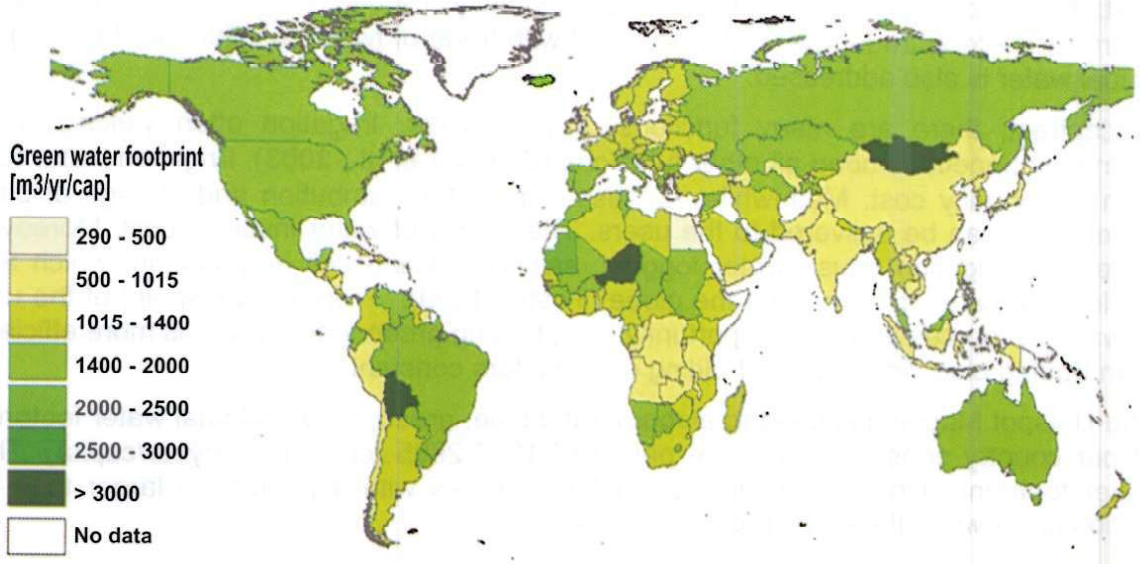


Figure 2: Period (1996-2005) Data: Makonnen, M.M. and Hoekstra, A.Y. 2011

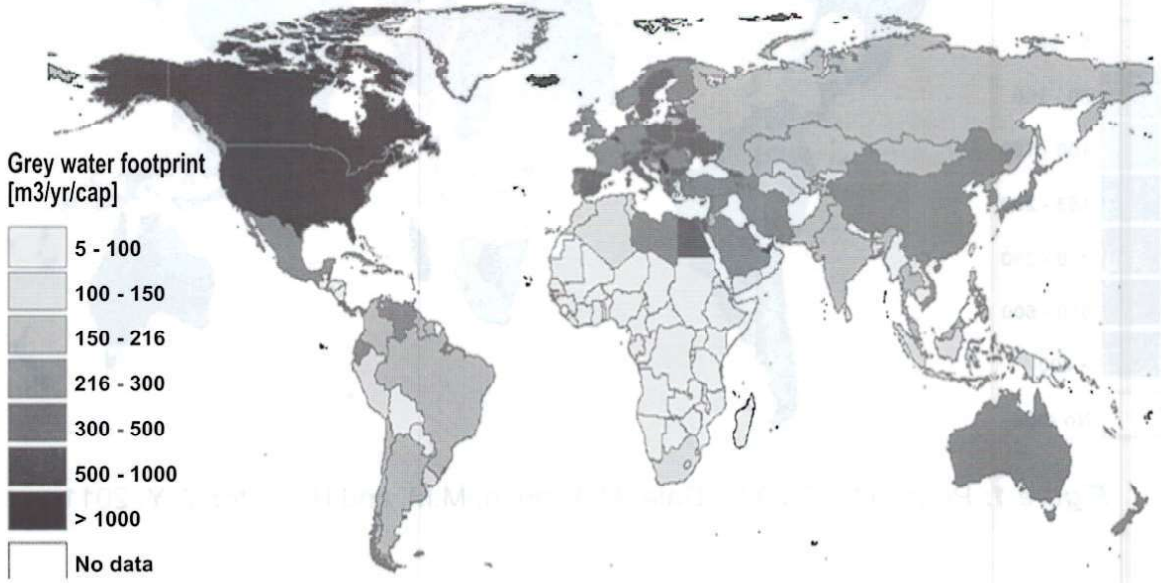


Figure 3: Period (1996-2005) Data: Makonnen, M.M. and Hoekstra, A.Y. 2011

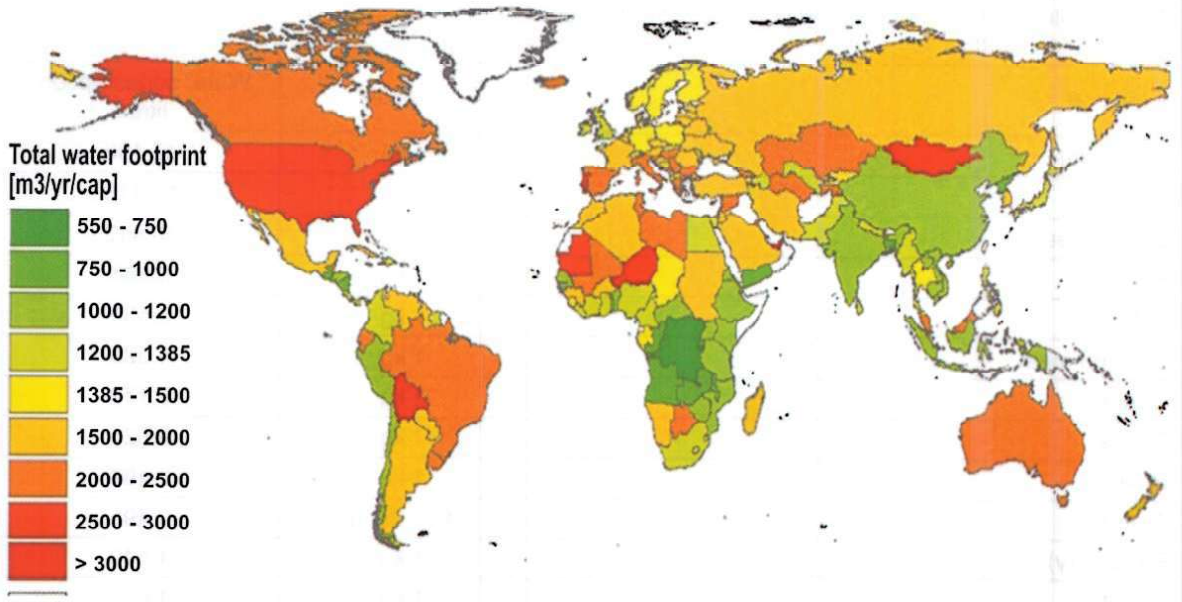


Figure 4: Period (1996-2005) Data: Makonnen, M.M. and Hoekstra, A.Y. 2011

Fresh water is the one-tenth from all the waters present on earth and available to humans for agricultural, industrial and household practices.70% water is used in agriculture, 20% is used in the industry and only 10% in household.According to this perspective, saving the part that has lowest share is not an appropriate solution to solve the problem of dehydration. The significant reduction in underground water resources in Middle East and African countries, we need to stop thirsty agricultural practices because they take a lot of water. And there is not dry a region to produce all crops it needs. We can divide our agricultural algorithm to the specific climate and geographical location of each country with the help of international cooperation and good policy.

IME (Institute of Mechanical Engineering) states that in 2050, the water requirements to meet food demands could reach 10-13.5 ton cubic meter/year, which is about triple amount of water being consumed currently by humans

Meat production require more water than vegetable production. IME states that, about 5,000 to 20,000 liters of water is required to produce 1kg of meat whereas it takes only 500 to 4,000 liters of water to produce 1 kg of wheat

The following table below shows the typical values for the volume of water required to produce goods. Chocolate tops the list, 17,196 liters of water is required to produce 1 kg of the chocolate. All kind of meat categories (Beef, Sheep and Pork Etc.) require very high amount of water for the production, and vegetable foodstuff considerably takes less water than meat. Tea, beer and wine use least amount of water for the production according to the list.

Take a look at the table below to see how much volume of water is required to produce a selection of common foodstuffs.

Typical values for the volume of water required to produce common foodstuffs		
Foodstuff	Quantity	Water consumption, litres
Chocolate	1 kg	17,196
Beef	1 kg	15,415
Sheep Meat	1 kg	10,412
Pork	1 kg	5,988
Butter	1 kg	5,553
Chicken meat	1 kg	4,325
Cheese	1 kg	3,178
Olives	1 kg	3,025
Rice	1 kg	2,497
Cotton	1 @ 250g	2,495
Pasta (dry)	1 kg	1,849
Bread	1 kg	1,608
Pizza	1 unit	1,239
Apple	1 kg	822
Banana	1 kg	790
Potatoes	1 kg	287
Milk	1 x 250ml glass	255
Cabbage	1 kg	237
Tomato	1 kg	214
Egg	1	196
Wine	1 x 250ml glass	109
Beer	1 x 250ml glass	74
Tea	1 x 250 ml cup	27
Source: IME (Institution of Mechanical Engineering,(2013)		

Despite of all the data differences, china, india and the united states are significantly identified as top consumers of the virtual water in the following study as well as in Hoekstra and Chapagain (2007) and Mekonnen and Hoekstra (2011). However this paper identifies the significantly smaller global as well as national water footprints.

This study tells about the virtual water profile and globalized world economy with suggestion of water management from many different perspectives. The water footprints composition at national and international level will help us to guide the regulations of economic as well as trade structure, especially for the countries with scarce resources of water to import water intensive products rather than producing them at national or domestic level. Virtual water dependency should be considered by the policy makers to enhance water security globally.

Moreover, the overall structure of global virtual water distribution pattern should be considered as the reference for water resource management for the future. However, it is challenging to support policy making process by integrating the accounting results with relevant institutional considerations.

Material and Method

The present study employs secondary research.Data has been collected from research papers and reports for Pakistan and other countries. The differences have been highlighted and compared to help identify the research gap for Pakistan, helping recognize the factors that leads to local and global water stress. They need to be addressed for economic growth and sustainability.

Results and Discussion

Those innovators provide the environmental and economic facts of life which contradict with strongly held belief system so if the message and is not shaped properly it will be ignored by whole system. To shape it pace its delivery to accord with political realities. In 1997 the authors of world development report (World Bank 1997: 144) used another way by quoting Machiavelli who captures the political flavor of

'The innovator makes enemies of all those who prospered under the old order, and only lukewarm support is forthcoming from those who would prosper under the new'. Machiavelli, N, 1513, The Prince.

It a harsh reality that worlds water resources are limited and no other phenomena can add water to the earth. The water crisis are serious and we are the beginning of the generation that will witness the endless war for water resources. As a matter of fact producing water is not possible or very difficult. But managing the available water resources is simpler, problem solving and logical. The agriculture and industries should be divided according to the geographical location to assess water in different countries

At present 844 million people which is about one in nine of earth's population, lacks access to clean water. Water is not affordable for them. Every year 300,000 children under age of 5 die of diarrhea which is linked to poor sanitation and dirty water. To provide water to those people is not just a vital need but also linked with human rights. It also provides great deal of economic and social benefits.The easily preventable diseases effects people of every age group, it effects children's education and adults that can't work because they are sick. It eventually effects the economy.

Girls in developing countries are worst off, as the stop going to schools when the hit puberty due to of sanitation system. Women in developing states suffer majorly as they have to fetch clean water for household every day. And every day they travel miles to get water and forced to defecate in open. These conditions makes women more vulnerable to violence. To provide affordable water to such people can save lives and reduces strain on healthcare as well as good for the economy. According to Water Aid statistics every £1 investment in clean water yields at least £4 in economic returns.The cost of £21bn a year to 2030, or 0.1% of global GDP, to provide hygiene and water to all those who need it, According to World Bank statistics the economic benefits would be $60bn a year.

Meanwhile, green virtual water dominates the virtual water trade, it takes less opportunity cost of water. A sensitive analysis suggests that there is high uncertainty in virtual water accounting and the estimation of the scale of water saving. This study raises awareness about limited effect of water scarcity on the global virtual water trade and negative implication of the global water saving for water use efficiency and food security for importing countries and also the environment in exporting countries. This paper shows the complexity in evaluation of efficiency gains in international virtual water trade. The findings of the study, nevertheless, call for the greater emphasis on rain fed agriculture to improve environmental sustainability and global food security.

Conclusion

The virtual water concept can help countries with scarce water resource to meet their food needs without using thirsty agricultural practices. For example it doesn't make sense for a water scarce country to use their water resources for agriculture when the food can be grown elsewhere and imported.

Water pessimism is considered wrong according to a paradox. But pessimism is extremely useful political tool which can help the innovators to shift the interdependent belief system of public and therefore the politicians. Water optimism is right but it is notion that enables the politicians to treat water as a low policy priority, it also delays the innovation and pleasing for the people who thinks world can progress according to old world order. Optimists bring unsensational good news but the good news is always complicated and indigestible.

This study critically assessed the water usage efficiency embodied in the international virtual water trade. Then the contribution of green blue water in virtual water trade is elaborated. In the view point of efficient use of global and local water resources and considering poor countries to develop irrigated agriculture, the agricultural technologies and investments should be devoted to development of rain fed agriculture. If we utilize the green water in agriculture and there would be less strain on blue water usage globally.

We need to clean and recycle water rather than searching for the water. We have to support the creative and dynamic businesses and to learn and train. Because in the end we are the responsible beings to be careful about the planet.

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