

Interactive comment on “Virtual water highway: water use efficiency in global food trade” by H. Yang et al.

A. Hoekstra

a.y.hoekstra@utwente.nl

Received and published: 14 February 2006

Comments on “Virtual water highway: water use efficiency in global food trade” (Hydrol. Earth Syst. Sci. Discuss., 3, 1-26, 2006).

by A.K. Chapagain [1], A.Y. Hoekstra [2] and H.H.G. Savenije [1,3]

[1] UNESCO-IHE Institute for Water Education, Delft, the Netherlands [2] University of Twente, Enschede, the Netherlands [3] Delft University of Technology, Delft, the Netherlands

The current paper addresses an interesting issue behind global food trade from the perspective of water. The basic concept behind the paper is simple and has been explored by a number of authors in the recent past (Oki et al., 2003; Oki and Kanae, 2004; De Fraiture et al., 2004; Chapagain et al., 2005a; 2005b). The methodology of

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper

the paper (definitions and virtual water flow accounting procedures) precisely follows the analytical framework as proposed by Chapagain and Hoekstra (2004), but lacks reference to this work. Sections 2-3 are presented as innovative, but just repeat what has been done earlier. The paper however is partially innovative if it comes to the partitioning of the virtual water flows into a blue and green water component (Sections 4-5). In our cotton study (Chapagain et al., 2005c) we have done this partitioning already (a reference would be appropriate), but this was for cotton only, whereas Yang et al. in the current paper carry out the partitioning for the full virtual water export flow for eight important food exporting countries. This is indeed innovative, leading to the apparent conclusion that global virtual water export is overwhelmingly green. It would have been better if the full paper had focused on that element of the study that does indeed provide added value if compared to the earlier studies.

The current paper concludes that the global food trade is beneficial in terms of water resources utilisation. The argument presented for this is that green virtual water constitutes lower opportunity cost and environmental impacts than blue virtual water. However, the paper does not present empirical evidence, or citations to the existing literature to support this.

The current paper does not raise the issue that the water savings in physical units are not necessarily beneficial from an economic point of view. In order to conclude something in that matter, a broader analysis is required, considering trade from the broader perspective of comparative advantages of nations (Wichelns, 2004). See also the discussion in our own papers (Chapagain et al., 2005a; 2005b).

The paper calculates the virtual water content of a primary crop by using the crop water requirement calculated from CROPWAT model, and dividing it by the yield (ton/ha). However the paper does not present a clear methodology to calculate the virtual water content of the processed products. It should be noted that the virtual water content of primary crops calculated by dividing the theoretical value of crop water requirement by the actual yield overestimates the virtual water content of a product. It assumes that the

[Full Screen / Esc](#)[Print Version](#)[Interactive Discussion](#)[Discussion Paper](#)

evaporative demand of a crop is fully met, which is not the case in many instances (viz. in cases when rainfall is not sufficient and when there is no or only partial irrigation). This should be acknowledged in the paper clearly.

A number of specific issues and comments are presented point-wise in the following paragraphs.

Page 2, line 14-16, the statement ‘the study raises awareness of negative impacts of increasing reliance on irrigation for food production in many countries, including food exporting countries’ is not supported by the text that follows. It appears as if the authors are going to elaborate on the issue of irrigation versus environment. However, the main objective of the paper is about global water use efficiency, and it does not analyse the consequences of irrigation on environment extensively. It raises expectations which are not met in the paper.

Page 2 line 23-26, the authors state that many countries have opted to import food to compensate the domestic water deficit and meet the food demand. This is an oversimplification of a complex issue of import of food by a country. Moreover such argument should be supported by evidences, examples or with the proper citations.

Page 3, line 1-3, in recent years a number of other studies appeared that estimate and analyse the global virtual water flows besides the three articles (Hoekstra and Hung, 2002; Oki et al., 2003; Zimmer and Renault, 2003) mentioned in the paper. Recent studies include (Chapagain and Hoekstra, 2004; Chapagain et al., 2005a; 2005b) which further elaborated the concept with wide coverage of agricultural and industrial products. Another study by IWMI (de Fraiture et al., 2004) discusses the issue of global water savings with international cereal trade in detail. The paper would be more valuable if the commonalities and the differences in these recent publications are discussed and would show what additional knowledge it adds.

Page 3, line 25-26, the statement ‘the rain-fed agriculture uses green water and irrigated agriculture uses blue water’ is incomplete. Irrigated agriculture is not synony-

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper

mous to the use of blue water as it also includes partly use of green water, unless otherwise it is practiced in dry period or dry areas and this is not always true. Except in some cases, such as Egypt where effective rainfall is zero, irrigation is mostly supplementary in nature.

Page 6, line 5-6, the statement ‘the study by Hoekstra and Hung (2002) is the only systematic study’ shows that the authors have not considered the recent literature, such as Chapagain and Hoekstra (2004), Hoekstra and Hung (2005), Oki et al. (2003), Oki and Kanae (2004), De Fraiture et al. (2004) etc.

Page 6, line 8-11, what would be the result if the authors use most recent results of virtual water content of the crops from the studies of Chapagain and Hoekstra (2004)? The virtual water content of crops in Hoekstra and Hung is for the period 1995-1999. Since the study period of the current paper is 1997-2001, and since the yield is not constant over time, the authors should use the virtual water content for the appropriate period. Chapagain and Hoekstra has improved the study by Hoekstra and Hung in many respect and presented the virtual water content of crop and crop products for the period 1997-2001. It is suggested that the current paper should use the most recent data available. The paper should clearly show the inherent limitations that are associated from the source of data used.

Page 7, line 2-3, the statement that the non-productive water losses are greater in developing countries should be supported with proper evidences or citations.

Page 9, line 16-17, the statement ‘the water productivity is generally lower in importing countries than in the exporting countries’ is not supported either by citations or by evidence. If this is based on regional averages, then the basis of estimating regional average water productivity should be explained which then may support the argument.

Page 19, line 18-20, the use of the factor C equal to 1.5 is a basic assumption that affects the conclusion. It would be interesting to see if the C value changes, say by 2 times (and this is reasonable in many countries where supplementary irrigation can

[Full Screen / Esc](#)[Print Version](#)[Interactive Discussion](#)[Discussion Paper](#)

boost up the production).

Page 21, Table 3. The major characteristics of blue and green water should be presented with proper referencing. The character ‘Adverse effect on soil’ is significant for blue water and insignificant for green water.

Page 23, Figure 2. The caption is incomplete. The units of water productivity should be shown clearly in the caption itself.

Page 24, Figure 3. It is not clear what these arrows show. Are these arrows for net virtual water imports or gross virtual water exports? It looks as if the thickness of the arrow is a visual representation of the volume of virtual water flows; however, it is not clear from the caption. Are the colours chosen randomly to show regional delineation or based on the intensity of virtual water imports?

Page 25, Figure 4. Should the caption not show the source of information? There is no use to show the scale in the map; better remove that.

In summary, we doubt whether the paper adds to the methods, calculations and insights from our own studies (Chapagain and Hoekstra, 2004; Chapagain et al., 2005a; 2005b) and the ones by Taikan Oki (Oki et al., 2003; Oki and Kanae, 2004) and by De Fraiture et al. (2004). It would be useful to take the earlier studies as a reference point and explain the differences in assumptions and outputs if any. The study can add most by focusing on the issue of green-blue water analysis, building on e.g. Postel et al. (1996), Rockstrom and Gordon (2001), and Chapagain et al. (2005c). In our view, it is a challenge here to show how exactly the green-blue partitioning is carried out, because the problem here is the lack of global data on green versus blue water use per specific crop type.

References

Chapagain, A. K. and Hoekstra, A. Y. (2004) Water footprints of nations. In: Value of Water Research Report Series No. 16, Delft, the Netherlands: UNESCO-IHE.

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper

Chapagain, A. K., Hoekstra, A. Y. and Savenije, H. H. G. (2005a) Saving water through global trade. Value of Water Research Report Series No. 17, Delft, the Netherlands: UNESCO-IHE.

Chapagain, A. K., Hoekstra, A. Y. and Savenije, H. H. G. (2005b) Water saving through international trade of agricultural products. Hydrology and Earth System Sciences Discussions 2: 2219-2251.

Chapagain, A.K., Hoekstra, A.Y., Savenije, H.H.G. and Gautam, R. (2005bc) The water footprint of cotton consumption, Value of Water Research Report Series No. 18, Delft, the Netherlands: UNESCO-IHE. [in revised form accepted for publication in Ecological Economics]

de Fraiture, C., Cai, X., Amarasinghe, U., M., R. and Molden, D. (2004) Does International Cereal Trade Save Water? The Impact of Virtual Water Trade on Global Water Use. In: Comprehensive Assessment Research Report, Sri Lanka: IWMI.

Hoekstra, A. Y. and Hung, P. Q. (2002) Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade. In: Value of Water Research Report Series No. 11, Delft, the Netherlands: UNESCO-IHE.

Hoekstra, A. Y. and Hung, P. Q. (2005) Globalisation of water resources: International virtual water flows in relation to crop trade. Global Environmental Change 15(1): 45-56.

Oki, T. and Kanae, S. (2004) Virtual water trade and world water resources. Water Science & Technology 49(7): 203-209.

Oki, T., Sato, M., Kawamura, A., Miyake, M., Kanae, S. and Musiaka, K. (2003) Virtual water trade to Japan and in the world. In: Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade, Value of Water Research Report Series No. 12, ed. A. Y. Hoekstra, Delft, the Netherlands: UNESCO-IHE.

Postel, S.L., Daily, G.C., and Ehrlich, P.R. (1996) Human appropriation of renewable fresh water, Science 271:785-788.

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper

Rockstrom, J. and Gordon, L. (2001) Assessment of green water flows to sustain major biomes of the world: Implications for future ecohydrological landscape management, *Phys.Chem.Earth (B)* 26(11-12):843-851.

Wichelns, D. (2004) The policy relevance of virtual water can be enhanced by considering comparative advantages, *Agricultural Water Management* 66:49-63.

Zimmer, D. and Renault, D. (2003) Virtual water in food production and global trade: Review of methodological issues and preliminary results. In: *Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade, Value of Water Research Report Series No. 12*, ed. A. Y. Hoekstra, Delft, the Netherlands: UNESCO-IHE.

Interactive comment on *Hydrology and Earth System Sciences Discussions*, 3, 1, 2006.

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper