Hydrol. Earth Syst. Sci. Discuss., 3, S40–S43, 2006
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European Geosciences Union

Hydrology and Earth System Sciences Discussions

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

Anonymous Referee #1

Received and published: 28 February 2006

General comments

The manuscript examines the efficiency of the water resource use "embodied" in the global virtual water trade from the perspective of importing and exporting countries respectively. It incorporates a partitioning of embodied water between blue water, i.e. liquid water involved in irrigation, and green water, i.e. naturally infiltrated rainfall consumed in rainfed production. The paper concludes that green water dominates the virtual water trade. The paper suggests a net saving of water as a result of virtual water trade estimated at 337 km3/yr. The reason is higher water productivity in exporting regions. There is however no effort to relate this saving to the total amount of water consumed in global food production as a whole. It is therefore not possible to realise whether this is little or much.

Overall the article is very clearly written and highly interesting. The partitioning into

green as opposed to blue water flows is interesting and rather new. It is of relevance in view of i.a. differences in opportunity cost. Blue water can be used in several higher value uses, whereas green water is seen to have low opportunity cost.

The paper is however in some senses rather superficial with a number of generalised statements that are poorly validated. The calculations cover cereal production with focus on 20 of the major crops, together representing 70 percent of the calory intake. What is excluded from the calculations is the 30 percent that basically represent animal products, vegetables and fruits. There is unfortunately no discussion of the implications of these limitations which might in fact be quite relevant for the overall conclusions: fruits may be produced in irrigated orchards; production of meat involves manifold consumptive water use per calory in feed production as compared to the consumptive water use per calory cereals.

There is also a discussion of the environmental impact implications of production in importing as opposed to exporting countries which to me is unacceptably superficial . No distinctions are for instance made in terms of types of environmental disturbances (deforestation, eutrophication from fertilisers, pollution from pesticides, salinisation from irrigation, etc.).

Specific comments/ scientific issues

1. The statement that export is overwhelmingly green (p 14):

Reference is given to the fact that exporting countries have basically temperate climate where irrigation is mainly supplementary and irrigation ratio is low (p 12, line 6), indicating that food production is dominantly rainfed. This may be valid for USA as a whole but is not evident for the reader having seen the huge irrigation schemes in C and W USA (Iowa, California etc). The statement has to be validated.

2. Environmental impact is seen as relatively small in exporting countries (p 15, line 25):

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This is another statement that has to be expanded upon and validated. It is wellknown that irrigated agriculture is causing severe ecological disturbances in both N America and Australia. Large scale eutrophication of coastal waters is now reflected even in oxygen free bottomwaters in Mexical Gulf. Large scale irrigation in Midwestern US has caused severe overexploitation of the Ogallalla aquifer under seven states. In Australia salinisation and river depletion caused by agriculture are core environmental problems.

Environmental impact of green water use is seen as relatively small, because it does not change the distribution of water resources and the hydrological cycle (p 11, line 12). Both eutrophication and water pollution from agrochemical are however spread all over the temperate zone. In S America, the effects of deforestation and clearing of new cropland are often referred to as serious environmental impacts from meat production, causing severe biodiversity loss.

3. Green water concept (p 10f):

The discussion p 10f is partly misleading. The concept “green water" was originally introduced by Malin Falkenmark at a Seminar in FAO in January 1993 as correctly stated on line 24. The concept was however introduced to refer to the water that supports rainfed agriculture, i.e. naturally infiltrated rainwater, stored in the unsaturated soil and taken up by crop roots (the FAO 1995 reference is correct). The concept "green water flow" was later introduced by FAO in their technical report to the World Food Conference in Rome, referring to the return flow of water to the atmosphere as ET.

4. Excluded food items:

The paper would benefit from a discussion of the implications of the exclusion of 30 percent of the calory intake in view of i.a. the fact that the consumptive use involved in meat production is up to eight times larger per calory produced than in production of cereals (see for instance p 56, Falkenmark & Rockström, Balancing water for humans and nature, Earthscan 2004).

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Technical corrections

* p3 line 26: says irrigated agriculture uses the “blue water"- should add “also" because a considerable part of the consumptive use is still green water

* p6 line 28: says “recent studies", referring to the non-beneficial evapotranspiration at the river basin level, but the reference is Seckler et al 1998, not so recent. The statement is a bit surprising since the same losses in Subsaharan countries amount to 80-90 percent on the farmers field. There is therefore evidently a difference between farmers field and river basin level which might motivate a comment

* the connotation C is used in two senses in the paper - should be avoided

Overall, I consider the article highly interesting but in need of complementary discussions to validate the different statements, commented upon above.

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