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

H. Yang et al.

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The authors would like to thank the anonymous referee 1 for the positive evaluation and constructive comments and suggestions on our paper. The following are our responses to referee's general comments and specific comments and issues.

- Responses to general comments:

The calculations cover 20 major food crops. These crops together provide about 70% of the total calorie intake on world average. The rest of 30% is primarily from animal products, vegetables and fruits. In the revised manuscript, we noted the relevance of the trade of animal products and fruits and vegetables to the assessment of global virtual water flows. However, we kept the original scope of the study. The justification of the scope is as follows (which is added in the revised manuscript. See pages 8-9): For developing countries, mostly food importers, the proportion of these 20 crops in the total calorie intake is around 80% (FAO, 2004). In this study, we confine the scope to

food crops. This is mainly because of the difficulties in estimating virtual water contents in animal products in individual countries, although it is generally the case that manifold water would be used for producing per calorie dietary energy in meat production as opposed to that in food crops. Even for the same kind of meat from the same country, the virtual water contents are highly variable depending on the ways the animals are raised, e.g. under stalled condition or range and grazing conditions. Moreover, the water used in processing animal products varies largely and the data are not available for most of the countries. As acknowledged by Chapagain and Hoekstra (2003), 'the data weakness posed a serious constraint to such effort (determining the virtual water content in livestock and livestock products)'. The exclusion of fruits and vegetables in this study is because of the small volume of the virtual water embodied in the global trade of these crops in comparison to major food crops (Zimmer and Renault, 2003).

Regarding the comments on the discussion of the environmental impacts, the authors agree with the referee that there is a need for validation and specification. In the revised manuscript, we dropped the statement that the environmental impacts of green water use are less significant than the blue water use, as this is a complicated issue and a generalized statement may not be appropriate. Section 5.2 is dedicated to addressing the environmental impacts of virtual water trade on the major exporting countries with respect to overexploitation of water resources in some areas and the water pollution caused by excessive use of chemical fertilizers and pesticides. References are provided to support the points addressed.

- Responses to the specific comments/scientific issues

1. The statement that the export is overwhelmingly green:

The suggestion is taken. The negative environmental impacts on the exporting countries are specified in Section 5.2 in the revised manuscript.

2. Environmental impact is seen as relatively small in exporting countries:

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We agree with the referee's comment and consider that our earlier study did not pay sufficient attention to the environmental impacts of the virtual water trade on the exporting countries. Changes are made in the revised manuscript (see Section 5.2).

3. The origin of the green water concept:

We did not find the text of Falkenmark's Seminar in FAO in January 1993, mentioned by the referee. We double checked the source of reference we cited in the paper, i.e., Falkenmark (1995) and consider that the citation is appropriate. However, we added a reference on the discussion of 'green' and 'blue' water by Rockström (Rockström et al, 1999), who has down an extensive research on the green and blue water issues following the inception of the concept.

4. Excluded food items: See the general response.

Technical corrections: p3 line 26. The comment is taken. p.6 line 28. 'Recent' is drop from the text. In addition, a more recent study by Molden and Bos (2005) is added. The high ratio of water loss to water supplied at the farm level is acknowledged in the text as 'the amount of water supplied to irrigated field is typically 2-3 times of that required for actual crop evapotranspiration' (page 12)'. The difference between the loss at the farm level and the loss at the river basin level is widely recognized in the agricultural water community. However, there is a debate on the magnitude of the loss at the river basin level. We provided two references for raising the awareness of the issue. A detailed discussion, however, is beyond the scope of this study.

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