Response to reviewers – The water footprint of Indonesian provinces related to the consumption of crop products

F. Bulsink, A.Y. Hoekstra, and M.J. Booij

2 December 2009

We thank both referees for their critical but constructive comments.

Reply to comments by referee #1

The primary concern of the referee is that we extend our discussion beyond the realm of our calculations. The remark specifically refers to the last paragraph of the discussion section, where we go beyond our calculations indeed. [The first four paragraphs of the discussion section remain very close to interpreting the results of our calculations.] We have deleted the whole final paragraph about alternative routes to increase water use efficiency in Indonesia. We do still subscribe to what we said there, but we acknowledge that we cannot do that based on the results of this paper. In the introductory section we have removed the claim that our data can feed a discussion on the role of trade in water resources management. We think that our paper lays the basis for others to apply water footprint and virtual water flow accounting in more detail, add economic analysis and thus provide insights that are useful in evaluating trade flows from a water perspective. But we acknowledge that our study is a first in its sort for Indonesia, so it is premature to use the results from the current study to make policy recommendations already now. We do not support the remark of the referee that the paper would not be innovative. On the contrary, we consider the paper as pioneering research, opening a whole new field of research. Applying the consumption perspective when quantifying water demand (i.e. looking at the water demand related to the consumption of people in a region) instead of the traditional production perspective (i.e. looking at the water demand in an area given regional production) is very new in water use studies, nowhere in the world applied in practice yet. Our paper lays the basis for change in this respect. The current paper is one of the first country studies that looks at virtual water flows within the country. Quantitative research on the relation between interprovincial trade and regional water demand has been done only in two earlier papers (Ma et al., 2005; Kampman et al., 2008).

The referee wonders why we quantify water use in a humid region where rainfall is often quite adequate. The reason is that humidity is not the same as water abundance. The island of

Java is a good example: it is humid but water is scarce. The innovation of the water footprint accounting method is that it shows that. We show that consumers on Java are dependent on virtual water imports. Included in the question of the referee is also why we look at green water (rainwater) at all. We refer here to the works of for example Rockström, J. (2001) and Falkenmark and Rockström (2004) who – in our view – have sufficiently made clear that the traditional (engineering) focus on blue water (groundwater, surface water) is insufficient and that a full analysis of water use should include an analysis of green water use. We have included a motivation of why look at green water in a humid country in the introductory section.

The referee questions the notion of the grey water footprint. The concept has been applied in a number of earlier studies. A more elaborate definition has been included now and a reference has been given. It is true that we have restricted the analysis in the paper to nitrogen. This has been a practical choice, because of lack of data. Since this restriction has been clearly stated we do not see this as a problem. Data assumptions with respect to spatial patterns in fertiliser use and dilution factor have been spelled out. One can argue – as the referee – that the assumptions are not necessarily true, but the assumptions taken are the most logic ones in the case of absence of better data.

Without providing a reference we state that the impact of blue water use generally has a larger effect than green water use (per cubic metre of water used). We have added a reference now.

Reply to comments by referee #2 (Jewitt)

The major concern of the referee is that the water footprint concept and methodology are too blunt for providing policy relevant information. We agree with the referee only in the sense that currently the new field of water footprint and virtual water studies is so young that it needs to grow to a stage where it is mature enough to feed actual decisions in water management. In the current stage, required data are often still lacking (because data collection has been geared to traditional water analyses), which means that assumptions have to be taken where full detail about spatial and temporal patterns (e.g. of consumption, trade and fertiliser use) are lacking. As a result, the current study is indeed weak as a solid basis for immediate interpretation for policy making. However, it is a first good step given available data and gives the basis for other researchers to further build on (and particularly refine). We agree

with the referee that we have to be careful in making conclusions that go beyond the analysis. This was also indicated by the other referee. For this reason we have deleted the last paragraph in the discussion.

We strongly disagree with the referee if he means to suggest that the water footprint concept and methodology are *inherently* too blunt for providing policy relevant information. For substantial arguments we particularly refer to the recent water footprint manual (Hoekstra et al. 2009) that shows that the water footprint accounting method allows for great temporal and spatial detail and how it can form a basis for impact assessment at catchment level and feed policy making. The fact that most studies so far do not show that great detail and that aggregated and global average figures like '140 litres for one cup of coffee' are so much cited, does not say that this is the level of detail where water footprint studies will remain. The most recent studies show an increasing level of detail and policy relevance, see for instance Aldaya et al. (2010, the book is already available although the date suggests otherwise....). Although very interesting, the debate about where water footprint studies will go, what they can mean for policy making, etc., is not the subject of the current paper for Indonesia. So we agree with the referee that in the case of this paper we should not go beyond what we can state based on the analysis in this paper, hence we have deleted the reflection on possible implications of our calculations for policy.

We agree with the referee that the water footprint figures can be misused in the media and that they sometimes are, but this has little to do with our paper. In our paper we use strictly defined concepts – following terminology as applied in earlier scientific publications.

The referee suggests to rethink the green water footprint definition. He suggest that one can better not look at the total green water footprint of a crop but rather at the additional evaporation if compared to evaporation from natural vegetation. This is a good discussion, but not for the current paper. As Hoekstra et al. (2009) explain, it depends on the question that one would like to address. The green water footprint measures total evaporation and is meant in the end to feed the debate about the allocation of water to different purposes in a context of limited availability. Information about increased or reduced evaporation is relevant from the perspective of catchment hydrology and potential downstream effects. The purpose of the green water footprint is to measure human's appropriation of the evaporative flow, just like the blue/grey water footprint aims to measure human's appropriation of the runoff flow. But

again – though interesting and highly relevant – this is not really about the paper, where a clear choice has been made to look at total water volumes used, not to quantify downstream effects of green water use at catchment or river basin scale.

Specific comments

- some more info on Indonesia's climate added in the intro.
- the period 2000-2004 can be taken as representative for the production and yield data; for climate data we have used average climate data (i.e. over 30 years), so we have not looked into dry or wet years, but at an average year only.
- the crops selected represent 86% of the total water use, etc: these percentages have been calculated as part of the study based on FAO data and water use estimates from Hoekstra and Chapagain (2008).
- crop areas and yields have been taken from Ministry of Agriculture (2008) and BPS (2008b); for crop parameters we have tried to select the most reliable local values, but in many cases there are no local data. The crop parameters are obtained from a variety of sources: Allen et al. (1998), Chapagain and Hoekstra (2004), IRRI (2008), Swastika et al. (2004), FAO (2008b), Taufiq et al. (2007) and Wood and Lass (1989).
- in the calculations of ET a ten-day time step is applied.
- the dryland versus irrigated land is shown in the table below; we think, however, that including the full table in the paper is not necessary, it is included in the source that we refer to.

Province	Land type [10^3 ha][1]		Irrigated area fraction				
	Wetland	Dryland	Rice	Maize	Cassava	Soybeans	Groundnut
Nanggroe Aceh D.	367	799	0.99	0.20	0.20	0.20	0.20
Sumatera Utara	575	813	0.90	0.21	0.21	0.21	0.21
Sumatera Barat	238	525	0.98	0.06	0.06	0.06	0.06
Riau	120	709	0.86	0.08	0.08	0.08	0.08
Jambi	161	733	0.84	0.12	0.12	0.12	0.12
Sumatera Selatan	484	662	0.87	0.27	0.27	0.27	0.27
Bengkulu	77	263	0.83	0.11	0.11	0.11	0.11
Lampung	313	786	0.84	0.13	0.13	0.13	0.13
Bangka Belitung	4	161	0.37	0.02	0.02	0.02	0.02
D.K.I. Jakarta	2	3	1.00	0.29	0.29	0.29	0.29
Java Barat	918	809	0.95	0.11	0.11	0.11	0.11
Java Tengah	968	764	0.96	0.21	0.21	0.21	0.21
D.I. Yogyakarta	57	96	0.73	0.10	0.10	0.10	0.10

Java Timur	1096	1153	0.94	0.21	0.21	0.21	0.21
Banten	195	260	0.91	0.13	0.13	0.13	0.13
Bali	80	134	0.99	0.05	0.05	0.05	0.05
Nusa Tenggara Barat	226	246	0.87	0.28	0.28	0.28	0.28
Nusa Tenggara Timur	116	738	0.66	0.08	0.08	0.08	0.08
Kalimantan Barat	275	847	0.71	0.16	0.16	0.16	0.16
Kalimantan Tengah	164	970	0.58	0.10	0.10	0.10	0.10
Kalimantan Selatan	434	383	0.89	0.40	0.40	0.40	0.40
Kalimantan Timur	124	456	0.56	0.16	0.16	0.16	0.16
Sulawesi Utara	58	359	0.94	0.05	0.05	0.05	0.05
Sulawesi Tengah	118	703	0.97	0.04	0.04	0.04	0.04
Sulawesi Selatan	569	625	0.99	0.26	0.26	0.26	0.26
Sulawesi Tenggara	73	300	0.89	0.11	0.11	0.11	0.11
Gorontalo	27	175	0.97	0.05	0.05	0.05	0.05
Maluku			0.81				
Maluku Utara			0.86				
Papua			0.81				

Source: BPS (2008b)

- we agree that the assumptions made to calculate the grey water footprint are coarse, most in particular the assumption of regional pattern of application; the dilution requirement and leaching fraction vary around the numbers we have assumed, but literature on these values does not show wide ranges. The fact that our estimates are a first crude estimate underlines what both referees have emphasised: do not suggest that in this stage the resulting figures are ready-to-use for policy making. We do no longer suggest that.
- Regional differences relate to regional variations in green and blue water footprint, not in grey water footprint.
- Reliance on data external to the paper: all input are external, the scope of study is broad, so the number of input data and reliance on these data is substantial, but that is inherent to this sort of study.

The referee rightly points at the fact that the water footprint data do not tell anything about the local impact of the water footprint. The paper does also not suggest that. The water footprint specifies the total water use related to consumption of the people in a province, no more and no less. See for a more elaborate treatment of this issue: Hoekstra et al. (2009).

References (in so far not in first manuscript)

Aldaya, M.M., Garrido, A., Llamas, M.R., Varelo-Ortega, C., Novo, P., and Casado, R.R. (2010) Water footprint and virtual water trade in Spain, In: A. Garrido and M.R. Llamas (eds.), Water policy in Spain, CRC Press, Leiden, The Netherlands, pp. 49-59.

Falkenmark, M. and Rockström, J. (2004) Balancing water for humans and nature: The new approach in ecohydrology, Earthscan, London, UK.

Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M. and Mekonnen, M.M.: Water footprint manual: State of the art 2009, Water Footprint Network, Enschede, the Netherlands, www.waterfootprint.org/downloads/WaterFootprintManual2009.pdf, 2009.

Rockström, J. (2001) Green water security for the food makers of tomorrow: windows of opportunity in drought-prone savannahs Water Science and Technology 43 (4): 71-78.