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Hydrology and Earth System Sciences Discussions



# *Interactive comment on* "The water footprint of Indonesian provinces related to the consumption of crop products" *by* F. Bulsink et al.

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GENERAL COMMENTS

The Water Footprint (WF) has been a useful illustrative tool for broad scale and broad brush analyses of "water use" and has provided a new idea in the context of "national water use accounts. However, when it comes to conclusions drawn from WF studies and recommendations for policy development, I believe that the approach has some major conceptual and methodological shortcomings. These are highlighted by the attempts to estimate the WF at smaller spatial scales and the conclusions being derived from such analyses. The WF is far too "blunt" for this and this particular paper highlights these problems.

The WF is defined as "the total volume of fresh water used for the production of that product at the place where it was actually produced" (Hoekstra and Chapagain, 2007). The promoters of the WF argue that it provides an opportunity to extend the "national water accounts" beyond "blue water accounts". Whilst this is a useful idea, what it does not do is provide a context for water resources managers, policy makers etc as the WF provides no information on the impact of that footprint. i.e. not brought back to a context which is useful. Regarding the green water component of the WF, there is an inherent assumption that because the crop transpires that there is an associated impact, but there is nothing in this paper to explain what the impact of the water footprint is. Just because the crop transpires water doesn't mean that there is a water resources impact - unless you assume that all that water is available and could be used for something else.

The simplifications inherent in the WF is symptomatic of many areas of natural resource management where the use of scientific information can degenerat into simple application of generalised values and a straightforward belief is allowed to pass as fact i.e. "pseudofact" The late Ian Calder pointed out that many aspects of land use and water resource decision making are based more on perceived wisdom (myth) than scientifically established reality (Calder, 1999). I am concerned that WF approach, particularly as analyses at smaller spatial scales and advice to policy makers seem to be the next step, is in danger of generating a body of pseudofact that may influence water resources decision making and ultimately result in a range of "peverse outcomes" and "unintended consequences". The WFs of coffee and beef are a prime examples. According to the WF network website (http://www.waterfootprint.org/), the WF of Coffee is 1100l per litre of beverage and 15500 litres of water is needed to produce one kilogramme of beef. It is stated that this is "This is equivalent to 1.5 times the annual Rhine runoff .." - the obvious implication being that drinking less coffee will result in more water being available in rivers. These types of generalisations are seldom explicitly tested and the danger is that a body of "pseudo-fact" becomes generated in a self-reinforcing mode which seldom challenges theory, and ultimately forms a barrier to effective, scientifically based management which can perpetuate inappropriate paradigms or myths (Gunderson et al., 1995).

The danger of the WF figures is well illustrated by the way they are interpreted in the press, and in this information age, the “blogosphere” e.g. “From a water conservation perspective, we shouldn’t ban bottled water, we should ban coffee.” - http://eaves.ca/2009/03/30/water-footprint-and-the-bottled-water-debate/ or suggestions that we should eat less beef (http://www.doobybrain.com/2009/03/18/ways-to-reduce-your-water-footprint/). As discussed below, these “order of magnitude” type estimates are of little use for water resources planning and when these sort of suggestions take hold, they have the potential to negatively affect development goals. For example, it is often argued that one way for nations to reduce their “water footprint” is too decrease imports of beef or coffee from these areas of high evaporative demand - typically found in developing countries. However, as I argue below, with more consideration of context, the WF of these products in many parts of the world is effectively zero! Whilst the interpretations of the press and the blogosphere may be outside of our control, I believe that it is incumbent upon us as scientists to protect against the development of this sort of pseudofact based decision making and provide carefully reasoned, scientifically rigorous recommendations if we are to influence water resources developments in a manner that will not, for example, compromise a country’s development goals.

Thus, I think that the green water component of the WF in particular, needs rethinking. One way to do this is compare the WF to a baseline - usually this is the natural vegetation. Coffee may have a high evaporative water use, but so too does the local natural vegetation, so the water resources impact is low. i.e. define the green WF as the total volume of freshwater used for the production of the crop relative to the natural vegetation where it is produced. This is the approach followed in the recent publication on the WF of beer (SAB-Millar and WWF-UK, 2009) and I think this approach must be developed further. Obviously, this does introduce additional uncertainty in the analysis as there may be little information on the water use of the natural vegetation. However, this provides are far more sensible indicator of the water footprint, and would, I believe, go a long way in resolving the problem that in regions where evaporative demand is high, so too is the water footprint (Hoekstra and Chapagain, 2007). For example, the green water component of the water footprint for "free range" beef which only eat natural grasslands would effectively be zero, as would any other activity which utilises the natural vegetation (Where beef is grazed on deforested land, the water footprint may be negative. How could this be considered? Obviously other environmental impacts and/or spatial and temporal scales may have to be considered – IWRM?).

The use of net green water is an advance in that it provides some indication of the relative impact of that crop. However, it still says nothing about the water resources impact, unless one adopts a simple mass balance approach i.e. a reduction in GWF implies a corresponding downstream blue water effect, but this reduces hydrology to a one-dimensional science - which it is not!

The reality is that components of the hydrological cycle, such as rainfall, evaporation, plant water use and runoff, show great variation in both time and space. Although it may be useful as a broad illustrative concept, to focus on a WF for a country, province, crop etc, it is not particularly meaningful for management of water resources, nor for future planning (Jewitt, 2006). Such macro level indicators cannot allow for adequate consideration of the complexities, processes and linkages at different levels which are essential for the sustained functioning of the hydrological cycle – and it is this that any resource dependent industry, such as agriculture depends. The role of the landscape, soils, climate etc and the spatial and temporal variability of these are fundamental and ultimately assessing whether a change in land use has a water resources impact. In this paper, the authors provide no information on the natural climatic, soil, etc variability in space and time. I would argue that a mean annual WF is meaningless at any spatial scale and that the WF cannot recognise this complexit so essential in the understanding of water resources analysis and planning and the hydrological science



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underpinning it.

The approach adopted in South Africa to regulating commercial forestry as a land use that has a water resources impact is informative (Jewitt, 2002). Whilst the green water “used” by a timber plantation can be estimated using variety of techniques, including remote sensing, commercial forestry is recognised as one of several water users for it’s impact on streamflow and under the South Africa National Water Act is termed a “streamflow reduction activity” defined as the difference in runoff generated by the vegetation under consideration and that generated under natural conditions. Thus “water use” is defined as the reduction in streamflow compared to a baseline, which is very different from the consumptive use to grow the plant and which is used in defining the green water footprint.

A similar argument can be put forward for the grey water component of the WF – it needs a water resources context and one could also argue that the Blue Water component ignores return flows etc etc

Finally, in this paper, there is a heavy reliance on “rule of thumb” parameters, an assumption that average crop and climatic conditions prevail, little consideration of soil properties etc all of which are extrapolated well beyond their limits of uncertainty leaving increasingly high uncertainty as the spatial and temporal scales are reduced. If the scale of analysis is decreased, the level of information must necessarily increase if the uncertainties in the analysis are to be minimised.

Rereading this review, one could assume that I am totally against the WF – I’m not. It is a useful illustrative tool. With some refinements in definition, method and calculation it can offer a better indication of broad scale water “use”. However, what I am opposed to is it’s use beyond what is scientifically acceptable. I am of the opinion that this an example, where conceptually, methodologically and procedurally, it’s application is questionable. Another reviewer has already pointed out the lack of rigour and low confidence in the accuracy of the results and the inappropriateness of the conclusions and recommendation derived from the study.

SPECIFIC COMMENTS There is too little information about the study area. I am not very familiar with Indonesia. I would like to see ageneral description of the area and its climate e.g. some information regarding rainfall of the islands, potential evaporation, rainfall seasonality etc.

The analysis is based on only four years of data – i.e. 2000-2004. I find this highly problematic. It is far too short a period of analysis to be representative. There is no analysis of whether these were "normal" years or not etc.

[Page 4] production value and land use. This selection resulted in the following list of crops: rice, maize, cassava, soybeans, groundnuts, coconuts, oil palm, bananas, coïňĂee and cocoa. The selected crops represent 86% of the total water use, 71% of the production value and 86% of the total agricultural land. The study basically follows the..

Reference for this statement?

[Page 5] 2008a) 15 and BMG (2008). Subsequently, the reference evapotranspiration is multiplied with a..

What is the area of the crops used? How representative is the CAY for the crops chosen? I'm sceptical of how the FAO56 parameters are at this scale.

[Page 6]The rainfall data are obtained..

What is the temporal resolution of the data and what was the time-step used for the analysis?

[Page 6] SunÂăSepÂă20,irrigated. The calculation of the irrigated area frac- tion is based on..

I would like to see an table showing the dryland and irrigated area of each crop before the results of the analysis. The fact that the "estate crops", are not irrigated and that the



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green water component is the largest part of the footprint re-emphasises the problem of not considering the water use of a natural vegetation. If this was included, the WF values would be completely different and so too all the analyses that build on this.

[Page 6] used as artiïňĄcial fertilisers in agriculture. The grey water footprint is..

I find the assumptions regarding the estimation of the grey water footprint problematic. It has argued that there is an advance in the methodology by adding the grey water component. However, is this simplified approach really and advance and are the assumptions valid in the context of predominant agricultural practices and issues in Indonesia? This coarse assumption is out of synch with the scale of analysis – surely there are differences between the islands. How representative are the leaching and dilution factors for the study area?

[Page 6] the 15 same in every province. The leaching factor is taken....

I could argue then - What is the point of estimating the water footprint at provincial scale. Surely the data availability should match the cale of anlysis!

[Page 7] junÂăSepÂă20, and is derived from the national food balance (FAO, 2008e). The population by...

See comments above re: scale of available information versus the scale of analysis

[Page 7] into Indonesia is taken from Hoekstra and Mekonnen (2009). 20 3 Results 3.1 Water..

In general far to much reliance on data external to this paper - it's difficult to accept all these assumptions. Because of these, there is extremely high uncertainty in the published results. It is quite likely that there are order of magnitude size errors.

[Page 7] Cassava has the lowest water footprint of the crops considered, namely about 500 m 3 /ton, and coïňĂee the highest, about 22 900 m 3 /ton. The water footprints of the..



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[Page 8] jby the high production quantity and the high water footprint per kilogram of rice pro- duced. Rice is the most important crop...

The footprint tells me nothing about the IMPACT on water resources. There is an inherent assumption that because the crop transpires that there is an associated impact, but there is nothing in this paper to explain what the impact of the water footprint is - the water footprint itself provides no spatial, temporal context for a reader to assess this. This is because the authors provides no information on the natural climatic, soil, etc variability in space and time. Do Cassava and Coffee even grow in the same area. Just because the crop transpires water doesn't mean that there is a water resources impact unless you assume that all that water could be used for something else. The major problem here is that the WF needs context and the way to do this is compare the WF to a baseline - usually this is the natural vegetation. So rice may have a high WF, but the water resources impact could be low. The authors need to calculate net green water flow. Using gross green water flow provides a very poor indicator of water use.

[Page 8] ThuÂăSepÂă24 the water footprint is marginal. Most crops are thus mainly grown with rainwater. Because blue water originates from groundwater or surface water, this component has a larger effect on the environment than the green water use. The crops rice, oil palm...

Exactly - and this is the key - what is the impact? In a water resources management and planning context, the return flows should also be estimated

[Page 10] ThuÂăSepÂă24, type of crops consumed) have been assumed to be the same 20...

Another broad and general assumption.

[Page 12] blue water contribution is higher. The blue water use has a larger eïňĂect on the environment than the green water use, because this component is withdrawn...

But the entire analysis of the virtual water trade is heavily biased by including the gross



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green water flows in the WF. These analyses would be very different if net green water was used.

[Page 12]crops in provinces where the water footprint of those particular products is low. When the pressure on the...

Unfortunately, the WF as it is estimated here, does not give an indication of the impact on Water Resources. Hence this conclusion cannot be justified.

[Page 13] But to achieve this the agricultural sector needs to be reformed on the basis of water- eïňČcient production and wise trade. There are two alternative routes....

This may be true - but the results in this paper cannot be used as the justification for such a broad statement.

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