

## ***Interactive comment on “Review and classification of indicators of green water availability and scarcity” by J. F. Schyns et al.***

**J. F. Schyns et al.**

j.f.schyns@utwente.nl

Received and published: 13 August 2015

We thank Referee #2 for the time and effort spent on reviewing our manuscript and the constructive and specific comments given. In the following we will respond to the six points raised by the referee.

1. As also indicated in our response to Referee #1 (AC C3075), we agree that our article can be extended beyond a listing of the indicators. We will add to our review more reflection on the indicator classes and the rationale behind them. Specifically, we will discuss per category of indicators (where not already done so): which insights are they able to provide and which not; for which purposes are they useful (rationale behind development); which processes, both natural and human, are of influence on

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



the indicators. This implies that we will transform our writing to a more discussive style where appropriate, as recommended by Referee #2.

2. We very much appreciate the suggestion to include an overview table of the indicator classes in the paper. We will include such a table, including a characterization of each class based on the specific points from our more comprehensive review (see point 1).

3. In accordance with the referee's proposition we will include the following sentences in the introduction of the paper: "A review of green water scarcity indicators is new in its kind. Past reviews of water scarcity indicators (Savenije, 2000;Rijsberman, 2006) date back a while and hence do not include recent developments in the field, especially those related to the inclusion of green water. There exist multiple reviews of specific green water availability indicators, such as indicators of aridity (Wallén, 1967;Walton, 1969;Stadler, 2005) and drought (World Meteorological Organization, 1975;Wilhite and Glantz, 1985;Maracchi, 2000;Tate and Gustard, 2000;Keyantash and Dracup, 2002;Heim, 2002;Hayes, 2007;Kallis, 2008;Mishra and Singh, 2010;Sivakumar et al., 2010). We classify and discuss these indicators in an overarching way." This addition will make two other sentences in the paper superfluous, which will therefore be removed (p.5529, lines 8-9; p.5532, lines 5-7).

4. As indicated in our response to Referee #1, we agree that the prevalence of multiple definitions is interesting to discuss in the paper. We will include a discussion of these alternative definitions in Section 2.3. We focus therein on the various definitions of green water. We think this focus is appropriate, because definitions of blue water are more or less comparable and an elaborate discussion on blue water does not fit the purpose of the paper.

5. We will carefully check the text once more.

6. In fact, the paper already mentions that the study by Gerten et al. (2011) (and also those by Rockström et al. (2009) and Kummu et al. (2014)) includes blue water in their combined green-blue water scarcity indicators. However, we will note this more

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



explicitly. The green water scarcity indicator by Hoekstra et al. (2011) does not include blue water (as mentioned in the paper). We will include a discussion in Section 3.2 on why the aforementioned authors have chosen to include blue water in their assessments (and what are the benefits of that) and why an accurate indicator of green water scarcity can better omit blue water.

## REFERENCES

Gerten, D., Heinke, J., Hoff, H., Biemans, H., Fader, M., and Waha, K.: Global Water Availability and Requirements for Future Food Production, *Journal of Hydrometeorology*, 12, 885-899, 10.1175/2011jhm1328.1, 2011.

Hayes, M.: Drought Indices, Intermountain West Climate Summary, 2007.

Heim, R. R.: A review of twentieth-century drought indices used in the United States, *Bulletin of the American Meteorological Society*, 83, 1149-1165, 2002.

Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., and Mekonnen, M. M.: *The Water Footprint Assessment Manual: Setting the Global Standard*, Earthscan, London, 2011.

Kallis, G.: Droughts, *Annual Review of Environment and Resources*, 33, 85-118, 10.1146/annurev.enviro.33.081307.123117, 2008.

Keyantash, J., and Dracup, J. A.: The Quantification of Drought: An Evaluation of Drought Indices, *Bulletin of the American Meteorological Society*, 83, 1167-1180, 10.1175/1520-0477(2002)083<1191:TQODAE>2.3.CO;2, 2002.

Kummu, M., Gerten, D., Heinke, J., Konzmann, M., and Varis, O.: Climate-driven inter-annual variability of water scarcity in food production potential: a global analysis, *Hydrology and Earth System Sciences*, 18, 447-461, 10.5194/hess-18-447-2014, 2014.

Maracchi, G.: Agricultural Drought – A Practical Approach to Definition, Assessment and Mitigation Strategies, in: *Drought and Drought Mitigation in Europe*, edited by: Vogt, J., and Somma, F., *Advances in Natural and Technological Hazards Research*,

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Springer Netherlands, 63-75, 2000.

Mishra, A. K., and Singh, V. P.: A review of drought concepts, *Journal of Hydrology*, 391, 204-216, 10.1016/j.jhydrol.2010.07.012, 2010.

Rijsberman, F. R.: Water scarcity: Fact or fiction?, *Agricultural Water Management*, 80, 5-22, <http://dx.doi.org/10.1016/j.agwat.2005.07.001>, 2006.

Rockström, J., Falkenmark, M., Karlberg, L., Hoff, H., Rost, S., and Gerten, D.: Future water availability for global food production: The potential of green water for increasing resilience to global change, *Water Resources Research*, 45, 10.1029/2007wr006767, 2009.

Savenije, H. H. G.: Water scarcity indicators; the deception of the numbers, *Physics and Chemistry of the Earth Part B-Hydrology Oceans and Atmosphere*, 25, 199-204, 10.1016/s1464-1909(00)00004-6, 2000.

Sivakumar, M. V. K., Motha, R. P., Wilhite, D. A., and Wood, D. A.: *Agricultural Drought Indices*, WMO/UNISDR Expert Group Meeting on Agricultural Drought Indices, Murcia, Spain, 2010, 197, 2011.

Stadler, S. J.: Aridity Indexes, in: *Encyclopedia of world climatology*, edited by: Oliver, J. E., Springer, Heidelberg, 89-94, 2005.

Tate, E. L., and Gustard, A.: Drought Definition: A Hydrological Perspective, in: *Drought and Drought Mitigation in Europe*, edited by: Vogt, J., and Somma, F., *Advances in Natural and Technological Hazards Research*, Springer Netherlands, 23-48, 2000.

Wallén, C. C.: Aridity Definitions and Their Applicability, *Geografiska Annaler. Series A, Physical Geography*, 49, 367-384, 10.2307/520903, 1967.

Walton, K.: *The arid zones*, Transaction Publishers, New Jersey, USA, 1969.

Wilhite, D. A., and Glantz, M. H.: *Understanding: the Drought Phenomenon: The Role*

## HESSD

12, C3081–C3085, 2015

[Interactive  
Comment](#)

[Full Screen / Esc](#)

[Printer-friendly Version](#)

[Interactive Discussion](#)

[Discussion Paper](#)



of Definitions, Water International, 10, 111-120, 10.1080/02508068508686328, 1985.  
World Meteorological Organization: Drought and Agriculture: Report of the CAgM  
Working Group on the Assessment of Drought, Technical Note No. 138, Geneva,  
Switzerland, 1975.

---

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 5519, 2015.

## HESD

12, C3081–C3085, 2015

---

Interactive  
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

C3085

