

For review article “A review of nutritional water productivity (NWP) in agriculture: why it is promoted and how it is assessed?”

Response to Reviewer 1 Comments

1. Summary

Thank you for your very useful comments and in-depth suggestions on the content of our manuscript. We have modified the manuscript accordingly, and the detailed corrections are listed below.

2. General comments

The NWP concept connects issues of crop choice for balanced human nutrition to the wise allocation of scarce water resources. The current manuscript has the potential to contribute conceptual clarity and operational 'devils in the details' of the way the concept has so far been used, but some further work is needed to achieve this.

In terms of the potential policy relevance of the NWP metric the starting points may be 1) the land and water allocation issues that center on the choice of crops (in monocultures, mixed cropping and/or rotations), the intensity of management (use of irrigation, fertilizer and other inputs), 2) the requirements of balanced human nutrition and the choices in import-vs-local production, and in vegan versus omnivore human diets.

One would expect to see a focus on the crop (and/or livestock) portfolio's that match nutritional requirements -- rather than crop-specific data as such, as no single crop can efficiently meet nutritional needs.

A major issue is that the appropriate scale of assessment for the policy choices would be one that allows for a life-cycle assessment of the components of the on-farm crop portfolio (rather than plot-level data), with clarity on local rainfall vs surface- and groundwater dependent irrigation -- at the relevant watershed scale. The WSI index addresses part of the latter issue but only partly.

General response: Thank you very much for seeing potential in our article! Our overview of the literature of the current use of NWP identified the operational 'devils in the details' of the way the concept has so far been used. Based on this we gave recommendations for future research and applications of NWP. We recommend that the assessment of nutritional water productivity must address not only nutritional value produced per unit of water used, but also potential risks of associated water scarcity and identify key processes for improvements of NWP and reduce water scarcity impact (WSI) of agricultural production systems.

We have also now reflected, in the section 3.3.3 “Implementation of NWP findings”, the appropriateness of scale of assessment and focus on a life-cycle assessment of the components of the on-farm crop portfolio (rather than a single crop), clearly put in context of local production environment and water scarcity impacts at the relevant catchment scale. We have also reflected, in the Conclusion Section, potential policy relevance points as suggested by the reviewer.

3. Point-by-point response to Comments and Suggestions for Authors

Comment 1: Line 16 You might start with something like: "The nutrient water productivity concept combines a metric of dry matter production per unit water use and the crop-specific human nutritional characteristics of the dry matter involved. As such it can rationalize the use of scarce water for a portfolio of crops that jointly matches human nutritional needs. For both components of the NWP concept, however, a range of operational definitions is in use in the literature, making results not directly comparable."

Response 1: Agree. We have now reflected this in the revised abstract.

Comment 2: Line 55. A fourth class is focussed on Human impacts on water cycles (HIWC) and takes the Et of natural vegetation as site-specific reference, arguing that both additional and reduced water use can disturb landscape-level water balance (Van Noordwijk M, van Oel P, Muthuri C, Satnarain U, Sari RR, Rosero P, Githinji M, Tanika L, Best L, Comlan Assogba GG, Kimbowa G. et al. Mimicking nature to reduce agricultural impact on water cycles: A set of mimetrics. Outlook on Agriculture 2022 51(1):114-28).

Response 2: Thank you for this interesting reference. The schema presented here refers to our study (Drastig et al., 2021)¹. We would prefer to keep these three main categories which all represent already established and well known methods. However, we have added the proposed reference in the section 3.2.1 Included water flows as “A water scarcity assessment provides insights into the potential water impacts associated with a production system. The FAO LEAP Water TAG guidelines [18] recommended the two methods, the AWARE [17] and BWSI [8], for assessment of water scarcity impact of livestock production systems and supply chains. Van Noordwijk et al. [74] proposed a set of hydrological indicators at the watershed level that represent the individual processes and environmental impacts of different watershed functions.”

Comment 3: Line 56 No need to start with "however", the following sentence builds on the preceding one.

Response 3: Deleted

Comment 4: Line 59 FM needs to be defined, as it is not part of SI units

Response 4: We added the definition of FM: “[e.g. kgFM, kg fresh matter potatoes]”

Comment 5: Line 61 Please clarify "It". You may need to first clarify the different scales of analysis that

¹ Drastig, K.; Vellenga, L.; Qualitz, G.; Singh, R.; Pfister, S.; Boulay, A.-M.; Wiedemann, S.; Prochnow, A.; Chapagain, A.; De Camillis, C., et al. Accounting for livestock water productivity - how and why? In Land and Water Discussion Papers, Food and Agriculture Organization of the United Nations (FAO), Ed. ROM, 2021; Vol. 14, p 58.

become involved in "indirect" water use: it is indirect from a local perspective, but maybe not when a watershed is taken as unit of analysis (depending on the sources used).

Response 5: We added "The water component" instead of "it". And the sentence "The distinction between direct and indirect water use is made based on operational use (direct water consumption) and supply chain use (indirect water consumption)."

Comment 6: Line 70 This may be a place to clarify the potential policy relevance of including or excluding various terms of a global water balance (and the human impacts on water cycles).

Response 6: We have now added the following passage: "Prochnow *et al.* [16] noted that the question of how to treat soil evaporation and plant transpiration from infiltrated precipitation is highly controversial among scientists involved in estimating water use in agricultural production. Hydrologists balance water inflows and outflows at different levels such as fields or watersheds and must include evapotranspiration. From an agricultural perspective, many scientists only consider evapotranspiration or transpiration as input for assessing water efficiency at different scales."

Comment 7: Line 77 Please clarify the difference between a 'farm' versus 'fork' perspective that involves food waste issues and circularity.

Response 7: We appreciate the reviewer's suggestion here. However, this will kind of disturb the flow of information here focused on quantification of water footprints.

Comment 8: Line 90 Somewhere here one would expect a discussion of 'yield gaps' versus 'efficiency gaps' -- part of the literature suggests that efficiency gaps widen (i.e. more inputs are needed per unit production) if yield gaps are closed (say, beyond achieving 80% of local production potential). Footprint data thus refer to current levels of agricultural intensification, rather than being 'generic'.

Response 8: This would open up a new aspect in the review article. To our point of view this discussion does not necessarily belong to our review of the current use of NWP in the literature, including its definition, analysis objectives, and any potential limitations and recommendations for NWP as a suitable metric for measuring water use in agriculture in relation to nutrition security.

Comment 9: Line 103. A further discussion of scale is relevant here: is the target a local autarchy (self-sufficiency in balanced nutrition) or an active participant in global markets where prices convey scarcity information?

Response 9: We added a paragraph regarding scales: "Depending on the objective of estimating water use in agriculture, various approaches at different scales, to assess the water demand in agriculture are known. Agricultural scientists often work on the crop or field scale to express the relation of water use to biomass generation, in terms of water efficiency or water productivity. The virtual water concept has been developed from an economical perspective and provides a basis for the estimation of the water demand for agricultural products and the derivation of the water footprint of nations from their agricultural production and food trade. "

Comment 10: Line 104 The 2.2 is redundant -- or do you intend to have a subheading? It would be good to state the targets of the current review around here. Maybe some of the preceding text can be shifted to section 2, as the text in lines 116-1299 is more introductory than what precedes it.

Response 11: Line 104 The 2.2 is intended to be a subheading.

We state the targets of the current review in line 141-151 “This paper presents a comprehensive review of the current use of NWP in the literature, including its definition, analysis objectives, and any potential limitations and recommendations for NWP as a suitable metric for measuring water use in agriculture in relation to nutrition security, and in turn as a valuable tool for addressing water scarcity and nutrition security. We firstly constructed an overview on the current state of development and application of the novel concept of NWP, and then evaluated usefulness of NWP as a metric for agricultural water use assessment to address current issues of water scarcity and nutrition security. The literature review aimed at identifying any potential limitations and offer recommendations for future research and applications of NWP to inform development of productive and sustainable water use in agricultural production systems.”

We would prefer to keep the state of the targets at this place.

Comment 11: Line 138 The Y term needs clarification where more than one crop component is harvested (e.g. grain plus stover used as animal feed). Even more so where intercropping produces multiple harvestable products. A further set of issues arises in the animal production applications where farms become a relevant scale of assessment.

Response 11: Thank you for this comment.

In multifunctional systems as the mixed crop-livestock farm yields several products. Although the water input to produce a single crop product can easily be assigned, it is difficult to separate the water input of single livestock products, such as milk and meat. Allocation rules to distribute the water input between coproducts are required. This was not done in any of the publications and reflects again the operational 'devils in the details' regarding e.g. the allocation of the water used. To our knowledge this is well known and discussed in reviews of water use in agriculture.

Up to now we did not take different harvested components from one field into account. The reason was furthermore that in our review of the current use of NWP in the literature we found only one study considering intercropping (Shelembe, 2017²). If the reviewer insists we would add the method used in the respective publication to calculate the ratio of the area required under sole cropping to one of intercropping at the same management level to give an equal amount of yield.

Comment 12: Line 115 The term "promote" seems to refer to a higher-level policymaking entity than a farmer -- what are the means available to "promote"? Do different ways to promote involve different scales and hence different preferred metrics?

Response 12: Agreed. Changed to “recommend”.

Comment 13: Line 116 "to" is redundant

Response 13: Deleted “to”

² Shelembe, P.J. Seed quality and yield of selected traditional and commercial crops: Vegetable water use and nutritional productivity perspectives. Master's Thesis. University of KwaZulu-Natal, Pietermaritzburg, South Africa. 2017.

Comment 14: Line 159 Inclusion of portuguese iss commendable, but french, spanish and chinese might yield more? I assume portuguese equivalents of the keywords were used?

Response 14: Only the keywords in English language were used.

Comment 1: Figure 6 -- Despite the disclaimer in Figure 6, showing the results carries the risk of misinterpretation. The paper would be stronger ifn these results are not shown, but only the ranges of reported values mentioned, with all the caveats that defy direct comparisons.

Response 1: In Section 3.3.1 Examples of NWP-values we show ranges of the energy productivity of livestock products, cereals, Legume seeds, and Starchy roots and tubers. The figures add the information of different values of different regions, which seem to be an important aspect. We discussed this within the group of authors and came to the conclusion that we would like to show the figures with the disclaimer.

The second reviewer was satisfied with Figure 6.

4. Response to Comments on the Quality of English Language

Point 1: (x) Minor editing of English language required

Response 1: We have done another around of careful-editing and proof-reading of the manuscript. Hopefully, this has addressed the minor English language issues.