

Analysis of Trade-offs between Food Security and Water-Land Savings through Food Trade and Structural Changes of Virtual Water Trade in the Arab World

Summary:

The authors describe an effort to quantify the virtual trade of water into and out of the Arab countries, as well as the water requirements associated with increasing self-sufficiency (decreasing import versus increasing domestic food production). They also analyzed the connectivity of virtual trade of water related to the Arab World. They argue that this information can be used for informing policy related to the nexus of water management and agricultural production.

Recommendation: Major revisions

Major Comment:

Overall, this is an interesting article with some interesting findings. My major comments are primarily related to the following:

- Usability of knowledge gained: The authors could go a little bit further in describing how this information is useful to policy or management. See specific comments 2 and 32.
- Ignoring of significant limitations: While the authors do discuss some of the limitations, there are some very important limitations that are entirely ignored. These should be discussed as well as the potential for these limitations to bias (and in which direction) the results/conclusions. The limitation I am most concerned with is related to specific comment 24, but there are others as well, as detailed below.
- The writing is in general rather difficult to comprehend. I make multiple suggestions below on how it can be improved and where the confusions lie – but those are really only a start. Furthermore, there are numerous grammatical/typographical errors that need correcting. Again only a few are mentioned below.
- Finally, the conclusions are poorly written and not fully developed – it is not clear exactly what was learned that would further policy development/analysis or improved water/food management.

Specific Comments:

1. Abstract: the abstract is somewhat impenetrable. It would be nice to have a bit more explanation on some of the concepts/jargon used.
2. Introduction: So the introduction provides a strong argument for the need to look at VWT, but then (after the objective is introduced) provides limited rationale for how this particular effort then feeds back into how it could be used for policy analysis/development. What is the rationale for this particular study within context of the broader VWT area of research?
3. L31-32: To what extent was the energy sector (and impacts to the environment, such as increased greenhouse gas concentrations) considered in the recommendation that water stress could be relieved through increased global food trade? I.e., there are negative consequences when considering this recommendation from the perspective of the food-energy-water(-environment) nexus. This should be mentioned somewhere.
4. L35: It would be helpful when giving this background information to include mechanisms. What is the reason for the ag water deficit? To support growth in population and need for food? Or is this for existing irrigated lands and the fact that climate change is causing increased vulnerability of these water rights in some locations?

5. L39-43: This is confusing. Is VWT quantified as the water that would have been needed to grow the food if it were grown locally? Otherwise, I don't understand how there can be an imbalance between VWT and "Real Water". BTW, "Real Water" should be defined. It might be nice to have a table of definitions somewhere: VWT, real water, blue water, green water, etc.
6. L51: blue water has not been defined, nor its relationship to VWT described.
7. L82-83: Why is this a particularly critical issue in the Arab world?
8. L83-84: This is a little bit confusing, possibly because the methods have not been presented yet, so it is not clear at this point what is meant by increasing 1% of self-sufficiency.
9. L86: Is there a citation that can go with "degree centrality" to insert here for those looking for background on it? Same with "eigenvector centrality". It would be nice if there would be a brief explanation of what these are, esp. given the broad readership of this journal.
10. L90 - "is as comparison as". Also, please provide an explanation for this statement - why these two tasks are both critically important, rather than just referring readers to recent literature for the explanation.
11. L99 - there are problems with the indices of the variables in the text (i.e. no subscript). It is also helpful to italicize the variables so it is clear that they are variables.
12. L101 - so this goes back to my earlier confusion on if VWT is determined based on the WFP of the importing or exporting country. Here, it looks like it is calculated on the exporting country (is this true for regardless if it is import VWT or export VWT?), in which case I am still confused on why there is a not a net zero of VWT at the global scale (i.e., import VWT - export VWT = 0 if WFP is determined always in the place where it is grown versus the place it would have been grow if there was no import). Certainly at the scale of a region or country, this would not need to be a net zero (because there could be, e.g. more imports than exports), but it is unclear in the context of where that was described if it is regional or global. This is likely to confuse several readers and so should be more clearly explained in the introduction.
13. L117 - why is only blue water considered in the water saving quantification? Green water should also be considered because most of the irrigation applied to crops is consumptively used, so lost to the system. This results in less water available for other uses. To be most robust, however, the water saving should be based on just the consumptive use portion of the sum of green and blue water.
14. L125 - define what is meant by "edge" versus "node" in the context of this study
15. L126 - explanation should be provided for what is meant by in-degree versus out-degree. i.e. "depending on the direction of trade (in = import; out = export)."
16. L132: Why (N-1)? is this like the Bessel correction for standard deviation?
17. L144-146: Not all of the variables in equations 6 and 7 are defined in the text.
18. L162: Although other data sources were used to estimate the water and land footprints of food production, there should still be a discussion of the limitations to the utilized datasets/approaches in terms of what these limitations mean for the conclusions derived from this study.
19. L173-174: awkward phrasing: "and the part of periods for water footprint is overlapped with the period of trade data"
20. L174-175: It is good to mention limitations, but it is even more useful to mention how these limitations may bias results/conclusions.
21. L194-195 - because of a relative low population in the UAE relative to the other Arab countries? Might be helpful to state that.
22. L197-200 - there are grammatical issues with this sentence.
23. L222 - this sentence also has grammatical issues.
24. L228 - not all ag lands are appropriate for growing every type of crop - this is going to be important to mention as a limitation. Also, some ag lands may produce very high yields of a particular crop than other land area in other country, even if receiving full water requirement. The role of temperature and soil characteristics play a strong role here and this should be mentioned in the discussion and in limitations. Therefore, this is not an apple-to-apple comparison in terms of

the amount of food produced in each region given the water and land needs. This will be important to consider if policies are developed or analyzed given this information.

25. Table 5 - wouldn't increasing self sufficiency also create a hit on land requirement as well? Another limitation related to increasing self sufficiency is that there is no analysis done on whether or not arable land and water are available to do this. So I'm not sure how this can be useful for policy analysis without at least describing these constraints as potentially major limitations.
26. L254-255 - nowhere in the methods is there discussion on how the InDC metrics are scaled. It is not clear from the current text what this is or how it was done (or even why). Therefore, I find it difficult to comment on the results from this analysis.
27. Figure 5 - it is not clear what the black numbers are versus the red numbers. Also, the country numbers are given - do those refer to the red numbers? Why don't the black numbers have country numbers - or do they? except that some of the numbers are very large (e.g., 50, 100) - or is that the y-axis? It's very confusing...
28. L271 - what is meant by "bring the security of import"?
29. Figure 6 - what are the units of these? It's hard to see the light text on each line - what do they say?
30. L300-301 - this is a very awkward sentence.
31. L304-306 - this sentence is important and relates back to the fact that the water/land footprints in the exporting country are very unlikely to match those (for the same food produced) in an importing country. I'd say this is the most important limitation to this study and should be discussed with respect to how this is likely to bias the results (esp. given that Arab countries are relatively hot and yields often are smaller in hot climates and require more water).
32. L330 - but HOW should policy makers do this? What is this missing step in translating the knowledge gained from this study towards analyzing/developing policy (without becoming policy prescriptive of course)?
33. Figure 7: "Impoters" and "Expoters" are misspelled in the figure.
34. Table 4: The caption says that these values are ratios but the values have units - so are they ratios or are they the absolute values of the water/land saved?
35. Table 5: Caption needs to reflect that there are values given for both percent change and magnitude of change.....