Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-4-AC1, 2018

Hydrology and Earth System Sciences
Discussions

Interactive comment on "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" *by* Sang-Hyun Lee et al.

Sang-Hyun Lee et al.

sanghyunsnu@gmail.com

Received and published: 13 February 2018

Dear Reviewer

We revised the paper in consideration of the reviewer's comments. We tried to answer to the important comments, however, some of the points made require more time to address. Once all of these comments have been addressed, the revised manuscript will be forwarded. We appreciate the feedback and comments, which have contributed to an improved paper.

Please find the answer of your major comments as followed.

1) Comment: The abstract of the manuscript does not state the problem statement. The abstract starts with the aim of the study. A. Answer: I agree. We worked on revising the abstract, and added more statement before mentioning the aim of the study. B. The MENA region (Middle East and North Africa or MENA) has the largest water deficit in the world; it also has the least food self-sufficiency. Increasing food imports while decreasing domestic food production can contribute to water savings and hence to greater water security. However, increased domestic food production is better way to achieve food security, even if irrigation demands increase under projected climate changes. There is trade-off between food security and the savings of water and land through food trade, and this trade-off a significant factor, especially in the MENA. This study analyses the impact of food trade on food security and water-land savings in the MENA region and in terms of virtual water trade (VWT). We estimate the total volume of virtual water imported for four major crops - barley, maize, rice, and wheat – between 2000 and 2012 to assess the impact on water and land savings, and food security. The largest volume of virtual water was imported by Egypt (19.9 billion m^3/year), followed by Saudi Arabia (13.0 billion m^3/ year). We concluded that Egypt could save 13.1 billion m^3 in irrigation water and 2.0 million ha of land area by importing food rather than producing crops. In addition, connectivity and influence of each country in the VWT network was analysed using degree and eigenvector centralities. The study revealed that the MENA region focused more on increasing the volume of virtual water imported during the period 2006-2012 with little attention to the expansion of connections with country exporters: a vulnerable expansion. The study sheds light on opportunities and risks associated with VWT and its role in food security and land management in the MENA region.

2) Comment: In Table 4, how did you compute the national blue water saving. As per the footnote, the values for the national blue water saving are estimated by you. As per your Table 3, if I consider Saudi Arabia, the total blue water imported is

(324.3+68.9+70.8+696) * 106 m3/year =1160*106 m3/year=1.160*109 m3/year. However, as per your Table 4, the national blue water saving in Saudi Arabia is 8.14*109 m3/year. You need to provide a sample calculation to support your values. You may also want to see LN 183. 3) Comment: As per the authors, the largest amount of blue water was imported annually by Saudi Arabia, followed by the UAE [see LN 183]. This statement contradicts with the values presented in Table 4. As per Table 4, Egypt and IRAQ have saved 13.05*109 m3 and 12.17*109 m3, respectively. A. Answer: Blue water import and blue water saving have distinct meanings. The blue water import is calculated by the water footprint of exporters. For example, Saudi Arabia imported wheat from various exporters and blue water import is calculated by multiplying the quantity of imported wheat with the respective blue water footprint of each exporter. However, blue water saving indicates the amount of water to produce the same quantity of imported wheat but as domestic production. Therefore, blue water saving is calculated by multiplying the imported wheat by the blue water footprint of Saudi Arabia. In the revised manuscript, we will include an example of this calculation for clarity. B. Answer: We added more explanation as followed: The import of crops could affect the water and land savings in the importing country. Therefore, the failure of trade could cause water and land shortages in the MENA region. Therefore, we analyzed water and lands requirements for producing as much crop as is imported in each Arab country. Virtual water import and water saving have distinct meanings. The virtual water import is calculated by the water footprint of exporters. For example, Saudi Arabia imported wheat from various exporters and virtual water import is calculated by multiplying the quantity of imported wheat with the respective water footprint of each exporter. In this study, we consider only blue water as resource which can be saved; therefore, water saving indicates the amount of blue water to produce the same quantity of imported wheat but as domestic production.

4) Comment: The magnitudes/values of virtual water import per capita need to be supported with the population data for the countries. As per the figure, though Egypt and Saudi Arabia import a very large volume of virtual water, UAE has a very high

value of virtual water import per capita. What does this lead to conclude? I think, to make a concrete statement, considering the land and water saving, you need to work with the population data distributed by the World Bank's Development Data Group that provides population and other demographic estimates and projections from 1960 to 2050(https://data.worldbank.org/data-catalog/population-projection-tables). See LN 57-59. A. Answer: We considered the amount of virtual water import per capita, which shows the differing viewpoints regarding food and water securities. For example, the population and area of UAE is much smaller than that of Saudi Arabia. Thus, if we consider only total amount of virtual water imported, the UAE might be not considered to be a significant importer. However, the virtual water import per capita in the UAE is larger than that of Saudi Arabia, indicating that the dependency on virtual water imported from exporters in the UAE is much more significant than in Saudi Arabia.

5) Comment: In Table 3, what is meant by green water import? Is this the amount of rainfed water [see LN 105-106] in the exporting country? Is this the amount of rainfed water in the importing country? Do we assume that the green water in the importing country is equal to the green water in the exporting country? Does this make sense without considering the climatology/hydrology and other crucial factors in the importing country? I think, few lines (may be from Mekonnen and Hoekstra, 2010) are required from the authors for the readers to understand. As per your equation (1), you are using WEP[ne,c]. A. Answer: Green water import indicates the green water used in the exporting country to produce crops for export. Actually, there are controversies about the meaning of green water. In this study, we referenced the green water footprint estimated by Makonnnen and Hoekstra (2010). In that study, Green water footprint is water from precipitation that is stored in the root zone of the soil and evaporated, transpired, or incorporated by plants. B. Answer: We added further explanation about the reference of green water footprint (Mekonnen and Hoekstra, 2010).

6) Comment: The equation (3) and equation (4) need to be re-written. Some of the variables are undefined. Moreover, the equations do not have the variable "w". A.

Answer: We removed the sentence “w indicates the water resource such as ground water, surface water, and treated water”, and added more explanation about equation. In addition, we added more explanation about equations (3) and (4). B. “where water (or land) saving c,i indicates the amount of water (or lands)to produce the same quantity of imported crop c but as domestic production in importing country i. Import c,i indicate the amount of imported crop c in importing country i. Lands c,i and production c,i indicate the average cultivated area and production of crop c in importing country i.

7) Comment: Does the Arab World strongly depend on water resources from exporting countries [see LN 310-311]? I think, based on your Table 4, only some of the countries rely on water resources from exporting countries. In fact, based on the values presented in Table 4, I am unsure the reason for some of the countries (e.g., Algeria) to rely on the exporting countries when they have the capacity. Probably, you need to bring the water price and the local conditions to realize the reason for the import in those countries. A. Answer: It may be related to various situations that are hardly defined. We are working on explaining this and will add description in the revised manuscript.

8) Comment: The equation that is used to compute the self-sufficiency is not understood. As per the authors, crop import could result in low food self-sufficiency in the Arab World [LN 222]. However, as per the authors, the self-sufficiency is defined as the ratio of imported crops to total consumption [LN 236-237]. A. Answer: Self-sufficiency is defined as the ratio of domestic production to total consumption. Therefore, the ratio of imported crops to total consumption is related to negative self-sufficiency. B. We added paragraph about food self-sufficiency as followed: We applied the concept of self-sufficiency as the index of food security, which is defined as the ratio of domestic production to total consumption, and estimated water requirement of increasing 1 % self-sufficiency of study crops in comparison to average self-sufficiency from 2000 to 2012. In order to increase self-sufficiency of crop, the increase of domestic production should be accompanied, and it derives additional water and land requirement which

can be issue of trade-offs between food security and water-land savings.

9) Comment: Based on this equation, the authors mention in the manuscript that the average self-sufficiency of Wheat in Egypt from 2000 to 2012 was 47.64%. Furthermore, the authors state that 278.77 million m3 irrigation water would be required to increase the self-sufficiency by 1% to reach 48.64% [LN 238-240]. Going by the definition of self-sufficiency, the 1% increase in the self-sufficiency has caused the country (i.e., Egypt) to import an additional 1% from the exporting countries. Does this lead to self-sufficiency? A. Answer: Self-sufficiency indicates the ratio of domestic production to total consumption. Therefore, the increase of 1% self-sufficiency drives the requirement of domestic production.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-4/hess-2018-4-AC1-supplement.pdf

---

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2018-4, 2018.