

## Comments on “Reviving the Ganges Water Machine: Why?”

### Summary

This paper assesses in rough terms the extent of “unmet” demand in the Indian portion of the Ganges Basin, as a way of assessing whether the idea of the Ganges Water Machine should be revived. In simple terms, this idea says that groundwater could be pumped during times of rainfall and surface water scarcity, and that aquifers could then be recharged during the monsoon, to better smooth water supply availability to meet demands in the basin. The authors find that there is indeed significant unmet demand in the basin, and posit that this amount will only increase in the future, making more detailed investigations of the feasibility of the GWM an issue of great importance.

### General comments

I have a number of general concerns with the paper, which chiefly revolve around: a) questioning its contribution; and b) the lack of consideration of issues beyond the simple balance of water demand and supply that would affect the feasibility of the GWM. The authors argue that these issues are the subject of additional research; I feel however that what is in this paper is not sufficiently novel and that those issues must therefore be addressed.

1. The authors take a singular “water” perspective when proposing the four conditions for the success of the pump-deplete-recharge-pump” (PDRP) cycle that characterizes the GWM. The problem however also relates to energy availability and energy poverty. Large swathes of the Ganges Basin have no dependable and consistent access to energy, whether through the electrical grid or via diesel pumping. Thus, the problem cannot be viewed through this singular water lens. The energy constraint receives mention in only a few lines in Section 5.
2. I am question whether this paper constitutes a significant contribution to the GWM debate. The authors acknowledge that there is unmet demand for irrigation water and argue that their contribution is to specify “the exact locations and quantities of unmet demand in the basin” (p.6). But this is mainly an accounting exercise that is not a substantive contribution by itself. I think the authors need to (and can) work harder to assess whether conditions 2-4 detailed on p. 6 can be met (in fact they already provide some details about annual recharge amounts). In addition, it is unclear why conditions 2 and 3 are strictly necessary, since partial satisfaction of unmet demand is sufficient to enable some useful PDRP. Condition 4 is critical, but it is unclear from the analysis whether it is likely to be satisfied. Without additional work on these issues, it is hard to know what to conclude from this paper.
3. I am troubled by the fact that the analysis of water accounting only covers the Indian portion of the basin. While this area does represent the bulk of water demand, the problem is that this approach neglects the transboundary nature of the river, and the fact that the GWM may have important distributional effects on the other riparians. Data on irrigated areas and hydrology in Nepal and Bangladesh are more easily obtained than data for India, so I do not think data availability should be described as a constraint here, contrary to what the authors assert on p.7. It seems more likely that the authors did not make the effort required to obtain those data.
4. The TRWR numbers in Table 1 are surface water runoff, right? This needs to be clarified, since “green (rainfall) + blue water” in the basin is much greater than these amounts. This also relates to my next comment.

5. It is not clear how the authors calculate the PUWR amounts on p. 10 and in Figure 2. This needs to be explained. In particular, I am worried about how the authors handle green vs. blue water use. The crux of the problem is that surface water irrigated area (as specified by the GOI) is unlikely to reflect all surface water use, if some of that water ends up in groundwater aquifers where it can be pumped out by other farmers not connected to the surface water irrigation network. Or conversely, some of the water use in surface water irrigated areas may be from groundwater pumping that comes from green (not blue) water. These two facts will lead to complicated water balance problems, which also underlines the significance of assessing conditions 2 and 3 on p.6, and not stopping at condition 1 and a partial water account.
6. EFs: I don't see much value in annual numbers for EFs, since the EF issue is mostly a critical one during the dry season. This is acknowledged on p.14, but there is no analysis of the issue.
7. Section 5 is useful in identifying a number of limitations of the analysis, and many are highlighted above in my comments. I think the authors need to do more than list these to create a strong and significant contribution to the literature.

### **Specific comments**

1. It would be easy to take issue with the initial statement in the abstract and introduction, namely that "The Ganges River Basin may have a major pending water crisis." In particular, it would seem more accurate to say that the Ganges River Basin already faces severe water-related challenges related to a mismatch between supply and demand, and that these challenges seem likely to increase as demands increase in the future.
2. Abstract, line 15: these estimates of 59 and 119 bcm/yr are on average, correct? If so, please specify that, since the numbers will vary from year to year depending on surface water availability as well as the contribution of rainfall.
3. Abstract: I would suggest the authors be more specific about the role and effect of enhanced SSS across years, since variability is a critical concern for riparians in this basin.
4. Introduction, p.4, line 10: I am unclear what the authors want the reader to conclude from the statement that water scarcity "barely allows cropping to only about 1.3 times the net sown area." This suggests that the water is not fully used since net sown area is lower than what water resources would allow. So why is water scarcity binding?
5. Introduction, p.4, lines 11-13: The authors should note that climate projections are widely divergent, and that the change in water scarcity is thus uncertain, even though variability appears likely to increase.
6. The methodology and data sources for the water accounting exercise are not well explained. With the information in the manuscript, it would be impossible to replicate the authors' analysis.
7. Results: I do not understand the authors' point about the potential for reuse. Are they trying to say that additional reuse of degraded quality water is possible? Clearly, the fact that water returns to the river and nonetheless remains inadequate to meet downstream objectives (in Bangladesh) suggests that very little reuse water remains by the time the flows reach Farakka during the dry season.
8. Discussion/conclusion: This section basically repeats the abstract and introduction. I would urge the authors to provide a more critical summary.

### **Technical corrections**

In general, there are many typos or grammatical phrases that could use work. I suggest the authors get their manuscript copy-edited prior to revision. I only note a few issues below.

1. Introduction, p.3 line 25: should be “megawatts”. Also this sentence is awkwardly phrased, since it seems to imply that the major financial benefits are navigation and hydropower. Much of the navigation benefit is not financial.
2. Introduction, p.3, lines 26-28: I don’t think the religious and cultural value of the Ganges is just for tourists, but this sentence implies it is. Local inhabitants also revere the river.
3. Introduction, p.4, lines 1-2: Can you be more specific about the ecosystem services that are provided?
4. Introduction, p.4, lines 5-7: Please rephrase this awkward sentence.
5. Introduction, p.4 lines 24-26 seems overstated: “...could change the despair to joy for many millions of inhabitants.”
6. Methods, p.7, line 21: Should read “which contains...”
7. Methods, p.10, line 5: “Maintaining EFs” cannot be “more prominent”. Please rephrase as this is unclear.
8. Results, p.13, line 15: Delete “another” which is redundant.
9. Section 5, p.15 lines 4-5: There are typographical errors here.