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Interactive comment on "Climate change vs. socio-economic development: Understanding the future South-Asian water gap" *by* René R. Wijngaard et al.

Anonymous Referee #1

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Comments on: "Climate change vs. socio-economic development: Understanding the future South-Asian water gap" Authors: Wijngaard et al. Submitted to: HESS Article ref no.: hess-2018-16

The research in the article under review is an attempt to predict the combined impact of climate change and socio-economic changes on water scarcity in the downstream portions of 3 rivers originating in the Himalayas: the Indus, the Ganga and the Brahmaputra. It seeks to improve upon earlier predictive modelling by using a larger ensemble of climate predictions, separate hydrological models for upstream (hill) and downstream (plains/delta) regions, and more careful simulation of agricultural water

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use in the downstream region through using recently developed models that simulate distribution through canal systems and timing of water demand in multiple cropping systems. It also draws upon recently published Shared Socioeconomic Pathways (SSP) developed by the climate change community that describe alternative socio-economic development scenarios.

The technical side of the research has been done quite competently for the most part and the writing is also mostly clear and well organized. My concerns with the paper mostly are at the macro-level, viz., as to what (value) assumptions it makes in framing the research, and what contribution it makes to our understanding of the likely outcomes of multiple-stressors operating in the study region. Also a couple of concerns about the modelling.

1. Water uses considered: The authors only take into consideration water use in agriculture, industry and the domestic sectors. In doing so, they leave out in-stream environmental (and fishing) needs, as well as minimum ecosystem flows that need to go out to the ocean. This framing creates the impression that it is 'okay' to consume all the surface flow, which is problematic. Given the higher temporal and spatial resolution that the models have incorporated, the authors can easily provide for these other uses also. Which uses to cater to is of course a value-loaded decision, but no more than the decisions already made. The authors could allow for variation in societal values by showing the tradeoffs between (e.g.) meeting minimum ecosystem flow standards (that might affect agricultural production) and prioritising agricultural needs (thereby violating minimum flows).

2. Definition of water scarcity: The manner in which water scarcity is defined (with respect to the above 3 uses) is in terms of a 'blue water gap' (gap between supply and demand of blue water) which then manifests itself as over-extraction of groundwater. But over-extraction has inter-temporal effects, so it seems that this is a definition of 'unsustainability'. On the other hand, the manner in which groundwater overextraction manifests itself is in the form of loss of base flows, which means either loss to

agri/domestic users downstream or loss to instream/ocean uses. Neither of which is captured here. Scarcity can be the outcome of distributional issues unrelated to absolute availability. So one definition of scarcity could have been the fraction of the population (in each sector) facing water shortages. More generally, ‘scarcity’ is a social construct, and if the research is to be useful to policy-makers in the region, the ‘outcome variable’ in the modelling must reflect local, multiple understandings of scarcity.

3. Contribution: The need to model the impact of multiple stressors rather than of climate change in isolation has now been recognized in the water resources community for a while. In a well-known coarse-scale analysis, Vorosmarty et al.(2000) pointed out that rising human demand for water will outweigh the impacts of climate change on water resources in the south Asian region. [The authors appear to have misinterpreted this study in p.2 line 30: Vorosmarty et al conclude “that impending global-scale changes in population and economic development over the next 25 years will dictate the future relation between water supply and demand to a much greater degree than will changes in mean climate.”] . So the question is in what way does this study deepen our understanding of this broad trend or likely responses?

My assessment is “not much, given the uncertainties involved and the limitations of the approach used” [uncertainties are also discussed below]. That climate change is predicted to increase water availability in all 3 basins is clear, once one reads the CC predictions for this region from the GCM runs chosen. That socio-economic developments will (in the absence of any adaptive responses) lead to increases in water demand is obvious to anyone who knows the region. The net result is that “The combination of climate change and socio-economic development is expected to result in increasing water gaps with relative increases up to 7% and 11% in the Indus and Ganges, respectively” [p.18, line 27]”. To my mind, this small change is well within the errors/uncertainties of all the modelling that has been done. (Since these results are not presented in tabular form but only in the bar charts in Figure 8, it is even hard to see that the water gap has actually increased vis-à-vis the reference scenario.) So one is unable to see the value

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of such a coarse result. The lack of endogeneity in the modelling framework (i.e., the fixed nature of landuse predictions driven by population growth and economic change and the lack of any adaptive response by any water user to water scarcity) means that we are unable to see to what extent adaptive actions might ameliorate the problem. And the lack of information on "who actually suffers because of the scarcity" prevents the analysis from throwing up any interesting social impact information.

4. Modelling: There are some concerns with the manner in which the modelling has been done. They may not all affect the results seriously, but need to be tabled and discussed:

a. Groundwater is treated as being separate from surface water. E.g., page 2, line 3 says the 3 sources of water are rainfall-runoff, groundwater and meltwater. This would be true if runoff did not include baseflows, which is groundwater returning to the surface as discharge (see Ponce, V.M., 2007. Sustainable yield of groundwater. http://ponce.sdsu.edu/groundwater_sustainable_yield.html, and Sophocleous, M., 2000. From safe yield to sustainable development of water resourcesâĂŤthe Kansas experience. Journal of Hydrology 235, 27–43.). But then on page 7, line 2, the authors say total runoff is sum of glacier & snow runoff (presumably melt), surface runoff, lateral flow and baseflow. This then leads to double counting, since "water for irrigation and other uses can be drawn from surface water in the grid cell [which would include baseflows], etc etc. and groundwater bodies" (page 8, line 10-12).

b. This treatment of GW as separate from SW also enables the authors to talke of the blue water gap in terms of unsustainable withdrawal of GW (i.e., withdrawal more than recharge) without realizing that the first impact of such over-withdrawal is the loss of baseflows, which will affect downstream grid cells. GW depletion is not a separate/separable phenomenon, unless one is talking about depleting non-renewable forms of GW.

c. The 'daily timestep' is clearly a case of spurious precision. Water use is definitely not known/predictable at such a fine temporal scale.

d. The assumption that 'water availability in upstream regions' (the Himalayan catchments) is dependent upon natural factors' may be true for the Indus and the Brahmaputra, but questionable for the Ganga basin. Uttarakhand and Nepal are witnessing massive interventions in hydrology in the form of dams (large and small) as well as traditional uses for agricultureâĂŤthese regions a dense network of community-scale irrigation systems.

e. To the best of my knowledge, the SPHY model has very litte stream gauge/river gauge data available (at least in the Ganga basin) to validate itself. So there must be major uncertainties just with the flow predictions for the 'upstream' model.

f. The predictions under climate change and SSP are compared with the 'reference' period results, which seem to be the average of the period 1981-2010. This is a lengthy period over which major changes have taken place in the water resource use in this region, and using an average for this whole period makes it unusable as a 'reference'.

Minor technical and editorial comments are given in the marked up pdf attached herewith.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-16/hess-2018-16-RC1-supplement.pdf

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