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Hydrology and Earth System Sciences
Discussions

Interactive comment on "HESS Opinions: The Myth of Groundwater Sustainability in Asia" *by* Franklin W. Schwartz et al.

Anonymous Referee #1

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The opinion paper by Frank Schwartz and coauthors discusses the lingering groundwater crisis in several Asian countries, some reasons how it could come so far, theoretically feasible technical solutions, and vague research directives.
It is clear, that groundwater exploitation is not sustainable in many countries with (semi)-arid climate, including actually large parts of the United States. However, besides climate and land use there are also societal boundary conditions, and these differ tremendously between the countries discussed in the manuscript. The People's Republic of China definitely does lack democratic participation, but it has a long standing tradition of a functional administration, and the economic growth of the last decades has led to the economic foundation for expensive technical solutions, if applicable. We see this in water treatment (both for freshwater and waste water) where tremendous

progress has been made in recent years. Of all countries discussed in the manuscript, China is the one where the educational and administrative conditions are the best to implement water-management strategies comparable to those of Southern California - if the Communist Party decides sustainable groundwater management to be an important issue.
In contrast, other countries lack the concept of groundwater rights. If traditionally the owner of a piece of property is allowed to extract all resources thereof, including groundwater, implementing rules of sustainable groundwater management is doomed to fail. There must be an accepted legal framework stating that you don't own the water of the land that you own, that drilling and operating a new well requires a permit, that the permit can only be issued based on a management plan of the entire resource, that abiding by the rules must be monitored, and that a breach of regulations must be punished. If this basic societal understanding does not exist, sustainability cannot be enforced.
I don't think that the authors should put Yemen into the mix of countries to consider. Yemen has been in a Civil War for years, and one cannot expect that anything functions. Almost the same would hold for Afghanistan where the German Geological Survey had spent millions on developing groundwater management rules, including hydrogeological mapping and implementing groundwater monitoring. All of that disappeared when the security of western advisors was no more guaranteed. In such dysfunctional countries, sustainable groundwater management cannot be of high priority. Whereas it could in India.
The authors present Orange County and Singapore as highly developed regions in which technical solutions for sustainable groundwater management have more or less successfully been implemented, monitored, and maintained. They could add Israel where advanced irrigation techniques and managed aquifer recharge has been developed on a world leading level. Like in Singapore, if even not much more so, Israel is in need of self-sufficiency, has a functional administration, and is home of some of the best engineers worldwide. Hence, when it comes to discussing why sustainable

groundwater management appears achievable in Israel but not so much in some of its neighboring countries with similar climate and geology, the societal and governmental boundary conditions must be analyzed to a depth at which geologists and engineers feel uncomfortable. Being a hard-core scientist myself, I lack an in-depth discussion of societal differences among the different countries that can explain differences and give predictions on the chances of implementing sustainable groundwater management practices. Iran, India, China, and Pakistan are quite different countries.

The authors rightfully point to water-quality issues related to groundwater management in arid climates and/or regions of intensive agriculture. However, you don't need to go to Asia to realize that salt accumulation in over-exploited aquifers is an issue largely unrecognized by many groundwater managers. In large parts of the western United States, a continuous increase in salinity has been observed in conjunction with declining groundwater levels. At the end of the day, balancing the volume of water is insufficient to obtain sustainability in systems undergoing strong evapotranspiration. We may come to the conclusion that managing the dissolved solids will require more aggressive treatments, such as membrane-based deionization before artificial groundwater enrichment. Luckily, the electricity needed for that can be gained by photovoltaic power in the arid regions that require such treatments the most. Likewise, arsenic (or fluorine) can be removed by technical treatment, but the premise of centralized water treatment is a centralized water supply. In as much, technical solutions for the supply of cities, where centralized treatment options are achievable, must differ from technical solutions for drinking water supply and irrigation agriculture in rural regions. And neither will work without a functional and responsible administration.

With respect to research directives, I highly recommend prioritization. Western researchers are interested in exciting science, but that is not always the gateway to practical solutions. Understanding the release and fate of arsenic in deltaic aquifers in south-east Asia is an example of a scientifically challenging question. Alas, among the hundreds to thousands of publications on mechanistic questions related to arsenic in south-east Asia, only a few have been useful to help the people affected. There have

been examples in which "cool" science actually contributed to developing sustainable groundwater management strategies, but most of the science is done by the flock of academic sheep following a research bellwether. Most likely, raising the level of education in water-related sciences is the best that university scientists can do to contribute; we need to train people with a solid understanding of hydrogeology and environmental engineering, who hopefully reach positions where they can make decisions. But how a society has to change that responsible decision making by administrative authorities is implemented and accepted, I have no clue.

A few minor comments.

1. line 33: Replace "by right" with "basically". Non-native speakers think you refer to a legal term.
2. lines 43-44: Are there only one continuous shallow and one continuous deep aquifer in the entire North China Plain? Otherwise use the plural.
3. line 58: Do the percentages refer to India or are the worldwide numbers? The same question refers to the "two prototypical settings for groundwater".
4. line 63: "recover to the levels pf previous years" or "recover from the withdrawals of previous years."
5. line 77: The term "regionalized" appears odd here. This is a term used in geostatistics for interpolation of point data, but it seems you mean "restricted to certain regions".
6. line 81: While the root cause of arsenic in the IGA system is in the Himalayan sediments, the mechanism are more complicated. I suggest dropping this explanation in order to avoid oversimplification.
7. line 92: Nitrate is sometimes measured as concentration nitrate, and sometimes as concentration nitrate-N. Be specific!

8. line 113: I don't think that the assessments are frustrated. Frustrated are the people performing the assessment, which renders the assessment frustrating.
9. line 139: drop "landward", seawater intrusion is always landward.
10. lines 150-156: I don't think that it is admissible to compare the situation in India (a functional government) to that in Yemen (Civil war)
11. line 174: Here is one of the points. You cannot assume that appropriate laws and regulations exist in all countries that need them. That is exactly the point.
12. lines 309: The authors may check on the work of Wolfgang Kinzelbach (who is not me, by the way), who has worked on stretching groundwater exploitation in northern Africa, a definitely non-sustainable resource.

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