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Aquifer Safe Yield: Hard Science or Boundary Concept?

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The negative impacts of groundwater overabstraction on the users themselves, other constituencies, and the environment have prompted a central question posed by decision-makers or managers: how much pumping should be allowed in a particular area? How much is too much? The answer has commonly revolved around the ubiquitous concept of "safe yield", which has suggested two things: first, there is a certain quantity of water which can be pumped while keeping (presumably all of) us "safe"; second, we need to turn to scientists dealing with such intractable matters to determine what that safety threshold is.

Groundwater resources are known to be replenished by a "recharge", coming from the infiltration of rainfall, water bodies, or snowmelt. It has become a deeply ingrained common wisdom that we should not abstract from aquifers more than what nature puts into them; and that less is just fine, or "safe"... Indeed, it is all too common to see authors calling repeatedly for governments to "limit the amount of groundwater extracted to recharge capacity", or stating –as does the Environmental Agency (n.d.) - that "groundwater over-exploitation occurs when groundwater abstraction exceeds recharge".

Although hydrogeologists have alerted since at least 1940 that this "water budget myth" (Bredehoeft, 1997), or "bathtube thinking", is deeply flawed these scientists also admit that these misconceptions are conspicuously persistent, even with their own community (Bredehoeft, 2002. Bathtube thinking is predicated upon a misconceived separation of surface and ground water and a vision of groundwater as a stock, which obscures both the variegated bi-directional fluxes between surface and underground and the conceptions around how much groundwater can be used. More qualified approaches consider aquifers as "underground rivers" (aside from particular configurations such as fossil aquifers), where groundwater flows and eventually (sometimes with a long time lag) re-surfaces in springs, river beds, evapotranspiration (uptake by plants), or in the seas.

Better consideration of the interconnectedness between underground and surface water stocks and flows leads us to emphasize the unavoidable negative externalities associated with groundwater abstraction, which eventually captures water that was flowing somewhere else and was either put to use, feeding aquatic ecosystems, or preventing sea water from intruding inland. The likelihood of reappropriation increases sharply as the basin "closes" and resources get (over)committed; in other words, in water-scarce basins, where the predictability and sustainability of the access to water are reduced, and where conflicts are heightened, groundwater abstraction is tantamount to reappropriation by stealth (Molle and Wester, 2008).

Some of these spatial reappropriations of water are quite obvious to the analyst and local users alike. Textbook examples include the destruction of qanat systems in most of the Middle-East and Northern Africa, and the desiccation of wetlands (eg the Azraq oasis in Jordan or the Tablas de Daimiel in Spain) by excessive groundwater abstraction. Other induced hydrological changes, however, are much harder to identify and to quantify. For example, base flows to river beds may revert and the river feed the aquifer instead of being fed by it; lower water tables may affect uptake by natural vegetation and result in its degradation.

These hydrologic realities have a major implication with regard to the central question on how much is "safe". Hydrological interconnectedness and situations of scarcity and high/over commitment of water resources makes water allocation very much of a zero-sum game. Your benefit here is likely to be my cost there; ones's short-term use here conflicts with next generations' use there; what is safe for you is unsafe for me; impacts may appear negligible to me no but not to another beholders's eyes, etc. In other words, because of the fluid nature of water my use, right, vision or values are not independent from those of other people equally connected to the same hydrologic regime. Groundwater use appears intricately linked to this wider cycle and inevitably speaks to issues of rights, equity, economic efficiency and environmental values.

Wary of the sloppiness of the safe yield concept and influenced by the wider emergence of the concept of sustainable development, some hydrogeologists have promoted the concept of sustainable development (or use) of groundwater resources (Alley et al., 1999). Departing from the very idea of establishing a "safe" uncontroversial threshold, and expanding Todd's (1959) definition of safe yield as "the amount of water which can be withdrawn... annually without producing an undesired result", Alley et al. (1999) define groundwater sustainability as the "development and use of ground water in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences".

This and other encompassing definitions are welcome in the sense that they recall the multiple dimensions of water resources and their role in development. But sustainable yield borrows all the attires of other nirvana concepts such as IWRM, water security, poverty alleviation, or sustainable development, that is, concepts that define overarching and necessarily consensual goals while glossing over both the very antagonistic natures of the desired objectives and the power-relations that mediate outcomes (Molle, 2008).

Economists have tried to reconcile goals through valuation exercises but these have faced methodological and epistemological difficulties (measuring all values with the same monetary metrics), and also to the need of disaggregating costs and benefits, both spatially and socially, rather than sticking to macro-level aggregates that only reflect economic macro-efficiency.

Interests and values are unfortunately not easily reconciled. Coastal aquifers provide a useful and stylised illustration. Farmers often use deep wells to irrigate their crops but this use is challenged by deeper wells and higher abstraction coming from nearby cities. Induced seawater intrusion and impact on surface waters, in turn, modify water quality in the aquifer and nearby wetlands or mangroves. How much is too much? How are urban uses "valued" against agricultural or environmental ones? This suffices to highlight the very political nature of what a "safe" or "sustainable" yield could be.

While nirvana concepts promise to fulfil the "objectives of society" without producing "undesired results", the relativity of what is "acceptable" or "desirable" and the necessity of (painful) tradeoffs is well recognized by those who seek to come to terms with overexploitation through deliberative processes in different guises. Social learning through multi-stakeholder platforms and other participatory mechanisms can/should be instrumental in coping with the conclusions that there is no such uniform thing as "society" and that no uncontroversial and neutral correct number representing sustainable yield exist. Safe or sustainable yields are therefore nowhere to be found except in a political process whereby concerned stakeholders will confront their respective interests and ideologies and attempt to find middle grounds and trade-offs that will not make everyone happy but will be socially legitimized and "stabilized" by the very process which produced them. If science is not in the driver seat, its role is however crucial to help identify and assess the externalities associated with particular manipulations of the water cycle.

As a result, the status of the concept of the safe/sustainable yield shifts from a threshold number that has to be constantly refined by cumulative neutral and rational scientific endeavours to that of a "boundary concept", constantly open to contestation, negotiation and adjustments, and allowing continuous (re)weighing of the different values in play. Needless to say, the eventual fairness and soundness of outcomes closely reflect how levelled is the playground and how sharp are power asymmetries among the stakeholders concerned; what is "safe" will also evolve with the distribution of political clout, or when circumstances call for drastic measures that are, then, politically mediated.

References

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