A roadblock on the path to aquifer sustainability: underestimating the impact of pumping reductions

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Abstract

Depletion of aquifers across the globe is challenging our ability to maintain critically needed agricultural production and provide potable water supplies for millions. In most cases, the only option to decrease the rate of depletion is to reduce the pumping of groundwater. Although implementation of large-scale pumping reductions in the absence of alternative water sources has proven difficult, recent work has shown that locally based, stakeholder-driven initiatives, coupled with regulatory oversight, can be a promising path forward. A critical question is how much must pumping be reduced to have a significant impact on decline rates. Data limitations and modeling uncertainties, however, have frustrated efforts to answer this question with reliable estimates of the needed reductions. We address this situation using a variant of the water-balance equation to identify a key factor, the misestimation of specific yield, that is limiting our ability to assess the impact of proposed pumping reductions. We find that common modeling practices can lead to large overestimates of the required pumping reductions, thereby inadvertently discouraging conservation efforts. We demonstrate the importance of this general finding using data from the High Plains Aquifer in the central United States where common practices have led to overestimates of required pumping reductions by a factor of three to six. We introduce a new metric, the coefficient of variation of net inflow, to help identify such conditions. The reliability of estimates of the impact of pumping reductions can be greatly improved when the constraints imposed by this new metric are combined with a recently proposed method for estimation of specific yield from field data. The ramifications of these findings are far reaching, as defensible estimates of the impact of proposed pumping reductions are an essential element of efforts to chart more sustainable paths for the world’s heavily stressed aquifers.

1. Introduction

Water levels in aquifers across the globe are declining at alarming rates as a result of large water-budget imbalances created by the intensive pumping of groundwater (Alley and Alley 2017, Bierkens and Wada 2019). Continuation of current decline rates will make it difficult to provide potable water supplies for millions and to maintain critically needed agricultural production (Scanlon et al 2012, Khan et al 2016). In most cases, the only option for diminishing decline rates is to reduce the pumping of groundwater. The preferred strategy for pumping reductions involves replacing the groundwater with alternative water sources. In many areas, however, alternative sources are not readily available due to a scarcity of surface water or water-quality concerns. Thus, pumping reductions with little to no water replacement are often the only viable option for decreasing water-level decline rates.

Large-scale implementation of pumping reductions in the absence of alternative water sources requires overcoming a series of administrative, legal, cultural, and logistical hurdles (Griggs and Butler 2017). Recent work has shown that locally based,
stakeholder-driven initiatives, coupled with regulatory oversight, can be a promising path forward (Deines et al 2019). However, even when implementation challenges can be overcome, the question of how much pumping needs to be reduced looms large. All too often, data limitations, coupled with model uncertainties, stymie efforts to address this critical question. The answer, however, has significant ramifications for an area’s hydrologic and economic future.

The purpose of this paper is to explore the factors that are limiting our ability to reliably estimate the impact of pumping reductions on water-level decline rates in heavily stressed aquifers. We rewrite the classic water balance equation in an alternative form to demonstrate that one can obtain essentially the same model calibration results (same fit to the water-level data) with virtually any value for specific yield (i.e. calibration results are insensitive to specific yield). We then show that the specific-yield assignment is a critical step for determining the pumping reduction required to have a measurable impact on water-level decline rates. We introduce a new approach for identifying when specific yield has been misestimated using a novel metric that can be readily calculated as part of modeling activities. We then demonstrate the importance of these concepts using areas in the data-rich portion of the High Plains Aquifer (HPA) in the state of Kansas to show that common practices have led to overestimates of the required pumping reductions by a factor of three to six; such large overestimates would likely be produced by models of many of the world’s unconsolidated aquifers. The paper concludes with an assessment of the implications of these findings for efforts to chart a more sustainable future for heavily stressed aquifers across the globe.

2. The aquifer water balance

The water balance for an aquifer can be written in its simplest form as:

\[ \text{Water Volume Change in Aquifer} = \text{Inflows} - \text{Outflows}. \] (1)

A major focus of groundwater modeling is to quantify the individual components that constitute aquifer inflows and outflows (Anderson et al 2015). Data limitations, however, typically frustrate that effort. Although modelers utilize the calibration process to get the most out of their limited data, the resulting uncertainty in the individual water balance components can be large (Hill and Tiedeman 2007). Groundwater pumping may often be one of the only components of aquifer inflows and outflows that can be (or has the potential to be) quantified with much confidence. If baseflow measurements are available for streams in a study area, the discharge from the aquifer to the stream can also be quantified with confidence for at least a portion of the time.

The current reality is that, except for work at a small number of highly instrumented sites, it is difficult to reliably quantify most of the components making up aquifer inflows and outflows. Thus, one strategy is to lump the difficult-to-quantify components of the water balance into a single term, net inflow (Butler et al 2016, 2018; see supplemental figure 1, available online at stacks.iop.org/ERL/15/014003/mmedia):

\[ \text{Water Volume Change in Aquifer} = \text{Net Inflow} - \text{Pumping}, \] (2)

where net inflow is equivalent to the ‘capture’ term often used in aquifer depletion assessments (Konikow and Leake 2014).

Equation (2) can be rewritten with commonly used notation for an arbitrary area of an unconfined aquifer:

\[ \Delta WL \times \text{Area} \times S_Y = I - Q, \] (3)

where \( \Delta WL \) is the average water-level change across the area [\( L \)], \( S_Y \) is the specific yield [\( L^{-1} \)], \( I \) is the total net inflow [\( L^3 \)], and \( Q \) is the total pumping [\( L^3 \)], with these quantities typically defined on an annual time frame.

In a well-monitored aquifer, the average water-level change and total pumping can often be considered known quantities, resulting in one equation with two unknowns (\( S_Y \) and \( I \)). This non-uniqueness is commonly addressed by assigning a value to \( S_Y \) and holding it constant during the calibration process, which, in this case, involves adjusting parameters related to the aquifer inflows and outflows that are lumped together in the net inflow term. The \( S_Y \) assignment is often based on tabulated values in textbooks (many of these values appear to be from Johnson 1967), as field data on specific yield at the scale of relevance for modeling investigations are typically scarce (Anderson et al 2015). This assignment has been justified by invoking the small range over which aquifer \( S_Y \) values are believed to vary, relative to that of many of the parameters within the net inflow term.

The ramifications of the \( S_Y \) assignment are significant, as this value determines \( I \) when \( \Delta WL \) and \( Q \) are known (equation (3)). The net inflow, in turn, determines the near-term impact of pumping reductions. The relationship between net inflow and pumping reductions can best be demonstrated for the case of the reduction required to stabilize water levels. At stable water-level conditions, \( \Delta WL \) equals zero, so the left-hand side of equation (3) is zero. Rearranging and solving for the pumping that would yield stable water levels (\( Q_{stable} \)) produces:

\[ Q_{stable} = I. \] (4)

The net inflow therefore determines the pumping reduction required to stabilize water levels or, more generally, to significantly impact water-level decline rates (Butler et al 2018). Thus, as shown by equations (3) and (4), the predicted impact of pumping reductions will be a linear function of the assigned \( S_Y \) value.
In the case of a depleting aquifer ($\Delta WL < 0$ for most years), misestimation of $S_f$ can lead to errors in the estimation of the impact of pumping reductions. If $S_f$ is overestimated, the left-hand side of equation (3) is more negative than actual. In order to balance the equation, the net inflow term ($I$) on the right-hand side must be smaller than actual. Thus, the calculated $Q_{stable}$ will be smaller than actual and, consequently, the estimated pumping reduction required to attain it larger than actual. Similarly, if $S_f$ is underestimated, $I$ must be larger than actual, yielding an estimated pumping reduction that is less than actual.

For an aquifer in which water levels, on average, change little, misestimation of $S_f$ should lead to a relatively small error in $I$ and, therefore, a small error in the estimation of the impact of pumping reductions.

In the following section, we demonstrate these concepts using data from semi-arid and subhumid areas overlying the HPA in the state of Kansas in the central US.

3. HPA demonstration

The HPA is one of the world’s largest and most important regional aquifers in terms of the agricultural production that its waters support (Marston et al 2015). The aquifer extends over eight states in the central US and provides approximately 30% of the groundwater pumped annually in the country (Nie et al 2018). The intensive pumping for irrigation has taken a toll on the HPA, particularly in its central and southern portions (McGuire 2017). The aquifer underlies a considerable area in the western half of the state of Kansas (figure 1). A large east-to-west decrease in annual precipitation causes an east-to-west increase in pumping and a large variation in aquifer conditions (Kansas Geological Survey 2019). In most of subhumid south-central Kansas, water levels have changed relatively little since the onset of widespread pumping for irrigation. However, in the semi-arid western third of the state, water-level declines threaten the continued viability of irrigated agriculture (Buchanan et al 2015, Whittenmore et al 2018). Given the scarcity of surface water supplies, pumping reductions without water replacement are the only near-term means of moderating decline rates in the western Kansas HPA (Butler et al 2018). Since 2012, Kansas has developed a management framework for implementing large-scale reductions that is based on grassroots-driven initiatives backed by regulatory oversight (Kansas Statutes Annotated 82a-1041 2012, Kansas Senate Bill 156 2015).

Estimation of the near-term impact of proposed pumping reductions requires data on past water-level changes and water use. Kansas has long placed an emphasis on collection of data for water-quantity assessments. Annual water-level measurements have been taken in a HPA well network (currently $\approx 1400$ wells; see supplemental figure 2) for decades (Miller et al 1999), while every high-capacity pumping well in the aquifer is now required to have a totalizing flowmeter. The pumping volumes must be reported annually and are subject to regulatory verification (see page 2006 and supplemental materials (text S1) in Butler et al 2016).

Given the Kansas water-level and water-use data, equation (3) can be rearranged and rewritten for the calculation of the net inflow for year $i$:

$$I_i = \Delta WL_i \times \text{Area} \times \bar{w} + Q_i,$$

where the underlined quantities are assumed known for that year and the double overbar indicates an assigned value (see supplemental text for a discussion of uncertainty in $\Delta WL_i$ and $Q_i$). The HPA in Kansas is at a mature stage of development, so the number of pumping wells changes little from year to year. Under those conditions, the mean ($I_{av} = \frac{1}{n}\sum_{i=1}^{n} I_i$), standard deviation ($\sigma = \sqrt{\frac{\sum_{i=1}^{n}(I_i - I_{av})^2}{(n - 1)}$), and coefficient of variation ($CV = \frac{\sigma}{I_{av}}$) of $I_i$ can be readily calculated ($n$ = period of analysis in years). From equation (4), the $Q_{stable}$ for the period is the average net inflow:

$$Q_{stable} = I_{av}$$

The percent reduction that is required to stabilize water levels is therefore:

$$\% \text{Pumping Reduction} = \left(1 - \left(\frac{Q_{stable}}{Q_{av}}\right)\right) \times 100,$$

where $Q_{av}$ is the average pumping for the period.

Equations (5)–(7) are now used to demonstrate the relationship between specific yield and the percent pumping reduction for areas in western and south-central Kansas. For this demonstration, the equations will be applied on the regional scale using two of the five Kansas groundwater management districts (GMDs) as the areas of interest (figure 1); similar results were obtained for the other three GMDs. The GMDs, which overlie the vast majority of the HPA within Kansas, assist the state regulatory agency, the Division of Water Resources of the Kansas Department of Agriculture, in the management of the groundwater resources of their areas (Peck 1980). The period of analysis is 2005–2016.

GMD4: This district encompasses 12 623 km$^2$ in semi-arid northwest Kansas (figure 1). Seasonal groundwater pumping in support of irrigated agriculture composes 98% of the total annual groundwater use in the area. The district is in a mature stage of development and was closed for new appropriations (water rights) in 2016; however, few water rights were granted after the early 2000s. Although only 30% of the irrigation wells were equipped with totalizing flowmeters in 2005, the proportion reached 99% by 2010. Reported water use for wells without totalizing flowmeters is typically calculated using duration of pumping meters and an estimated pumping rate.
Butler et al. (2016). As a result of the decades of groundwater development, virtually all of the streams are ephemeral and receive no baseflow.

The relationship between $S_Y$ and the percent pumping reduction required to stabilize water levels in the district can be calculated using equations (5)–(7), the annual water-level and pumping data, and a range of $S_Y$ values. Figure 2 displays that relationship, revealing that the calculated pumping reductions vary dramatically with $S_Y$. An unconsolidated aquifer is commonly conceptualized as a unit that is dominated by coarse sands and gravels. That conceptualization has been widely utilized in Kansas; the solid-line ellipse in figure 2 encloses the $S_Y$ values (0.175–0.2) that have been used in modeling studies in the Kansas HPA (Republican River Compact Administration 2003, Balleau Groundwater Inc. 2010) and that are consistent with values reported by Gutentag et al. (1984) and others (see supplemental text for further discussion). For these $S_Y$ values, the percent reduction is 75%–85% of the average annual pumping (an $S_Y$ value of 0.235 would require a 100% reduction, i.e.
pure groundwater mining). Not surprisingly, reductions of this magnitude generate little enthusiasm within the irrigation community because of the perception that the impact on the area’s economic vitality would likely be severe.

Since the mid-1970s in Kansas, regulations have required that a record of the geological material encountered during drilling be submitted for every water well completed in the state (digitally available at www.kgs.ku.edu/Magellan/WaterWell/index.html). Although these driller-reported records are approximate representations of subsurface conditions, they provide valuable information about the general characteristics of the HPA. That information, however, should be considered an overly optimistic assessment of the lithology of the aquifer as the location of a high-capacity well is typically based on the selection of the most permeable site among multiple test holes (a record is only required for the completed well). In GMD4, these records indicate that the aquifer is not a sand-and-gravel dominated system but is, instead, a system dominated by finer materials (fine sands to clay—figure 3). This conceptualization is supported by $S_Y$ values (0.027–0.085) that were calculated for the various Kansas GMDs using the water-balance approach of Butler et al (2016) and are enclosed in the dashed-
Additional support for the fines-dominated conceptualization can be found in the year-to-year variation in net inflow, which is characterized by the coefficient of variation in figure 2. For the sand-and-gravel conceptualization, the CV varies from 1.2 to 2.6. Such large interannual variations in net inflow are unrealistic for an unconsolidated aquifer in an area in which the average depth to water is nearly 41 m. One would expect that the vadose zone would act as a low-pass filter on surficial recharge (Stephens 1996), resulting in a relatively low interannual variation in net inflow. These large CV values also are not consistent with the interannual variation in annual precipitation (from radar) and pumping, which are characterized by CV values of 0.17 and 0.15, respectively (dashed horizontal line in figure 2 is the average of these two CVs). The similarity between CV values for precipitation and pumping is expected because pumping is primarily being driven by precipitation in this area (Whittomore et al. 2016). For the fines-dominated conceptualization, the CV of net inflow varies from 0.10 to 0.17, which is consistent with the low-pass filter hypothesis and the precipitation and pumping records.

GMD5: This district encompasses 10120 km² in subhumid south-central Kansas. Seasonal groundwater pumping in support of irrigated agriculture comprises 96% of the total annual groundwater use in the area; the district is in a mature stage of development and was closed for new appropriations in 1998. In 2005, 93% of the wells were equipped with totalizing flowmeters; that percentage increased to 97% in 2010. The majority of the streams in the western portion of the district are ephemeral and receive no baseflow; streams are perennial or intermittent in the central and eastern portions of the district.

Figure 4 displays the specific yield versus percent pumping reduction relationship, revealing that the required pumping reductions are much less than those calculated for GMD4, an expected result for an area with greater precipitation and a slowly falling water table (Whittomore et al. 2018). For the sand-and-gravel dominated aquifer conceptualization (Sₜ = 0.175–0.2), the percent pumping reduction is 14%–16%. The percent pumping reduction is less than 7% for the fines-dominated conceptualization (Sₜ = 0.027–0.085). The open circle is the Sₜ value for GMD 5 (0.033; Butler et al. 2018); the longer sediment transport distances and entrapped air and water in the vicinity of a near-stable water table are likely responsible for the lower Sₜ value than in GMD4 (Butler et al. 2018).

Additional support for the fines-dominated conceptualization can again be found in the year-to-year variation in I. For the sand-and-gravel conceptualization, the CV varies from 1.4 to 1.6. Such large interannual variations in net inflow appear to be unrealistic for an unconsolidated aquifer for which the average depth to water is over 10 m and for which the CV values for annual precipitation (from radar) and pumping are 0.19 and 0.16, respectively (dashed

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**Figure 4.** Percent pumping reduction required to attain stable water levels (left y-axis) and coefficient of variation for net inflow (right y-axis) as a function of specific yield for Groundwater Management District 5 (GMD5; figure 2); calculations performed using annual water-level change ($\Delta WL$) and pumping ($Q$) data for 2005–2016 (table 1). $\Delta WL$ is the average for the 189 wells measured every year from 2005 to 2017, while $Q$ is the sum of reported use from a maximum of 6532 pumping wells for 2005–2016 (well total varies slightly from year to year). Climatic conditions for this period were wetter than normal (SPI = 0.38; Whittomore et al. 2018), so required pumping reductions under normal climatic conditions would be expected to be considerably greater. The filled circles and triangles correspond to the bounding $S_Y$ values for the aquifer conceptualizations defined in the text; the open circle and triangle are the percent reduction (3%) and coefficient of variation (0.14) values, respectively, for the $S_Y$ determined for GMD5 (0.035; Butler et al. 2018). Dashed horizontal line is the average of the CVs for $Q$ and radar-determined precipitation for GMD5.
GMD4, the appropriate CV of net inflow, is critical for extending the lifetime of the resource. The key often the only option for decreasing decline rates and economic vitality. In this work, we focused on the practice of adopting the traditional sand-and-gravel conceptualization and assignment of yield, common modeling practices (adoption of the traditional sand-and-gravel conceptualization and assignment of SY values based on tabulated values for that conceptualization) may produce a large underestimate of the impact of pumping reductions (i.e. predict much larger reductions than needed). The result is that past modeling studies may have inadvertently discouraged conservation efforts because the required reductions calculated with the model were perceived as practically infeasible. That has certainly been the reaction of many in the irrigation community in the HPA in Kansas (pers. communications, numerous irrigators in western Kansas, 2016–2018).

This study reveals the importance of specific yield for assessing an aquifer’s response to pumping reductions. As shown here, use of inappropriately large SY values leads to sizable underestimation of the impact of pumping reductions in the Kansas HPA. However, adoption of the traditional aquifer conceptualization (sand-and-gravel dominated unit) in highly heterogeneous systems for which other conceptualizations are more appropriate is likely not unique to the Kansas HPA. As a result, such practices may have led to use of overly large SY values in models of many unconsolidated aquifers. Indications of that possibility can be found, for example, in the tabulated SY values for consolidated and unconsolidated formations provided by de Graaf et al. (2017). For general unconsolidated settings, their SY value is 0.235, while values of 0.36 and 0.11 are given for coarse- and fine-grained unconsolidated materials, respectively. Thus, it appears that the underestimation of the impact of pumping reductions may prove to be a global phenomenon in unconsolidated aquifers. The ramifications for efforts to achieve a more sustainable future for these aquifers are significant.

### 4. Discussion and conclusions

For many heavily stressed aquifers, pumping reductions in the absence of alternative water sources are often the only option for decreasing decline rates and extending the lifetime of the resource. The key questions are how much should pumping be reduced to significantly impact decline rates and what is the effect of such reductions on an area’s economic vitality. In this work, we focused on the first question to show that, as a result of the insensitivity of calibration results to specific yield, common modeling practices (adoption of the traditional sand-and-gravel conceptualization and assignment of SY values based on tabulated values for that conceptualization) may produce a large underestimate of the impact of pumping reductions (i.e. predict much larger reductions than needed). The result is that past modeling studies may have inadvertently encouraged conservation efforts because the required reductions calculated with the model were perceived as practically infeasible. That has certainly been the reaction of many in the irrigation community in the HPA in Kansas (pers. communications, numerous irrigators in western Kansas, 2016–2018).

A closely related issue is how to assess if a particular SY value is appropriate for a given aquifer. We introduced here an important new metric for that assessment, the coefficient of variation of net inflow. In an unconfined aquifer with a sizable depth to water, a model-determined CV value for net inflow that is much greater than those of potential drivers, such as pumping and precipitation, should be viewed with skepticism in the absence of a compelling justification. Many areas have monitoring programs, similar to that in the Kansas HPA, for obtaining water-level data. Few areas, however, have programs to obtain

### Table 1. 2005–2016 average annual water-level change and annual volume of reported groundwater use data for Groundwater Management Districts (GMDs) #4 and #5 (average annual water-level change calculated using data downloaded from http://kgs.ku.edu/Magellan/WaterLevels/index.html; water use data downloaded from http://hercules.kgs.ku.edu/geohydro/wimas/index.cfm).

| Year | GMD4 average annual water-level change (m) | GMD4 groundwater use (10⁶ m³) | GMD5 average annual water-level change (m) | GMD5 groundwater use (10⁶ m³) |
|------|-------------------------------------------|-----------------------------|-------------------------------------------|-----------------------------|
| 2005 | −0.132                                    | 0.494                       | −0.014                                    | 0.595                       |
| 2006 | −0.090                                    | 0.540                       | −0.369                                    | 0.656                       |
| 2007 | −0.305                                    | 0.519                       | 0.956                                     | 0.504                       |
| 2008 | −0.091                                    | 0.504                       | 0.184                                     | 0.549                       |
| 2009 | 0.010                                     | 0.374                       | 0.213                                     | 0.571                       |
| 2010 | −0.164                                    | 0.456                       | −0.141                                    | 0.649                       |
| 2011 | −0.177                                    | 0.341                       | −0.896                                    | 0.853                       |
| 2012 | −0.435                                    | 0.678                       | −0.580                                    | 0.746                       |
| 2013 | −0.205                                    | 0.586                       | 0.176                                     | 0.567                       |
| 2014 | −0.141                                    | 0.303                       | −0.216                                    | 0.584                       |
| 2015 | −0.186                                    | 0.476                       | −0.078                                    | 0.635                       |
| 2016 | −0.154                                    | 0.462                       | 0.164                                     | 0.535                       |
pumping data of a similar quality. In lieu of such programs, pumping estimates are often based on proxies, such as utility records or remotely sensed values of evapotranspiration. The viability of such estimates for identifying inappropriate Sy values is unclear and is the subject of ongoing research. As we have argued in previous papers (e.g. last paragraph of Butler et al 2018), the community must place a greater emphasis on obtaining high-quality pumping data if we are to meet societal expectations for reliable assessments of future prospects for aquifers across the globe.

The impact of pumping reductions without water replacement on an area’s economic vitality was not a focus of this paper. However, recent analyses of the first five years of pumping reductions in a 256 km² area in GMD4 indicate that irrigators were able to reduce pumping by about 28% while maintaining their profitability through more strategic application of water and changes in crop type (Golden 2018, Deines et al 2019). Thus, modest pumping reductions do not necessarily equate to losses in net revenue. The 28% reduction, which significantly diminished the decline rate (Butler et al 2018), did not stabilize water levels as would have been expected from figure 2 because the pumping in the area was considerably above the GMD4 average and the sediments are somewhat coarser (Sy = 0.10 according to an initial analysis in Butler et al 2018).

The magnitudes of the pumping reductions discussed here represent average values for the two GMDs we considered. If such reductions were implemented, water levels would continue to decline, albeit at a much lower rate, in the most heavily stressed areas of the GMDs (as discussed in the previous paragraph), while water levels would increase in the most lightly stressed areas. Finer-scale analyses can be performed to assess the required reductions for such areas but do not alter the conclusions presented here (Butler et al 2018, Whittemore et al 2019). Furthermore, the magnitudes of the pumping reductions are based on the assumptions that the net inflow of the recent past will be the net inflow of the near future (Butler et al 2018) and that the specific yield does not change with time (Butler et al 2016). Pumping reductions, however, will have an impact on aquifer conditions and, consequently, will produce changes in net inflow. The time span for those changes depends on the aquifer response time, which is likely on the order of a decade or two, if not longer, in large regional aquifers (Bredehoeft and Durbin 2009). As changes in net inflow or specific yield do occur, they will be recognizable from plots of water-level change versus water use (Griggs and Butler 2017), allowing for adaptive management in response to those changes. In the case of net inflow, the magnitude of the changes will depend on the mechanisms responsible for that inflow, such as the proportion of recharge that is derived from precipitation versus that due to irrigation return flow or the proportion of net inflow produced by lateral flow versus that due to vertical recharge. Although this issue does not affect the discussion of the importance of specific yield, it is a reminder that the water-balance approach used here is not a substitute for numerical modeling. For example, it cannot readily be used to assess the impact of pumping reductions on baseflow to streams. Thus, with respect to numerical modeling, the water-balance approach should be viewed as a complementary method that provides insights into appropriate parameter assignments and helps chart more sustainable paths for many of the world’s heavily stressed aquifers.

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Data availability statement

Any data that support the findings of this study are included within the article.

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