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EDITORIAL

Groundwater: an unseen, overused and unappreciated resource

Globally, water management as a whole, for nearly all countries, has been on an unsustainable path for over a century. If the current trends continue, there is no question that much of the world will soon be facing a water crisis which no other earlier generation had to contend with. There is currently enough knowledge, technology and funds available to circumvent such a crisis. However, there are no visible signs that the solutions available are likely to be used to significantly improve water management practices and processes so that it could be averted, over the mid- to long terms, in most parts of the world.

The situation is complicated by the fact that climate change is making occurrences of extreme hydrometeorological events, such as floods and droughts, more frequent, and their durations much longer (Biswas & Tortajada, 2022). In addition, observations during the past three to four years indicate that climatologists and hydrologists may have significantly underestimated the magnitudes, durations and frequencies of these events. The changes to these events may occur at much faster rates than has been the scientific consensus and compared with even five years ago.

There is no question that the world is now facing a perfect storm in terms of managing surface and groundwater, in terms of both quantity and quality, due to a host of uncertainties, some known, but others unknown. Decades of continued neglect and mismanagement of issues associated with good water management by all levels of governments, central, provincial and municipal, and ad-hoc approaches to plan and manage water have meant most countries are currently confronted with scarcities of this resource. Even when water is available, it may often be too contaminated with known and unknown pollutants so that it cannot be used for most purposes.

The problem is further complicated by the fact that policymakers in most countries have not given water any long-term political priority (Biswas, 2019). They become primarily interested in water only when there are major floods or prolonged droughts. Once these events are over, their interest in water simply disappears.

Unfortunately, water problems cannot be solved without the long-term sustained interest of policymakers. It takes time to make a good and implementable long-term plan. After such a plan is formulated, it has to be executed. Thus, depending on the projects, and their scales in terms of magnitudes and complexities, the plans could easily take 20–50 years to execute. For example, the planning for China's South-to-North Water Diversion Project started earnestly in the mid-1970s. Some 45 years later, its completion is in sight. During this entire period, the project has continued to receive strong interest from China's different generations of policymakers. Accordingly, not only has the political interest in the project consistently remained high, but also this has ensured appropriate funding has been available regularly and in a timely manner to complete it. These are

prerequisite conditions to ensure large investments needed in constructing and managing large-scale water infrastructures are available when necessary.

In addition, when a country has formulated a long-term water management plan, this alone is not enough. The plans have to be regularly updated to incorporate changing political, economic and climatic conditions as well as scientific, technological and management advances. For example, Singapore has a long-term water plan to 2060 (Tortajada et al., 2013). This is regularly updated every five years and then approved by its cabinet.

In recent decades, sustained interests shown by the Chinese and the Singaporean policymakers in water management issues have been exceptions rather than the rule. Unsurprisingly, in those countries where policymakers show sustained interest in water-related issues, their water management shows steady progress and improvement. The situations are significantly worse in most other countries where political interests are generally ad-hoc and short term. In fact, in such countries, which include much of the world, prospects for long-term water securities are declining steadily.

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The perceptions of the general public and politicians on water are mostly dominated by overwhelming interest and vision of surface water, comprising rivers and lakes. Groundwater is rarely part of this overall discourse and thus vision and action. This is rather ironic since groundwater constitutes over 98% of the Earth's liquid freshwater.

Currently available global and national water data are not very reliable for surface water, even though the overwhelming percentage of data available on quantity and quality at present are primarily focused on rivers and lakes. Groundwater-related data are conspicuous by their relative paucity and unreliability. This is in spite of the fact that the general global consensus at present is that groundwater currently provides 42% of irrigation water, 36% of potable water and 24% of industrial water requirements.

These are, of course, global statistics. They could vary widely from one country to another. However, overall, agriculture accounts for the majority of groundwater use. Unfortunately, in nearly all countries around the world, during the post-1960 period, groundwater has been extracted unsustainably over long periods, a result of which is that groundwater levels have continued to decline steadily. This has made continued groundwater extraction both expensive and energy intensive.

This sad and unsustainable condition related to groundwater can be witnessed in both developed and developing countries. Take one of the world's most advanced countries: the United States. Its Ogallala aquifer, which stretches from South Dakota to Texas, produces at least one-fifth of the nation's total annual harvest. Some six decades ago, all six states over this aquifer made a Faustian bargain: short-to-medium term economic benefits against long-term permanent water scarcity when water demands for domestic, industrial and agricultural uses would be higher. To take advantage of short-term economic opportunities, for decades politicians and landowners have resorted to extracting as much water as anyone wanted to pump to maximize economic returns without any concern of their long-term implications.

This has meant levels of the Ogallala aquifer have steadily declined over the past decades. According to the Kansas Geological Survey, water levels in the south-western part of the state have dropped 61 cm by 2022. Kansas alone was estimated to have

withdrawn more than 7570 megalitres of water in 2022 alone. In addition, none of the six states sharing the Ogallala aquifer has drawn up an implemental plan on how to best manage what is left of this aquifer on a sustainable basis.

Developing countries are also facing the adverse consequences of unbridled groundwater extractions. South Asian countries are now the largest abstractors of groundwater. Extensive use of groundwater and rural electrification made the Green Revolution possible in South Asia. This contributed significantly to improve and ensure food security of these countries, at least over the short and medium terms.

Groundwater abstraction in India has been increasing steadily and significantly. It has become progressively more unsustainable over the past six decades. Consequently, in many parts of the country, groundwater levels have been declining by more than 1 m per year.

During the past four decades, there has been an explosive growth in the use of tubewell irrigation in agriculture in South Asia. This is because of several important reasons. First, the absence of reliable canal water for irrigation. Second, farmers themselves control their groundwater irrigation and can use it whenever they consider it necessary. They cannot irrigate their fields with canal water whenever they want. Third, during the 1970s, encouraged by the World Bank, India adopted the policy of providing free electricity for pumping for irrigation to increase agricultural production. The only costs to farmers were the pumps and their installations. Fourth, in the post-1970 period, cheap Chinese pumps flooded the South Asian market, which made such pumps widely available and affordable.

All these developments meant that groundwater abstractions in South Asia have proliferated extensively over the past five decades. Data on groundwater availability, use and quality in South Asia are patchy at best, and mostly unreliable. It is estimated that India alone now is using 230–250 km^3 of groundwater annually. Currently, more than 85% of domestic water use and 60% of irrigated agriculture in the country depend on groundwater. Because of poor groundwater management, India now accounts for nearly one-quarter of the global groundwater extraction and use. The country now uses more groundwater each year compared with China and the United States combined.

Unsurprisingly, in 2009, NASA estimated that the Indus Basin is the second most overstressed aquifer in the world. The basin includes Punjab and Haryana, two main food-producing states of India. NASA further reported that the groundwater depletion rate in North India is about 1 m every three years. This rate is one-fifth higher than what the Indian Water Ministry had estimated previously. The situations most likely have further worsened during the post-2009 period.

A major problem in many parts of the world, including the United States and India, is groundwater laws stem from the 19th century when knowledge about its scientific management was extremely limited. Thus, laws still stipulate that all landowners can extract as much groundwater as they wish from their landholdings, without any restrictions. The concept of groundwater as a common societal resource simply did not exist in the 19th century. Also, if landowners extracted as much groundwater as they wanted, they would adversely impact the water availability of their neighbours. This fact was basically not understood or appreciated in the 19th century.

During the post-1960 period, in both the United States and India, a number of groundwater abstraction wells started to increase exponentially. Such massive withdrawals

ensured that rates of withdrawals steadily exceeded the rates of recharge Consequently, groundwater levels under the existing legal regimes in both countries have steadily declined. Unless the legal regimes are updated to meet the needs of the second quarter of the 21st century, the status of groundwater management can only become increasingly more precarious.

Since farmers are important stakeholders in groundwater management and the majority of them benefit economically from the current unsustainable legal regimes, it would be a difficult task, at least politically, to modify the existing regulatory systems significantly and quickly. On the positive side, policymakers are now appreciating the fact that the current legal regimes cannot lead sustainable groundwater management. On the negative side, politicians have to be elected regularly and they are afraid if they strongly support the needed changes, they may be voted out of office by disgruntled farmers. Thus, even though over-abstraction problems are already serious in many countries, legal changes may come slowly and perhaps incrementally.

It will probably need major water crises of historic proportions to galvanize politicians into making major changes in groundwater laws. As the impacts of climate change, especially in terms of prolonged and severe droughts over the long term, become evident, perhaps the views and attitudes of politicians, farmers and the general public towards sustainable groundwater management may change for the better.

Sustainable groundwater management

Given the deteriorating groundwater situation in most parts of the world (United Nations Environment Programme [UNEP], 2019), in terms of both quantity and quality, it will be essential that over the next decade serious attempts are made to put ground water's management on a more sustainable path. At the very least, countries should formulate and implement policies that should consider reducing significantly the rates of current declines of groundwater levels, and also reduce the level of contaminants reaching groundwater. Even these limited objectives are difficult to achieve, given the vested interests involved in maintaining the current practices.

If groundwater levels can be maintained within 8 m of the surface, it would be of tremendous benefit to the rural people of developing countries. When groundwater levels can be maintained at less than 8 m from surface, low-cost centrifugal pumps can be used which can use atmospheric pressure to raise water above ground. Beyond 8 m, costlier submersible pumps are necessary to pump water. Submersible pumps are generally 2.5 to three times more expensive than centrifugal pumps and are thus beyond the financial reach of small farmers.

This fact has many policy implications in terms of poverty alleviation, stabilization and improvement of rural income levels, the raising of living standards and improvements in food and water security conditions of rural people in developing countries.

Studies from rural India indicate that in villages where groundwater levels are more than 8 m deep, poverty rates are 9–10% higher, and self-reported disputes over irrigation water increased by 25% (Sekhri, 2014). Thus, if groundwater levels can be maintained at no lower more than 8 m, it could have important ramifications for rural poverty alleviation in developing countries.

Unfortunately, however, many developing countries now have enshrined policies where pumping from higher depths is actively encouraged by government policies by providing farmers with free electricity or highly subsidizing electricity for pumping, for both large and marginal farmers. As a result, farmers have been often pumping water much more than necessary, and this has further contributed to the steady decline in groundwater levels. This has meant that after a very few years of collective over-pumping, farmers have had to buy new, more powerful and expensive pumps which could extract water from increasingly greater depths. This vicious cycle can be seen in many countries where groundwater levels are steadily declining as a result of which farmers use more and more electricity which the government has to supply free or at very subsidized rates. In the long run, everyone loses by these unsustainable policies: farmers and government as well as the environment.

Unlike surface water bodies such as lakes and reservoirs, whose declining levels all can see, declining groundwater levels are not visible, and thus are not of much concern to policymakers, media or the general public. When the levels of Lake Mead declined steadily and levels of flows in rivers such as the Rhine and the Yangtze declined, everyone around the world became more aware of these facts. However, when the groundwater levels in aquifers decline, whether in the United States, several European countries, India or China, there is no similar media or public interest. In these cases, ignorance may be a temporary bliss, but over the long term they are serious national issues.

Papers in this issue

The January issue of the journal contains several very interesting and exciting papers. These include projecting conflicts risks in transboundary river basins under different scenarios (de Bruin et al., 2023); the water–tourism nexus research in the Mediterranean during the past two decades (Ricart et al., 2023); the governance of technological innovations in water use in Uzbekistan (Hamidov et al., 2022); the assessment of economic and water leakages efficiency in Chilean water utilities (Molinos-Senante et al., 2023); urban water governance in Mexico during the COVID-19 pandemic (Valdovinos & Soria, 2022); salt for Mexico but fresh water for Arizona (Pineda-Pablos, 2023); and water ways' transformation and green stormwater infrastructure in Adelaide's river Torrents catchment (Ibrahim et al., 2023). The issue also contains an excellent review by Quentin Grafton of the book *Dead in the Water: A Very Angry Book About Our Greatest Environmental Catastrophe . . . the Death of the Murray–Darling Basin*. In their own ways, each of these publications has considerable food for thought.

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