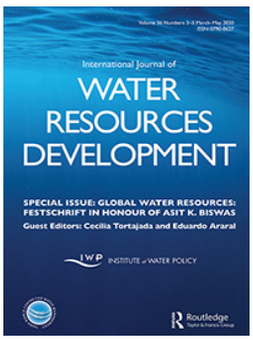

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VIEWPOINT

Scarcity of water or scarcity of management?

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ABSTRACT

This article investigates the relation between water scarcity and water management. There are many different perceptions of water scarcity, which can include the conditions of arid environments, a general lack of access to water, insufficient water at a basin scale, or difficulty in meeting competing needs. All these issues will intensify with greater consumption and climate change. Asit Biswas reminds us that the root cause of scarcity is the way water is managed. Following this wisdom, I examine different contexts of scarcity I have encountered in my work and reflect on the management challenges which drive and transform water scarcity.

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Introduction

'There is no scarcity of water, only a scarcity of management.' I have heard this provocative comment several times from renowned water leader, Prof. Asit Biswas. I knew of Asit Biswas when I was a graduate student at Colorado State University, but had a chance to meet him through the International Water Management Institute, where I worked. Since then we have met frequently, and recently I had the privilege of working with him and Cecilia Tortajada to produce special issues for the *International Journal of Water Resources Development*. Both Asit and Cecilia have been tremendously supportive of the work of the International Centre for Integrated Mountain Development (ICIMOD) and its work on water management.

In the 20 years I have known him, Asit has always been someone who makes me critically examine my work. When I first heard the statement above, I thought that surely there are a lot of cases of water scarcity, such as in very arid environments where there is a physical lack of water. Then again, when water is well managed it is possible to thrive in difficult environments; and even in wet environments people may struggle with water scarcity. To elaborate on Asit's point I draw on personal and professional experiences in Southern California, Egypt, Lesotho and the Himalayas. I will start where the inspiration for my career began: Southern California and the Mountain Kingdom of Lesotho.

Los Angeles

When I was growing up in a suburb of the city of Los Angeles in the 1960s, I thought water was plentiful. Our neighbourhood was a delightful green space with grass, trees, gardens

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and sprinklers. As a water user, I could turn on the tap and not worry about quality or quantity. I did not know where the water came from.

Later, I learned about Los Angeles' hydraulic infrastructure, which was developed to source water from great distances through pipes and channels. That infrastructure diverts water from the Colorado River and fertile irrigated areas, like the Owens Valley. The book *Cadillac Desert* (Reisner, 1993) recounts the hydraulic development of the Western US. Los Angeles's mega-infrastructure project, aimed at promoting growth and development, did not recognize the limits of water resources development, at a time when supply from distant sources seemed plentiful. As the movie *Chinatown* can attest, the hydraulic project of Southern California has always been controversial.

As Los Angeles grew, surrounded by profitable agriculture, failures of that large-scale hydraulic infrastructure and increasing competition for regional water supplies brought to light the important question of management over scarcity. The recent California drought, for example, shows not only that we have reached water limits, but also that such scarcity is driven by poor planning and management.

Lesotho

My first postgraduate job was at Butha Buthe High School in Lesotho, teaching mathematics, science and English to a very energetic group of youths from Lesotho and South Africa. I had the opportunity of living in the wonderful village of Tlokoeng, which in many ways was as far away as possible from where I grew up in Los Angeles.

While the village had no shortage of joy and friendship, there was no electricity, nor any running water. My neighbour and friend 'Me Masebabatso offered to carry a bucket of water of about 25 litres to the roundhouse or *rondaaval* where my wife, Karen, and I made our home. That water came from a local spring, which was also a social gathering place for the village women, and it was about a 30-minute walk away. We would use 25 litres for a day or two, saving enough water after cooking for a nice bucket bath and reusing it for our vegetable garden. Unfortunately, both of us came down with typhoid fever, probably because the source of water was not protected well enough.

My first experience with water management was to help instal a well for the village. The villagers organized to make a request and copayment, and fortunately, there was a project that could fill the demand. To my delight, they named the well Sediba sa David (David's well). The handpump made a big difference in both the amount and the quality of water that could be obtained and in the lives of people. But even with the handpump, the women still had to carry buckets of water on their heads, and for some, the distance was still far. This was a life-changing event: I changed my career course and went back to university to learn more about water.

Lesson 1: There are many different views of water scarcity

While 'water scarcity' is a common term, it has different meanings in different contexts. There are physically water-scarce environments, such as the deserts of Egypt or the Kalahari Desert (where I worked finding water wells). In these arid environments, the lack of rainfall makes water use a key concern. I will refer to this as physical water scarcity. However, if I hear that someone is struggling to acquire enough water, I understand that often this is more an issue of access. In this article, I will call this use

scarcity. As described in this article, the reasons for use scarcity are many, and it is ultimately this type of scarcity that humanity must overcome. Another type of scarcity emerges at the basin level when it becomes difficult to allocate the existing supply to all users and uses. This is the situation in Los Angeles and many other areas of the world, such as Egypt's Nile Valley, and I will call it basin scarcity. Much of my career has been aimed at understanding scarcity (Seckler, Amarasinghe, Molden, De Silva, & Barker, 1998) and how to deal with it (Molden, 1997).

Egypt

Egyptians proudly say that their country is a gift of the Nile. My family had the fortunate experience of living in Cairo, and I did field research for my PhD in Upper Egypt. We also lived in Alexandria, where I worked in the Nile Delta area on irrigation rehabilitation. We then moved back to Cairo, where I conducted strategic research on the long-term usage of Nile River water in Egypt.

At the edge of the Nile Delta, one can easily see the contrast between the sandy, barren desert and the rich green fields of the Nile Valley. This is an area of intense irrigation, as well as a large, dense and thirsty population. In fact, the water is so intensively used that very little flows to the sea – a sign that the limits are being reached, or more likely breached. It is an area that has received huge investments in hydraulic infrastructure development, with a major step being the creation of the High Aswan Dam in the 1960s, and the expansion of irrigation in the Nile Delta.

The critical question, 'How far can the Nile water be stretched to feed the need of burgeoning cities and the growing demand for food?' was one of my tasks when I worked in Egypt in the early 1990s. Working on the entire Nile River basin 10 years later, it became clear to me that upstream countries also needed water for their people, food and energy. Today, management of this transboundary river basin remains an issue to be addressed (Awulachew, Smakhtin, Molden, & Peden, 2012; Conniff, Molden, Peden, & Awulachew, 2012).

In this situation where water limits are reached, there is apparently no water for additional uses, so that an increase in use, say by cities, typically means that water gets reallocated and shifted from one use to another. Even saving water in agriculture is not as easy as it seemed (Seckler, 1996). Water management issues become much more complex as a change in use by one user can readily impact other users: the different water use sectors are closely connected.

Cities, agriculture, industry and water must be managed with a holistic basin approach. Equity becomes a concern, as water is often allocated away from those with less wealth and power. Issues of pollution, water reuse, and enough water for navigation all become interrelated, and variability in supply can really challenge water managers. Unsustainable practices arise when people try to obtain more water from declining groundwater tables, or tap too much from river systems, such that not enough environmental flows remain. Water management agencies set up to expand irrigation or manage city water alone are not geared up to solve these issues. The Nile River is also shared between many countries, raising difficult political issues. Such issues of 'over-development' and allocation emerge over and over in many river basins throughout the world (Falkenmark and Molden, 2008).

Lesson 2: Development can solve water scarcity, but also create water scarcity

The situations in California and Egypt, in contrast to Lesotho, offer different insights. Clearly in Lesotho water was a scarce commodity. People really had to struggle for a few drops. In spite of water in springs and in the river valley, access to water was a real issue. Infrastructure investments are often intended to ease scarcity at the user level. In the Lesotho, case, the pump eased access and brought relief to households. In Southern California, huge investments were made in hydraulic infrastructure to support and expand a growing economy. And in Egypt, dams, barrages and canals were built to expand and control the water supply so that more people could have more access to water for household uses and irrigation, not to mention the industries and economies this supported.

Another type of scarcity occurs when societies reach the physical limits of water availability. In Los Angeles, the solution was to go farther afield and tap water from distant sources. In Egypt there are limited options, as the upstream countries are demanding more. With too many demands on rivers countries over-rely on groundwater, which has its long-term limits and remains a serious water challenge. Water users become interconnected sometimes in direct ways and other times in subtle ways, and the complexity of management increases many times.

As the cases of Egypt and Southern California illustrate, the expansion of irrigated agriculture is a major driver of basin-level scarcity. With its high consumptive use of water, growing food takes a lot of water. Expanding irrigated agriculture in Egypt and California is a major factor in driving up basin water use to the limits and thus to basin scarcity. This is because of the high consumptive water use by irrigation, or liquid water being converted to evaporation and transpiration that is not available for reuse.

The politically more difficult question is when, where and by how much to limit irrigated agriculture. Reducing agriculture in Egypt or California could free up water. I remember hearing Tony Allan (1994) talk in the early 1990s about how trade could free up water in Egypt. On the one hand, a growing, wealthier population will require more food, and more water to grow the food (Molden, 2007). On the other hand, where and how should the food be grown is an important global question. This also brings to mind the relationship between what we eat and how much food we waste. Food habits and the relation of food and water remain important considerations for individual users, cities and nations (Lundqvist et al., 2008).

There are patterns of water use and development which seem to be common across the globe and can be thought of in terms of trajectories of water basin development (Keller, Keller, & Davids, 1998; Molden, Sakthivadivel, Samad, & Burton, 2005; Molle & Wester, 2009). To overcome problems of scarcity at the user level, hydraulic infrastructure is built to supply more water to various uses, for example by putting in water pumps in Lesotho, or building dams and canals in Egypt. With increasing demands and more and more expectations for water to support expanding agriculture, more water is removed from its natural system and diverted to meet various needs. However, there is a point when hydrologic limits are reached, and if it is technically too difficult or expensive to get more water, or water rights become a concern, societies have to learn to live with what is available, and deal with the natural variability of water cycles. As these limits are reached, there is much more concern about ecosystem functions, and the struggle is how to reallocate precious water amongst various users – environment, agriculture, industry, drinking, energy and more. When this upper limit

is reached, when there is no additional water in natural systems to be tapped, there is human-made scarcity. There is not enough water for all the apparent needs, and the question of who gets water, and whether there is enough for the environment, remains a real issue. So we see a shift from dealing with scarcity at a local level to an overall induced scarcity at river basin and larger scales, which may again cause use-level scarcity if not managed well.

Kathmandu Valley

I now live in a ring of hills (in other countries they would call them mountains) surrounding the Kathmandu Valley, near the hill called Phulchowki (2780 m). Our house is at the head end of one of the valley's water systems. Fortunately, we have a good water supply: a village district committee-run water system that is fed by a forest spring. However, moving down the hill towards the main city of Kathmandu, the situation becomes worse and worse. It is quite common to see leaky pipes spilling water on the ground, and many water tankers on the road, delivering water to water-starved Kathmandu.

There are several streams and springs flowing down from Phulchowki Hill. Beautiful ancient temples, ponds and stone spouts show the importance of and reverence for water since ancient times. The streams support rich wildlife and are a favourite place for Karen to photograph dragonflies and birds. But many of them are now dry for most of the year.

When looking for birds and dragonflies, Karen and I notice a water management issue similar to that of the Nile basin but on a much smaller scale. Curious about why these streams are dry except when it rains, we explored upstream. There is a surprising network of pipes tapping into the water to feed nearby downstream urban settlements. In one of our favourite biodiversity habitats, water developers built a water harvesting bund to capture water and to deliver it downstream and to the water tankers that deliver water into Kathmandu. With all the pipes in place, the streams below have dried up for most of the year, a clear case of breach of environmental flows.

Just as in the case of the Nile, the use of these small streams has already reached a limit, and the management issues become more complex as users become more interconnected. When people walk upstream they see the stream flowing and assume that by tapping it they can add more water to their system. The reality is that they are simply taking water from other users downstream – including the traditional ponds and systems that have served the area for hundreds of years. There is significant damage to the aquatic ecosystem. But when you point this out to water developers, they simply state that people need water and such development is necessary. Yet, I sincerely doubt that such planners conducted or took heed of hydrologic analysis and water accounting. With better planning, management and foresight, the same amount of water could be delivered to the city without damaging such important ecosystems.

Lesson 3: Institutions are more important than infrastructure in overcoming scarcity

People and politicians often view hydraulic infrastructure as a quick fix to water problems, whether it be major dams, or developers tapping into more supplies upstream in the Kathmandu Valley. There is no doubt that water infrastructure is a necessity worldwide, but the key lesson is that infrastructure development must go hand in hand with institutional

development. In managing water there is often a complex web of institutions responsible for water management, and understanding institutional needs is often beyond the engineering training that many water managers receive.

The Kathmandu Valley, like so many other places I have witnessed, struggles to meet growing multiple demands on water resources. Kathmandu's irrigated agriculture is declining, but even that does not free up water for the sprawling city. Planners and managers have just not been able to keep up, and mismanagement exacerbates both use and basin-level scarcity.

I would say that in terms of river basin trajectories, Kathmandu lies midway between the Lesotho village situation and the Los Angeles or Egypt water case. The city population is burgeoning, with more than 3 million inhabitants, up from the 1 million when I lived there in the 1990s and was working on irrigation in Nepal. Agricultural fields are rapidly turning into urban landscapes. The Kathmandu Valley receives about two metres of rainfall, and heavy monsoons; it is the source of the Bagmati River and has a significant aquifer system. It seems like nature supplies enough water for the inhabitants, yet most people in Kathmandu lack adequate clean drinking water. People ultimately learn how to fill the gap. The situation is well described by my daughter, who studied the situation in depth (Molden, Griffin, & Meehan, 2016; Molden, Khanal, & Pradhan, 2018). Her studies showed the dire consequences of water mismanagement as women, men and recent migrants spend inordinate amounts of time, money and energy on accessing and saving water. They also showed the ingenuity in how groups organized to overcome difficulties. Several user groups in the Patan area overcame scarcity by working together to operate their own groundwater systems and revitalize ancient water systems.

During my stay in the Kathmandu Valley in the early 1990s, the Melamchi water project was designed to bring water in from sources north of the valley, through a tunnel. This large hydraulic infrastructure for trans-basin river diversion was seen as the way to provide adequate access to water for the citizens. Remarkably, the project is not yet complete, nearly 30 years later. My sense is that even if the project comes, it will not solve the water problems. There are a plethora of water management issues, from inequitable distribution of water to lack of maintenance, and a very weak institutional infrastructure. Until these are addressed, there will still be water problems, and water scarcity will be a reality.

The mountains

Mountain areas are referred to as water towers, or sources of water for river and groundwater systems. The hills and mountains of Lesotho and the Hindu Kush Himalaya (HKH) are home to some of the poorest people on earth, with little investment in water infrastructure to benefit the local people. Population densities in mountains are typically much lower than in the surrounding plains, and typically there is a high flow in rivers, supporting a small population, so water availability per capita can be very high, suggesting no scarcity (water availability in Lesotho is 2599 cubic metres per capita per year; in Nepal, 7366; in Egypt, 20; and overall in India, 1116). So from the perspective of water availability, the impression is that mountain areas should not be water-scarce at all. Yet, experience in the Himalayas and in Lesotho shows that people in the hills and mountains indeed struggle a lot to get adequate supplies of water for drinking, sanitation and agriculture. What is happening?

The basic physical challenge in hills and mountains is to overcome gravity. Villages and towns are often on the top of hills or on the slopes, and one reason for this is to avoid

floods. The town of Cherapunjee has some of the highest recorded rainfall values on earth, with an average annual rainfall of over 11 m, but paradoxically it is known as a wet desert, because the water quickly flows downhill. The rivers are down in the valley, so to use river water, people have to work against gravity. The traditional solution is to capture water before it runs downslope to the rivers. Springs are an important source. People also try to store water in the soil, as well as ponds and reservoirs.

As a result, for much of the year, people in the hills and mountains suffer from severe use-level water scarcity. Women spend much of their day fetching water from springs, and each drop is precious. There are examples of excellent water management in the hills, where farmers have organized to capture streams or springs on the slopes of hills and divert it to irrigation. People have marvelled at these traditional systems, and the management system for resource mobilization, operation and maintenance (Ostrom, 1990; Pradhan, 1989). In a world full of water mismanagement, experiencing these can really be a positive experience, showing hope for the future.

Lesotho is also known in water circles for the Lesotho Highland Development Project, a massive undertaking begun in 1986 to supply water and electricity to Lesotho and South Africa (Keketso, 2003). So there is investment in water, and this was also meant for the overall economic development of the country. My initial stay in Lesotho from 1977 to 1979 was before the project was built, and I remember that people talked about the project, how it would bring water and electricity to light up villages. I visited again many years later, in 2007, when the project was complete. The dam and reservoir were strikingly beautiful, and a mark of great engineering. However, when I visited the village of Tlokoeng, where I had lived, water access was still an issue, although the scarcity had been reduced with more wells. During my visit, Tlokoeng received an electric connection for the first time – 10 years after completion of the first phase of the Highland Development Project. Most of the water and electricity are flowing into South Africa. The question of *who benefits* from water development remains one of the key water management issues we have to face.

Climate change

I joined ICIMOD in 2011. It is ideally placed to address the issue of sustainable development in mountains, as it covers the mountains and hills in the eight countries of the HKH: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan. Ten major river basins, home to about 2 billion people, have their sources in the HKH. Clearly the governments and people are concerned about what is happening in the mountains and how it will impact their river systems. Downstream of the HKH, water from the mountains serves over half the irrigated area on earth, and there are huge cities such as Delhi, Lahore, Dhaka and Chengdu. Seven of these 10 rivers are transboundary, and in almost all the basins, water managers struggle to provide enough water for everyone. Disasters from floods and droughts are on the rise; water pollution is already high; and ecosystem services from rivers are diminishing – all symptoms of poor water management.

And what will happen with climate change? There was a striking lack of data and research in the mountains in spite of their importance as the water towers of Asia. But, fortunately, over the last 10 years there have been robust scientific studies on the HKH cryosphere and its changes and subsequent impact downstream; these are synthesized in the HIMAP report (Bolch et al., 2019; Wester, Mishra, Mukherji, & Shrestha, 2019).

Overall studies show that most glaciers across the HKH are thinning and retreating rapidly. In the short term, over say 10 to 40 years, melting glaciers and snow will add more water to the rivers, but there will be a turning point ('peak water') when it starts decreasing.

In the long term, most climate models point to more rain in the region. The overall result is that the overall annual volume of water in the main rivers may not decrease by 2100, but hydrologic patterns will change, and variability in flows will increase. This points to lower flows in the lean season, and higher flows in the flooding season. For people in the mountains who live close to the glaciers and who are well adapted to glaciers and snow, less water from melting will have its impacts. In other words, water managers will have to face more uncertainty and more variability. Given the water management regimes that already struggle with existing supplies, this will certainly be a challenge for Asia, and indeed segments of society could suffer from water scarcity. China Water Risk (Hu & Tan, 2018) estimates that US$ 4 trillion of business assets are at stake from climate change and water management in these river basins.

During my time with ICIMOD, we have been trying to understand the impacts of climate change on the cryosphere – the snow, glaciers and permafrost – and thus on downstream river systems. In 2014, I had the good fortune to visit the mountainous areas of Pakistan to understand what was happening to the glaciers and its impact on the Indus River. What was striking during that visit was the melting glaciers, but also the difficulty of getting good measurements. I was impressed by the green agricultural fields and fruit orchards, and the irrigation systems built and managed to supply water equitably to villagers. But what struck me most was the voice of the mountain community. We were warmly welcomed in village after village. Villagers explained to us their problems with water. They were losing their water source because of retreating glaciers, and they were in danger of floods from glacier lakes and storms. They even asked what methods they could use to stop glaciers from retreating. While there was plenty of water in the rivers, it was very silty, and not seen as a potential source of water because of the silt and difficult access. There was a plea for help, and we tried to respond with some interventions, such as solar pumps to tap the rivers and early flood warning systems aimed at adapting to climate change. I returned five years later and was proud to learn that some of these interventions were successful – but some were not, in this very difficult environment. It really made me reflect on our global systems, where the people who contribute so little to climate change are its biggest victims.

Lesson 4: Realizing the human right to water is a growing concern and needs targeted approaches

I have learned that while mountains are isolated, and sometimes at the back of people's thoughts, they are also our early warning signal on how humanity is dealing with sustainable development. Climate change is already real for many mountain people, and challenging their resilience. Global management of our resources impacts people at the local level, and indeed adds to water management challenges.

In the future, more demand for water from a larger, wealthier population will require additional water for cities and agriculture than supplied at present. Then there is the gap between rich and poor, with people being left behind in water development. It is already

a struggle to keep enough water for ecosystems to support biodiversity. Then on top of that is the uncertainty and shifting hydrologic patterns that will arise from climate change. If we as a global community do not do better at managing our water resources, many people will experience scarcity. And unfortunately those who have less of a political voice, or less money, will be more at risk.

Asit Biswas invited me to a seminar hosted by the Pontifical Academy of Sciences, where we discussed the human right to water. There was a wide recognition that inequalities exist, and that water is a main concern for the poor and marginalized. It was also clear in the meeting that water access is related to complex societal issues and power relations between communities and people that need to be addressed at the same time. This will require targeted approaches with an understanding of social and political issues as well as water issues. This is very apparent in the hills and mountains of Lesotho and the HKH, and even more urgent in view of the disproportionate impacts of climate change.

Conclusions: reflections on water scarcity

A simple way to think about water scarcity is that it is a situation where there is not enough water to meet essential needs, like drinking or growing food. When water scarcity hits, supply is less than demand or expectations, and when it is poorly managed, people spend a lot of time and money to get water. This can happen at different scales, and with interactions across scales. Most water users in the Kathmandu Valley face immense problems getting enough water due to failures in water governance. In many mountain and hill villages, including my village in Lesotho, people spend an inordinate amount of energy fetching water.

At a larger scale, supply has to meet competing and growing demands. With population growth, situations can change from where there was enough water to meet everyone's demands, to a situation where there is not enough to go around. Allocation decisions are made that can force scarcity at the use scale. This is certainly the case in Egypt and in California: there is not enough water to go around for the various demands. Societies tend to not recognize the limits of water supplies, and they tend to focus on acquiring additional supplies rather than managing existing supplies. In so many places, like Egypt, there is a misdirected sense that more irrigation can be done, in spite of a limited water supply. This is repeated in many basins around the world. Because we overbuild and expect too much, we arrive at a situation where there is not enough water to go around, and when water is reallocated it tends to meet the needs of wealthier and more powerful people, rather than the poor or marginalized.

We do have cases of good water management, where the supply of water closely meets demand. Where water is managed well, scarcity can be overcome, but when there is mismanagement, scarcity can be devastating. Water managers in farmer-managed systems in Nepal have demonstrated the ability to share a limited supply equitably amongst users. However, in many irrigation systems across Asia, mismanagement is pervasive, and the head–tail problem is common, where those near the source of water get more than those downstream. In the Kathmandu Valley, some users have a plentiful supply, but most suffer.

With high levels of basin scarcity, the water management challenges are daunting. Growth in demand, and rapidly changing societal demands, and mechanisms to fairly allocate water in ways that best support economies, are a challenge. Pollution issues exacerbate the problems of water use and reuse. People tend to look for other sources of water, but that is

not always the solution either, as it might take away water from other uses – essentially robbing Peter to pay Paul. On top of this, we will have to face the challenge of climate change and even greater variability in water supplies. With growing demands for water superimposed on poor water management regimes, and the challenges of climate change, we have some daunting challenges ahead. Water scarcity will still be an issue, even though there is enough water, and enough money.

We need another way of looking at water, and we need to take some brave steps. Politicians need to be involved, and to look beyond easy and short-term fixes, and somehow society will have to be educated to demand this. Unfortunately, water management can be an incredibly complex issue, with intersecting issues of governance, and different positions in society – rich and poor, men and women, powerful and marginalized. Water also crosses sectoral interests, such as environment, energy and food. We will need more water managers and people engaged in water who are trained to be able to take a more holistic view of water, and who can understand not only the complexities of hydrology but also the social sciences. If we are to realize the dream of a human right to water, we have to be able to focus on the issues of the poor and marginalized. We will need more and better investments in water, and in the human capacity to manage water.

Let us go back to the original statement by Asit Biswas: we don't have a scarcity of water, but a scarcity of management. Clearly a major cause of scarcity is mismanagement, and unfortunately this abounds across the world. It is true in areas of high development of water resources. There are also places where access to enough water remains an issue, for example in the hills and mountains of the HKH and Nepal. In the world there is plenty of water, and also plenty of financial resources. The question is whether we are adequately managing our financial, human, and natural resources so that water flows to the places it is most needed.

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