After Covid-19 | Governing groundwater | **Trees that help water** | What can save India's aquifers? | **Sanitation in Latin America**

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John Cherry fights to protect

GROUNDWATER

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Protect groundwater – Earth's support system!

In this issue of *WaterFront* we are reminded of one of the greatest but most neglected threats to human existence: the depletion and contamination of groundwater. About half of the human population relies on groundwater for drinking water and food production today. In a warmer climate, groundwater will be even more crucial to the survival of humans and for the endurance of fragile ecosystems, but this support system is now being jeopardized by reckless over-pumping and pollution.

One of the first people to understand the dangers associated with groundwater contamination was Dr John Cherry, who is awarded the Stockholm Water Prize 2020. Meet him on page 4 in an interview where he talks about what must be done to protect groundwater.

On page 14, we learn about how India became the world's largest groundwater user and what it will take to break today's unsustainable habits. Good groundwater governance will be fundamental and on page 10, SIWI's Jenny Grönwall takes a closer look at this topic. On page 12, we explore new research on the complex relationship between trees and groundwater recharge, which brings hope to millions of people.

The recent outbreak of Covid-19 has cast long shadows over the water world. Read more about the impacts on page 3 and in the Last Word on page 17, with perspectives from Dr Sergio Campos of the Inter-American Development Bank.

Enjoy the read!

Torgny Holmgren
Executive Director, SIWI

SIWI

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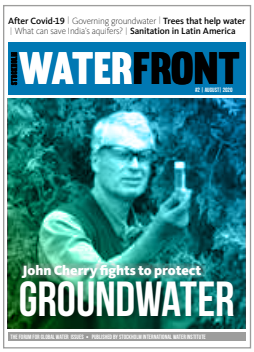

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7 WAYS COVID-19 CHANGES THE WATER WORLD


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1 Calls for sanitation for all

Hopefully, the many handwashing campaigns can lead to important health gains. But can the pandemic also raise awareness of the plight of the 40 per cent of the global population who don't have water and soap at home? The world is still not on track to achieve universal water and sanitation by 2030, as pointed out by global leaders in a Call to Action on Covid-19 initiated by Water and Sanitation for All.

4 New role for water utilities

Underinvestment in the water sector is a chronic problem in many countries and the economic crisis could make matters worse. At the same time, the water industry is now courted by other sectors interested in monitoring wastewater to detect signs of disease at an early stage. The increased use after the Covid-19 outbreak could lead to new technology and speed up the digitalization of the sector, according to Dragan Savic, Chair of the IWA Digital Water Programme Committee.

2 Vulnerable groups hardest hit

SIWI and UNICEF are monitoring the global response to Covid-19 from a water, sanitation and hygiene perspective. Many governments now ensure that people are not cut off from water and sanitation services in the middle of the pandemic for failure to pay a bill. Water is also being trucked to informal settlements and more handwashing facilities have sprung up in public places. But more needs to be done for vulnerable groups, including people without a home or who are living in shelters or refugee camps.


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3 Growing interest in One Health


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The pandemic has made more people aware that rapid population growth and rampant development are putting humans and animals in increasingly close quarters, making it easier for diseases to jump between species. To tackle this kind of zoonotic epidemics, countries need to apply the concept of One Health, recognizing the links between humans, animals, and the environment. A new report from the UN Environment Programme calls for governments to develop plans to combat future pandemics by addressing root causes such as poverty, environmental degradation and increased demand for meat.

5 Water more important

The CEO Water Mandate has issued a pledge for the business sector to strengthen its commitment to responsible water and sanitation policies in response to Covid-19. It is likely that access to water will be an increasingly important factor when companies are starting to rethink their supply chains. Though many struggling companies may temporarily be less focused on sustainability, many believe that focus on resilience will grow. Research indicates that socially responsible companies performed better during the first corona-related stock market downturn.

6 Weaker environmental protection

Illegal deforestation and poaching have in many places spiked during lockdowns and could be further fueled if the economic crisis forces national parks to lay off staff. Ecotourism, which used to be an important source of income, has almost disappeared. There is also concern over growing violence against environmental defenders, which could be facilitated by the increased use of surveillance to stem the pandemic and that may be a lasting legacy of Covid-19. In Brazil, indigenous leaders fear increased violence and that their land will be invaded by illegal loggers. .

7 Time for a blue-green recovery

A growing number of international institutions call for green stimulus packages and more focus on resilience. In many countries, people are returning to the countryside after losing their jobs in the city. Investments are needed to help small-scale farmers cope with challenges such as floods, drought, and unpredictable rainfall. Many will need to shift to new practices, including agroforestry, rainwater harvesting and the growing of less thirsty crops. Rethinking agriculture is one of the main challenges in the post-Covid world.

Leading the fight against **groundwater pollution**

Dr John Cherry is one of the world's leading experts on groundwater contamination. He was awarded the 2020 Stockholm Water Prize for research that has led to new ways of tackling the pollution problem. In this interview, he talks about how he wants to use the Prize as a platform to raise the alarm about the acute danger facing the planet's groundwater.

Text | Maria Sköld **Photo** | G360 Institute

One would think that 99 per cent of water conversations would be about groundwater, reflecting its share of the planet's liquid freshwater. But even most water experts do not seem to remember the water under their feet.

Dr John Cherry finds this genuinely puzzling. He argues that since all water is linked through the hydrological cycle, it makes little sense to only protect it when it appears in rivers and lakes, but not when it is underground. To change this, he has dedicated his professional life to understanding groundwater contamination and to raising awareness of a growing threat.

Dr Cherry was awarded the Stockholm Water Prize on 23 March in recognition of a life's work that has caused a paradigm shift in the study of groundwater. In the 1970s, he was one of the first scientists to see the risks of groundwater contamination, leading him to establish a new academic field: contaminant hydrogeology.

He set up the Borden Groundwater Field Research Facility in Ontario, Canada, where he and his colleagues developed a new systematic approach to monitoring, controlling, and cleaning up contaminated groundwater. In the process, they made important discoveries about how contaminants behave in groundwater, especially dense non-aqueous liquids (DNAPLs), which are commonly used in industries such as dry cleaning and vehicle repair.

Today, effective monitoring technology is available, but it is only slowly starting to spread across the world. Few people seem aware of the growing threats from the combination of over-abstraction and contamination.

John Cherry has, therefore, set out on a new quest, The Groundwater Project, to make groundwater knowledge available to everyone on Earth. In this interview, he explains why groundwater will be increasingly important for humans and ecosystems and how it can be protected.

What does receiving the Stockholm Water Prize mean to you?

I am very pleased to receive the Stockholm Water Prize and to get this opportunity to warn about the threats to our groundwater. Though the global water crisis is starting to get more attention, most people do not understand how this is primarily about groundwater. Even most water experts tend to forget how

"With the Stockholm Water Prize, John Cherry is recognized for his contributions to science, education, practice and for translating his well-earned stature into a passionate and highly effective advocacy for groundwater science to inform current and future policies, laws and collective deliberations that governments must establish to protect water, our most essential and yet most imperilled resource."

The Stockholm Water Prize Nominating Committee

John Cherry revolutionized groundwater research by taking it into the field. Here he is monitoring groundwater in Canada ar

surface water and groundwater are linked.

Since groundwater is out of sight, it is also out of mind. In many parts of the world, it gets more and more polluted and it is pumped so aggressively that this extra water has caused about 25 per cent of sea level rise. But we seldom hear about this. At least in the industrial world, the quality of air and surface water is improving because people demand strong action, but groundwater keeps getting depleted and polluted without any public outcry.

"Groundwater makes up 99 per cent of all freshwater that is not frozen. It provides nearly 50 per cent of the global population with drinking water and contributes to about half of global food production."

John Cherry

Why is groundwater so important?
Groundwater is the Earth's life support system. Almost all available freshwater is groundwater: much of the water that falls as rain moves into the soil to become groundwater and later appears as water in rivers. Groundwater makes up 99 per cent of all freshwater that is not frozen. It provides nearly 50 per cent of the global population with drinking water and contributes to about half of global food production.

In coming years, groundwater will be even more important due to climate change and the fact that the planet may soon have three billion more inhabitants, most of whom will drink groundwater and rely on it for their food. We need to understand that groundwater sustains our ecosystems and food production, but that it is dangerously mismanaged.

Can you describe what climate change means for groundwater?
Experts on climate change predict more extreme events such as droughts that last for an exceptionally long time. When droughts occur, the only water to sustain many rivers, lakes and wetlands is groundwater. Groundwater is the great regulator of the freshwater cycle, like a wet but permeable sponge. It is the groundwater reservoir that allows rivers, lakes, and wetlands to exist. But if we deplete the groundwater reservoir as we are doing now, we weaken its ability to sustain our surface waters and their ecology during droughts. This also diminishes our ability to produce food because our wells for irrigation cannot pump as much and our rivers have less water to irrigate our crops.

This means that even if there were no population increase, we would still be facing a huge crisis. With the expected population growth, however, the severity of the problem is almost unimaginable for parts of the planet. The problem is unprecedented in its complexity because of the multitude of unsustainable actions scattered across the globe, where each one seems, on its own, to be a local problem. But taken all together in an interconnected globalized world, we have a global scale problem that is largely unrecognized.

At the same time, you also argue that, in some places, more groundwater should be pumped?
Yes – as long as it is done sustainably so that groundwater is recharged. More

nd China (middle picture).

than a billion poor people around the world need safe drinking water wells and groundwater can be especially important in remote areas. One of the projects I am involved in uses small, low-cost portable drills of the type used in the mining industry, which makes it possible to drill shallow wells almost anywhere.

What made you get into the field of groundwater research?
My parents taught me the value of water. They made documentary films about water and many other topics, and they were shaped by having lived through the Great Depression in the 1930s when the countryside in western Canada dried out, which was a disaster for many people. But when I got my PhD in 1966, the focus was on pumping groundwater out of the ground. I later studied groundwater chemistry in France and then became the first groundwater professor in Canada, at the University of Manitoba in Winnipeg.

The direction of my career changed dramatically in 1967. An American engineering student, Barbara Lund, told me how she suspected that radioactivity from a nuclear facility near Winnipeg leaked into the groundwater and wanted me to investigate. I said I was not interested in the topic and knew basically nothing about it, but she insisted and said I should feel obligated to look into it. After a while, I realized she was right. That's how it started.

You were awarded the Prize for having revolutionized the study of groundwater contamination. Can you describe your work?
Hydrogeology has traditionally been conducted by groundwater scientists in laboratories or on computers, but I got a drilling machine and went out in the field. Together with colleagues, I did field work to really map out the levels and chemistry of groundwater, to understand how contaminants migrate.

Today I work at the G360 Institute for Groundwater Research in Guelph, Canada. Much of our research aims to improve monitoring devices, to better see what is really happening at different depths at each monitoring location.

Groundwater monitoring technology has really matured in the past twenty years, but it is hardly used. In Canada, this is only done substantially in the city of Guelph. Countrywide monitoring is still rare, though China has established 20,000 monitoring sites in the past five years. The Chinese government is now behaving responsibly, though this comes after 30 years of uncontrolled contamination of their groundwater, as was done in the West after the Second World War.

What would you like governments to do?
Monitoring is very important: how can we know the quantity and quality of our groundwater if we don't monitor? We also need stricter regulations for industries and agriculture to limit emissions and to encourage a more circular economy. When we don't know the impacts of, for example, chemicals, the Precautionary Principle must be applied. The main problem is that groundwater is so

JOHN CHERRY

Works: Adjunct Professor at the University of Guelph, Canada, Founding Director at the University's Consortium for Field-Focused Groundwater Research, and participates in research at the G360 Institute for Groundwater Research.

Lives in: Guelph and Ottawa, Canada

Hobbies: Like a true Canadian, John Cherry has been playing ice hockey since the age of 5. He also enjoys downhill skiing and canoe trips.

seldom taken into consideration in decision-making that it just ends up suffering unintended consequences that we do not see until decades later.

When did the scientific community begin to understand the dangers of contamination?
Some contaminants, such as chromium, petroleum products and detergents, had already been found in groundwater in the 1950s, but they did not seem to do any harm. They seemed to be "assimilated", either biodegraded or retained by the geologic media. But in the 1970s, chlorinated solvents were found in thousands of public water supply wells across the United States and soon also in Europe. This demonstrated that some types of chemical compounds are not readily degraded and travel far in many aquifers.

What are the greatest threats today?
PFAS (Per- and Polyfluoroalkyl Substances) may be the worst of all groundwater contaminants. They are a group of several thousand individual chemical compounds that are widely used as oil and water repellents and coatings for common products including cookware, carpets, and textiles. In many countries, PFAS chemicals are increasingly found in drinking water supplies near facilities where the chemicals have been used or disposed. This is especially worrisome because they bioaccumulate, they are not prone to degradation, and the safe drinking water levels are likely to be extremely low, much less than one microgram per litre.

There are of course many other threats as well, for example from agriculture and the expanding fracking business. We must also not forget how personal care products and pharmaceuticals are unintentionally discharged from municipal and private wastewater treatment systems. It is important to consider the cumulative and synergetic impacts of many different chemicals that degrade slowly.

What role does agriculture play?
Agriculture is the main reason why groundwater is not used sustainably. It causes both over-pumping and contamination as nutrients applied to crops flush nitrogen and phosphorus into the groundwater. We are only now starting to understand the consequences of the Green Revolution, with mass irrigation and widespread use of fertilizers and pesticides that leave aquifers and soils depleted. Not only does this release carbon dioxide into the atmosphere, it depletes groundwater reservoirs when soils can no longer trap rainfall, causing massive runoffs. There are important interactions between climate, soil, land use and groundwater, that are not yet sufficiently understood or reported. Unfortunately, this means that groundwater again tends to get lost in the big calculations of what is going on.

The question of agriculture is one of our greatest challenges. I follow a plant-based organic diet since the people who study food are telling us that eating meat, especially beef, is the worst thing you can do for the environment. To feed the ballooning population, without destroying the Earth's water and soil, is likely the biggest challenge that humanity will ever face.

Now you are launching The Groundwater Project – what is that?
The idea behind The Groundwater Project is to have all things groundwater available in one place online in several languages, with a complete series of free electronic books on groundwater that will be available for anyone to download. It started when I was asked to update a textbook on groundwater that Dr Allan Freeze and I wrote in 1979, but it felt a little insufficient. So much has happened in groundwater research since then that people are not aware of, partly because science has become so fragmented, and partly because it is mostly published in academic journals that people do not have access to. What if all that knowledge could be made available online, for free, for the people who need it the most? That is what we are trying to achieve with The Groundwater Project. Now more than 300 well-recognized scientists and practitioners from around the world are contributing, making some 200 books available. The project is growing fast and I am amazed by the volunteer commitments of so many extraordinary people!

So, what is the most important thing people need to know?
Most of all, that groundwater sustains all ecosystems and human activities. And that it is no longer the abundant, pristine source of water that people tend to think it is. People must realize that the world's groundwater, and therefore all freshwater, is under threat. It needs our immediate protection! ●

"The idea behind The Groundwater Project is to have all things groundwater available in one place online in several languages, with a complete series of free electronic books on groundwater that will be available for anyone to download."

John Cherry

Photo: iStock

5 THINGS GOVERNMENTS CAN DO TO PROTECT GROUNDWATER

With the current approach to groundwater, the world is headed for disaster, according to John Cherry. Here are five actions governments should take to reverse the trend:

1 Apply the Precautionary Principle. Recognize that the dire situation for groundwater is a result of many unintended consequences. The Precautionary Principle (PP) must, therefore, be the guiding principle for groundwater governance, which is currently not the case.

2 Shift to cradle-to-cradle production. In today's current cradle-to-grave manufacturing, groundwater ends up as the grave for harmful chemicals from manufacturing processes and from products. But cradle-to-cradle thinking is becoming more common – and this is the way forward. In a circular economy, no manufacturing processes and products emit chemicals harmful to water.

3 Change food habits. Nearly all of groundwater depletion and most groundwater pollution result from 'modern chemical agriculture'. Ecological agriculture is better as it is a form of cradle-to-cradle production applied to food. We should also move away from eating beef. Impose taxes or penalties on groundwater pollution caused by agriculture and eliminate government subsidies that contribute to groundwater unsustainability.

4 Establish effective groundwater monitoring. Use modern monitoring methods for groundwater levels and hydrochemistry with data transparency in all areas where groundwater is a significant resource. Effective monitoring networks are still rare, but modern cost-effective methods exist, including technology for real-time data recording. In most cases, the data should also be fully available for the public, to view on their smart phones or tablets.

5 Strengthen groundwater governance. Groundwater depletion and pollution can often be attributed to poor governance, frequently stemming from a lack of knowledge about groundwater. There is a need to make groundwater science more accessible: for example, through the **Groundwater Project,** and to raise capacity about groundwater governance.

Governing the invisible: Putting

Text | Jenny Grönwall

Groundwater is often referred to as an 'invisible resource'. In 1859, an English judge lamented the difficulty to regulate something that is "percolating or oozing through the soil ... according to the quantity of rain that may chance to fall"[1]. Even today, with vastly improved sources of data, groundwater governance suffers from large knowledge and awareness gaps that translate into institutional and policy voids, writes SIWI's Jenny Grönwall.

Groundwater provides half of all drinking water, more than 40 per cent of irrigation water and a third of the industrial sector's global need for water. Around the world, some 2.5 billion people depend solely on it to satisfy their daily drinking and other domestic water needs. As with water in general, demand for groundwater is increasing because of population growth and new, global consumption patterns. Groundwater depletion is largely driven by irrigated agriculture, to satisfy needs for basic global food security as well as for, what can be seen as, luxury crop outputs. Ever-deeper boreholes and tubewells, and more powerful pumps, put a strain on groundwater reserves that are not rejuvenated in a lifetime. Our shared groundwater resources are also threatened due to climate variability and change, and quality deterioration.

Groundwater governance is key in addressing the multiple concerns and challenges that face the resource and its users. Governance can in short be summarized as involving processes and people: mechanisms and frameworks for decision-making, and actors engaged in, and/or affected by, the outcome of the decisions.

In terms of modes and mechanisms to limit harmful impacts on groundwater resources and aquifers, the regulatory system includes permits and licences. This is a critical part of the command and control approach but one that is notoriously constrained. Challenges involve problems to interpret and administer legal rules and enforce them effectively. Complementary ways of regulating conduct and behaviour are therefore constantly sought.

Photo: Holger Motzkau

Elinor Ostrom

Photo: Shutterstock

A complicating factor is that the use and abuse of groundwater is often a local, small-scale matter. If India alone counts more than 20 million pump sets attached to as many tubewells, predominantly owned by individual farmers, it is doubtlessly difficult to rule irrigation practices efficiently from the top.

Notable in the field of groundwater is the 'tragedy of the commons' notion of the 1960s, according to which users, acting in their own self-interest, abuse a common good. The theory emerged in light of difficulties in controlling the depletion of a shared resource.

Elinor Ostrom, political scientist, and recipient of the Nobel Memorial Prize in Economic Sciences, studied groundwater as a typical example of a common pool resource. She came to advocate for countermeasures with 'governing the commons' through local institutions that take collective action and decide their own rules for water management. Ostrom's ideas for self-organization are characteristic of the 1990s when the trend in the wider resources use sector aimed for 'governance without government'. With reduced state involvement, private sector and civil society actors should instead take over responsibilities in allocating resources, delivering public services, and exercising control and coordination. Self-regulation as a concept also defies centralized policymaking and interventions, and the inherent difficulty in backing formal laws and regulations to operationalize them through monitoring and surveillance.

Ostrom observed and suggested that small-scale resource users in many cases develop credible commitments and joint strategies to regulate their own behaviour. This was also in recognition of how multi-level, multi-actor arrangements are at play, with decision-making happening at interconnected places and territories. Partnerships and networks, and active involvement of a multitude of non-state actors, mattered and were increasingly supported also by formal governments.

Fast forward to the 2020s. The calls for strengthened groundwater awareness, development, and protection are getting louder. They are voiced amid groundwater being described as all too often out of sight and — consequently — out of mind. This is despite the increasing acknowledgement of the

1 Chasemore v. Richards 7 H.L.C. 349 = 11 E.R. 140, pp. 140, 147.

groundwater centre-stage

growing dependence on groundwater worldwide, in all sectors.

Today, many forms of decentralized decision-making have been tried and tested. Advocacy for reform of the public sector involves a partial turning against the belief in market forces and self-regulation. A set of normative principles aim to bring about (additional) legitimacy and efficiency in decisions regarding natural resources. In particular, prescriptions for what constitutes 'good' governance — marked by transparency, accountability and participation — are meant to permeate work methods and decision-making with new values. An example is Community-Based Management that has been encouraged for villages but also peri-urban areas to improve inclusion and build capacity. Participatory groundwater mapping and monitoring, ground-truthing and field surveys that complement remote sensing, and other ways of generating knowledge, all serve to inform decision-making.

Photo: Martchan /Shutterstock

"The understanding of groundwater and aquifer vulnerability to climate change is constantly evolving but it needs to be linked to users' ability to process complex information."

Jenny Grönwall

Another example is how parts of the private sector now publish supplier lists to increase traceability and transparency. This enables scientists, planners, and advisors to visualize groundwater availability and variation overtime in the areas where factories are located. It also allows for holding companies accountable against their own voluntary agreements and codes of conduct as well as formal regulation of polluting discharges and (ground)water use for industry purposes.

Photo: SIWI

Jenny Grönwall

Instead of replacing old approaches and processes, at present the modus operandi for groundwater governance is to combine policy instruments. However, diversification alone is not sufficient, and the quest continues for yet more — and other — ways to effect societal change that can result in stronger environmental performance, sustainability, and equity. Promoted since some time is a focus on cognitive science to provide another piece to the puzzle (see WaterFront #1 2020). The renewed interest in human behaviour is promising; much can be learned from environmental and climate change psychology to design functional nudging and steering tools. As an example, social norms and cultures around discharges of liquid and solid waste that can potentially affect groundwater quality are more likely to be changed by invoking a sense of pride among wrongdoers than by using the 'name and shame' method.

Even with this enriched toolbox, data, information, and knowledge remain critical. For instance, we need to get the drivers behind households investing in their own wells and boreholes for domestic use, and what they comprehend about the safety and treatment of the water they consume. The understanding of groundwater and aquifer vulnerability to climate change is constantly evolving but it needs to be linked to users' ability to process complex information. In turn, regulations and guidelines need to be packaged and communicated in smarter ways to achieve intended targets.

Many more of the issues at stake are rooted in the knowledge gaps that arise from groundwater being part of the underground. In the best-case scenario the individual user and community have the necessary capacity to make everyday decisions relating to local wells and their interaction with land, forests, and the subsurface space. At a higher, administrative level the need to coordinate and streamline resource usage and activities increases. Here, it is imperative that neither the local actors and their needs, nor the groundwater conditions themselves remain invisible in the process. At all governance levels, actors need to manage the steps from data acquisition to awareness-raising campaigns. A multitude of stakeholders need to take proactive and collaborative action to ensure that groundwater and aquifers in their entirety are regarded from a systems perspective. ●

ABOUT THE AUTHOR

Dr Jenny Grönwall is SIWI's Advisor for Water Policy & Rights and has devoted much or her career to applied research in the field of groundwater governance. In 2019 she reviewed Ethiopia's groundwater law and policy, commissioned by the country's Ministry of Water, Irrigation and Energy. Jenny Grönwall also represents SIWI in a Pan-Africa Groundwater Program group focusing on Policy, Governance and Institutional Systems Strengthening.

More trees can boost **groundwater recharge**

Do more trees always mean less water? This used to be the predominant scientific view, but new research paints a more nuanced picture. It appears that intermediate tree cover can boost groundwater recharge in African tropical drylands, which is great news for people living there.

Text | Maria Sköld Photo | Private and iStock


Ulrik Ilstedt

Everybody loves trees for the fruit, fuel, construction material, and soil restoration they provide. Not to mention their role when it comes to carbon storage. Yet in the African drylands, development organizations have often advised against tree planting since they thought it would deprive the soil of much-needed water.

"The predominant scientific view used to be that each tree would withdraw more water than it contributed, leading many to believe that tree planting should be avoided in arid areas. In South Africa, schoolchildren were even sent out to uproot trees in order to improve the water situation," says Ulrik Ilstedt, Associate Professor of Forest Ecology and Management at the Swedish University of Agricultural Sciences (SLU).

But in 2016, the long-held beliefs about trees and groundwater were challenged. In the article *Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics*, published in Nature Scientific Reports, the researchers demonstrated that, under certain conditions, trees can actually contribute to groundwater recharge in arid regions. Ulrik Ilstedt was one of the authors, together with colleagues from the Swedish University of Agricultural Sciences as well as from the Center for International Forestry Research (CIFOR), the CGIAR Research Program on Forests, Trees and Agroforestry, the Congolese Institute for Agronomy Research (INERA) and World Agroforestry (ICRAF).

The article was a game changer since the results indicated that many water-scarce tropical regions could, in fact, benefit from having more trees. Research carried out in Burkina Faso shows that when a certain number of trees are present, the amount of groundwater recharge is maximized. Trees turned out to be crucial for maintaining the large pores that characterize the soil in the area and which lead water into the ground. If there were no trees, the water would just run off or evaporate. But if the trees were too many, the water they consume would override the benefits they bring to soil improvement.

"It is important to recognize that this issue is very complex. We are now continuing studies to understand different types of conditions – for example, the impact of different kinds of soils, trees, and climate management systems. With that knowledge, it will be possible to manage landscapes more wisely to protect both soils and groundwater recharge," Ulrik Ilstedt says.

The new findings do not mean that the old way of looking at the relationship between trees and groundwater is necessarily wrong, only that it is not relevant everywhere. So far, most tree-water research has been carried out in northern, temperate regions where conditions are very different to the arid tropics. It is also more common to study forests than trees that are scattered in a landscape, which for example is the case when agroforestry is practiced.

The "optimal tree cover theory", suggested by Ulrik Ilstedt and others, argues that in tropical drylands there is an ideal level of tree coverage in the landscape that maximizes groundwater recharge. If that optimal tree-cover can be identified in specific contexts, and improved through better management, this could mean an important breakthrough in sustainable landscape management, according to Ulrik Ilstedt:

"Better landscape management can be life-changing for hundreds of millions of people in water scarce areas. With improved access to water, women and children especially will lead healthier lives and have more time to earn money or get an education. And people everywhere can then enjoy the many benefits of trees," he says. ●

3 PERSPECTIVES ON FORESTS AND WATER

- The dominant view of the forest-water relationship has been the "trade-off theory", where more trees equal less water, which may be true in many parts of the world.
- The opposite view, "the sponge theory", instead holds that forests soak up water during rainy periods (much like a sponge does) and then release it during the dry season, which could also be an accurate description under certain circumstances.
- The third approach, suggested by Ilstedt and others, is the "optimal tree cover theory" which argues that there is an optimal level of tree coverage that can maximize groundwater storage in tropical drylands.

Groundwater crises threaten the poor in India

In Rajasthan women and also children often walk long distances through the desert to bring back jugs of water that they carry on their heads.

India has its groundwater resources to thank for many of its greatest success stories. But now the country's aquifers are dangerously depleted and polluted – just when they are needed the most. New research indicates that the problem may be even worse than previously assumed.

Text | Maria Sköld **Photo** | iStock

Almost a quarter of the world's groundwater is used by India. The country's remarkable rise in agricultural productivity, dubbed the Green Revolution, was based on the development of groundwater resources, combined with extensive use of fertilizers and pesticides. Starting in the 1950s, India encouraged and subsidized massive pumping of groundwater, with the number of drilled tube wells increasing from 1 million to nearly 30 million. The rapid industrialization of recent years has also been achieved through intensive groundwater use.

The result? A massive drop in poverty rates: the Green Revolution drastically improved food security and the more recent economic expansion between 2006 and 2016 helped lift 271 million people out of poverty. But what also dropped were the water tables. According to the World Bank, groundwater is being abstracted much faster than it is being replenished, so that 60 per cent of India's districts are likely to reach critical levels of groundwater depletion within two decades. Another study of Indian districts shows that in 60 per cent of them, groundwater is already depleted, contaminated or both.

This spells serious trouble for the country's farmers, most of whom rely on groundwater. Close to 90 per cent of the groundwater consumed in India is used to irrigate crops. The current race to the pumps means that farmers who can afford it drill deeper and deeper in search of precious water. However, for the majority of smallholders, this is not a feasible option. In recent years, many have given up and moved to the cities.

According to groundwater expert Dr Veena Srinivasan, India's escalating water crisis is a big, but often overlooked, driver behind the mass migration to urban areas. "The truth is that the situation is worse than anyone can imagine, and after Covid-19, this will become much more apparent. Many poor people who abandoned farming for a new life in the city have now lost their employment and are being pushed back to the villages. But the question is: how will they feed themselves?" she says.

As Director of the Centre for Social and Environmental Innovation at the Ashoka Trust for Research in Ecology and the Environment (ATREE),

Dr Veena Srinivasan wants to draw attention to the plight of villagers and farmers, which is closely linked to the groundwater crisis. Approximately 700 million Indians living in villages depend on groundwater for their daily needs and 85 per cent of rural households rely on groundwater, compared to 45 per cent in cities.

Her research also shows that this is a looming problem in large parts of the country, not just in north-western, western, and peninsular India, as official statistics would have it. When Dr Veena Srinivasan and her colleagues Tejasvi Hora and Nandita B Basu carried out research in the field, they kept hearing the same stories about disappearing groundwater in southern India too, where the official numbers indicated *rising* water levels. "We just couldn't understand this discrepancy. Farmers were killing themselves to get out of a terrible situation, but in the high-end journals we read stories based on official data that described how things were getting better, thanks to rainfall and successful government interventions. It just didn't make sense," Veena Srinivasan says.

Eventually they found what seems like a plausible but worrying explanation. In the article *The Groundwater Recovery Paradox in South India*, published in the publication Geophysical Research Letters, the researchers describe how the numbers had become skewed because wells that went dry were subsequently removed from the data set. The groundwater trend assessment methods most frequently used have turned out to be less suitable for the hard-rock aquifer systems that characterize southern India.

"This should be another wake-up call that India needs to start taking its groundwater situation much more seriously. It is not just a water problem, but a livelihood problem. And it is about to get much worse," Veena Srinivasan says.

The World Bank and the government think tank NITI Aayog point to several trends that could exacerbate the current crisis. For starters, the number of Indians could rise to 1.7 billion by 2050. With that comes growing demand for water, food, and consumer goods, as well as an increase in pollution and wastewater. The United Nations also estimates that over 400 million Indians will have moved to cities by 2050. In the same time period, climate change will make India much more susceptible to extreme weather events and unpredictable monsoons.

"It is important to emphasize that India's current groundwater depletion is not primarily caused by climate change; manmade interventions are much more important. But climate change exacerbates the situation, and in a more unpredictable climate, we will really need groundwater as a buffer. Instead we have wasted much of it through mismanagement. It's like burning your insurance policy right before the fire," Veena Srinivasan states.

She does not feel that India is prepared for the challenges ahead. Many incentives remain in place that encourage wasteful practices, including massive use of irrigation and pesticides to grow very thirsty crops such as rice. Most wastewater is released untreated into nature, which is one reason why 70 per cent of the country's freshwater is polluted. In a recent article, written together with David Blakeslee and Ram Fishman, Veena Srinivasan also calls for more research on suitable adaptation strategies.

A compounding factor is the country's groundwater regulation, which she describes as 'fundamentally flawed'. "The traditional approach to groundwater regulation in India is not only fragmented between several different national agencies and the state level, we also tend to look at surface water separately from groundwater," Veena Srinivasan says. In an article written together with Sharachchandra Lele, she argues that this often leads to mismanagement. When decision-makers disregard the integral link between surface and groundwater, they may, for example, opt to "solve" groundwater depletion by building a dam to inject water directly into an aquifer, with detrimental effects for rivers and wetlands in the area.

Veena Srinivasan would like to see much more collaboration between different agencies and an increase in monitoring of both surface and groundwater, so that decision-makers can plan based on hard facts and data. "When we know how much groundwater we have, it will be much easier to regulate and create the right incentives at district and aquifer level. For that, we also need a mechanism to allocate who gets what water. It will not be easy, but we don't really have much choice. We must protect the groundwater we have," Veena Srinivasan concludes. ●

Photo: Private

"In a more unpredictable climate, we will really need groundwater as a buffer. Instead we have wasted much of it through mismanagement. It's like burning your insurance policy right before the fire"

Dr Veena Srinivasan

INDIA'S GROUNDWATER CRISIS

- Groundwater overuse or overexploitation is defined as a situation in which, over a period of time, the average extraction rate from aquifers is greater than the average recharge rate.
- Groundwater contamination is the presence of pollutants such as bacteria, phosphates and heavy metals from human activities including domestic sewage.
- In parts of India, high levels of arsenic, fluoride, nitrate, and iron are also naturally occurring in groundwater, with concentrations likely to rise as water tables fall.
- India is home to 17% of the global population but only 4% of its water resources.
- 820 million Indians face high to extreme water stress.
- 200,000 Indians die every year due to inadequate water, sanitation and hygiene.

Source: NITI Aayog's Composite Water Management Index

A hands-on approach to water and sanitation

Text | Sergio Campos

The coronavirus pandemic, Covid-19, should serve as a reminder of how vital safe water and sanitation services are to us all, writes Sergio Campos, head of the Water and Sanitation Division of the Inter-American Development Bank.

The pandemic caused by, what is now the most famous virus in the world, has caught us off guard and with an enormous pending task: ensuring that all our citizens have access to safe, drinkable water and adequate sanitation services. We all know that washing our hands and keeping social distance are the best ways to prevent contagion. However, what happens when water is scarce and staying home is not a viable option to make a living?

That ever-pressing issue is now a matter of life or death. Governments and service providers in Latin America and the Caribbean have made great efforts to respond to the emergency, working in an extraordinary way to provide water to those who need it most and have suffered a historical lack of access. From suspending payment for essential services to those who cannot pay, reconnecting residential customers with service suspended for non-payment, to delivery in the most vulnerable areas with tank trucks and other methods.

But those emergency actions are not sustainable. Like most global crises, the coronavirus pandemic poses a greater threat to the most vulnerable citizens. In Latin America and the Caribbean, we have made significant strides in providing access to water, but universal services are still far away. This is particularly important for our region, the most urbanized on the planet, where nearly 80 per cent of the population lives in cities.

During this global emergency, a good part of our efforts must focus on the most vulnerable populations. Today about a third of the region's city dwellers lack safe drinking water service. The situation is much more precarious in terms of sanitation service, since 70 per cent of households do not have access to adequate human waste management. A significant percentage of households also do not have access to hygiene facilities: about 75 per cent or less of households in at least six countries do not have basic hygiene services.

It is also important to ensure the provision of water, sanitation, and hygiene services in health centers. About 5 per cent of healthcare centers in Latin America and the Caribbean do not have access to water services. This presents a double challenge for these healthcare centers, as they experience high patient demand and lack the means to maintain a clean environment.

In this scenario, water and sanitation utilities are an important ally to contain the pandemic. Emergency measures must be taken, including developing contingency plans, if they do not already exist, to ensure the continuous provision of quality services.

Right now, the rational use of water is critical to facing the pandemic. It is extremely important to use water primarily for personal hygiene, without excesses and to postpone other less urgent uses, so as not to expose the water production and distribution systems to limitations that are difficult to manage. The pandemic forces us to act quickly, but appropriately, without forgetting that the great pending task is to ensure that basic water and sanitation services are accessible to all citizens.

World Water Week At Home is a great opportunity to remind all of us that the best investment any country can make in these uncertain times is to ensure access to water and sanitation services for its citizens. Now more than ever, we need to put our clean hands to work to make services accessible to all. ●

Photo: Inter-American Development Bank

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WELCOME TO **WWWEEK AT HOME**!

Join world-leading water and climate experts at WWWeek At Home! This collection of unique virtual sessions will take place 24–28 August to accelerate action on climate change – and it is open to anyone, free of charge.

WWWeek At Home offers an important opportunity to explore water-related solutions to climate change, which could be part of the massive recovery efforts during the current economic downturn. The voice of water must be heard in the discussions on how to build back better after the Covid-19 pandemic.

WWWeek At Home is a great chance to hear many sessions that were approved to be part of World Water Week 2020, before it was cancelled due to Covid-19.

Check out the programme and plan your week!