GROUNDWATER

Critical for Sustainable Development

Groundwater represents close to 99% of all unfrozen fresh water in the world. Groundwater makes up one third of all water being used, provides almost half of the world's population with domestic water[1], and is the source of almost half of the water used for irrigation worldwide.

For example, in Denmark, 100% of all water used (domestic, agricultural, and industrial) is derived from groundwater[2]. This extensive global dependence on groundwater is quite recent in human history, with withdrawals tripling over the last 50 years. Groundwater underpins many terrestrial and aquatic ecosystems, and is critical for a host of the ecosystem services and natural habitats on which humans depend.

GRIPP
GROUNDWATER SOLUTIONS INITIATIVE FOR POLICY AND PRACTICE

CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

LED BY: IWMI International Water Management Institute

A TIMELINE OF GROUNDWATER DEVELOPMENT[3]

2000

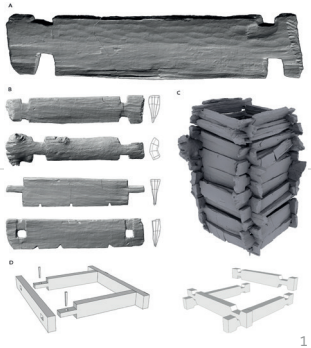
1500

1000

500

0

Groundwater abstraction [km³/yr]



1

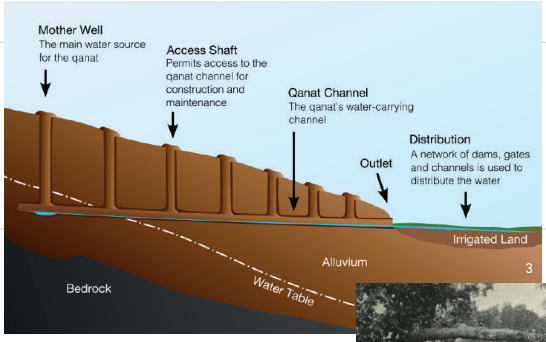
WORLD'S OLDEST WOODEN WELLS

Prehistoric farmers in Europe are skilled carpenters long before metal is discovered and make water wells out of oak timber[4]. Water was for human and animal consumption.

2

OLD CHINESE WELLS

In ancient China, wells are dug to manually extract groundwater for drinking[5] water and later for irrigation as well.



3

UNDERGROUND AQUEDUCTS

Underground aqueducts (locally known as Qanat or Karez) are used to extract groundwater in the Middle East[6].

4

OX-POWERED SAKIA

Mechanical water lifting devices (Sakia or Persian wheel) powered by oxen to lift groundwater from wells are common in places like India[7] and Pakistan.

ANCIENT TIME

Year

5000 BC

4000 BC

Before 1st millennium BC

300 BC

2000

1500

1000

500

0

Groundwater abstraction [km³/yr]

DONKEY WHEEL

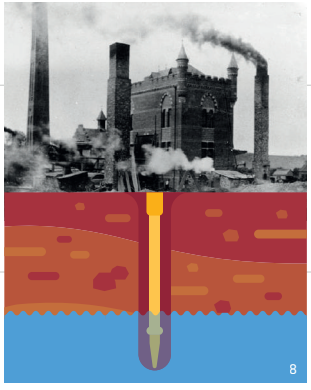
Donkey-powered water lifting system is developed at Carisbrooke Castle (Isle of Wight – UK) to use animal power to draw water from about 20 meters depth[8].

CLEAN GROUNDWATER FROM DUNES

Jacob van Lennep, a well-known Dutch writer and lawyer, with funding from English investors, starts supplying Amsterdam with groundwater drained from the dunes, as alternative to the polluted surface and groundwater in the city. Forty years later, the company is sold to the municipality of Amsterdam for almost five times the investment[9].

FIGHTING CHOLERA

Groundwater development and management for safe water supply in cities becomes critical to solving cholera epidemics. The link between water supply and cholera epidemics in European cities is discovered in London. Better groundwater development, protection and water treatment for safe water supply become critical to solving water-borne diseases.



MECHANIZED PUMPING

Mechanized drilling and pumping using steam engines are introduced in the industrial revolution in Europe, allowing larger quantities of groundwater to be extracted from greater depths. This water is used for industry, agriculture, and supplying clean water to growing urban centres[10].

PAST

Year

1588

1847

1850s

1895

BETTER PUMPS AND DRILLING

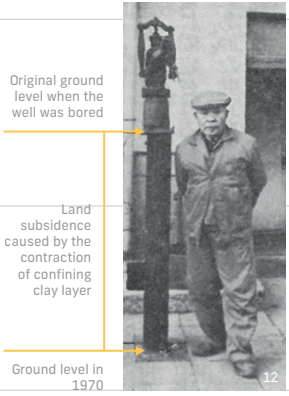
Groundwater exploitation at any significant level starts in the 1950's as more advanced drilling and pumping technology develops. Electricity also becomes a more widely accessible energy source, fuelling groundwater development. Farming and industry are major users of groundwater resources, causing a huge transformation in these sectors[11].

SCIENCE TAKES A LEAD

Engineers and hydrogeologists, in collaboration with diverse partners and stakeholders, establish the International Association of Hydrogeologists (IAH)[12] in order to better understand the resource and to help identify solutions to groundwater risks.

MAR PICKED UP

Practical solutions, such as managed aquifer recharge (MAR)[13], are put forward to enhance stability of groundwater reserves and to support ecosystem services, for example in Orange County, California.



LAND SUBSIDENCE

Signs of subsidence (downward settling of the ground's level) become evident in major cities, like Mexico City, Jakarta and Tokyo and Osaka, Japan, due to groundwater overexploitation[14].

Groundwater abstraction [km³/yr]

2000
1500
1000
500
0

Year

1950s-1960s
1956
Mid-1950s
Late 1950s

13

THE GREEN REVOLUTION

India's Green Revolution to successfully increase food production is made partly possible through the use of groundwater as tube-well technology and rural energy access become more widely available. Around 2000, groundwater would surpass surface water in importance for irrigation in India[15].


14

TUBE-WELLS SPREAD

Tube-well irrigation for agriculture becomes widespread in China[16].


15

URBANIZATION

51% of the global population lives in urban areas, compared to 30% in 1950. This rapid global urbanization, especially in developing countries, leads to major stress on groundwater resources because of increasing demand and degraded groundwater quality due to pollution[14].


16

THE GREAT MAN-MADE RIVER

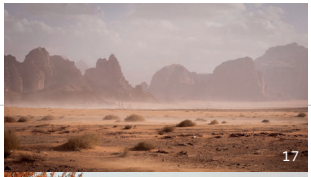
The Great Man-Made River, the largest irrigation project in the world, delivers water to the first of many cities in Libya. The project, which supplies 6,500,000 m3 of fresh water per day, takes water from the Nubian Sandstone Aquifer System, a fossil (non-renewable) aquifer discovered in 1953[17].

Groundwater abstraction [km³/yr]

2000
1500
1000
500
0

Year

1960
1970
1980s
1984



AZRAQ WETLAND RESERVE

The main springs that feed the Azraq Wetland Reserve in Jordan, an oasis that used to cover 25 square kilometres, are dried out due to excessive pumping of groundwater for agriculture and use in nearby urban areas[18] starting in the 1960s. The critical bird habitats are later partially rehabilitated by pumping water for the wetland[19].

DRINK UP

Almost half the world's population relies on groundwater for its drinking water supply[20].

FLOURISHING ECONOMIES

Groundwater is a key driver of social and economic development. Globally, agricultural groundwater use supports annual output valued at $210–$230 billion[16]. California's annual $90 billion agricultural economy depends heavily on groundwater.

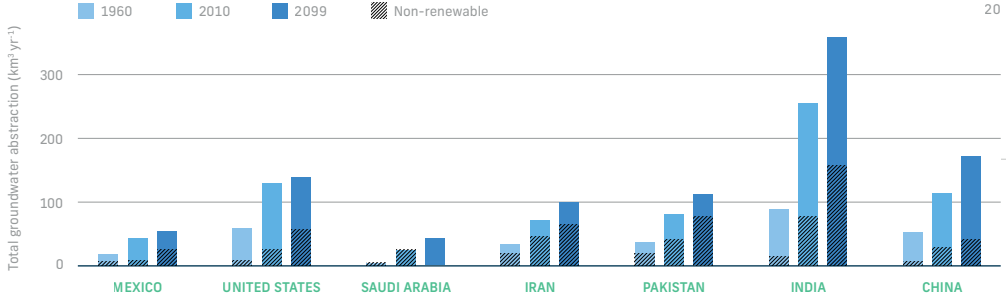
NEED FOR A CHANGE

More than half of the world's largest aquifers are being depleted, with the US having lost more than 1,000 cubic kilometers of water from its aquifers . Globally, non-renewable freshwater use is 50% higher than in 1960 due in part to groundwater abstraction from non-renewable groundwater sources[21]. Overabstraction is also taking place in aquifers that replenish much slower than the rate of pumping.

2010

TOP USERS

China, India, Iran, Mexico, Pakistan, Saudi Arabia, and the United States account for 74% of global groundwater withdrawals, with India accounting for one fourth of the global groundwater use[22].



20

2000

1500

1000

500

0

Groundwater abstraction [km³/yr]


21


22


23


24

SEAWATER INTRUSION

Seawater encroaches on emptied aquifers along the east coast of India, tainting drinking water supplies in places like Chennai. Bed dams along the coast are implemented to arrest the intrusion[23].

DRIED UP WELLS

Public and private wells and aquifers in Maharashtra state in India dry up, leading villagers to receive water trucked in every day[24] or travel two miles a day to find water.

GROUNDWATER INSULATES RURAL COMMUNITIES

Communities in rural Ethiopia with access to reliable groundwater sources through the major El Niño drought have greatly improved water security[25].

ABANDONED FARMS

As springs dry up and groundwater is depleted, many Moroccans give up citrus farming and move to the cities[26], following the trend in other Middle Eastern and North African countries.

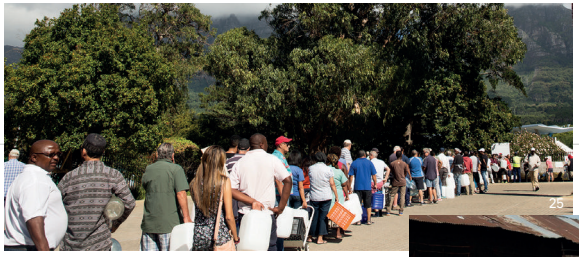
Year

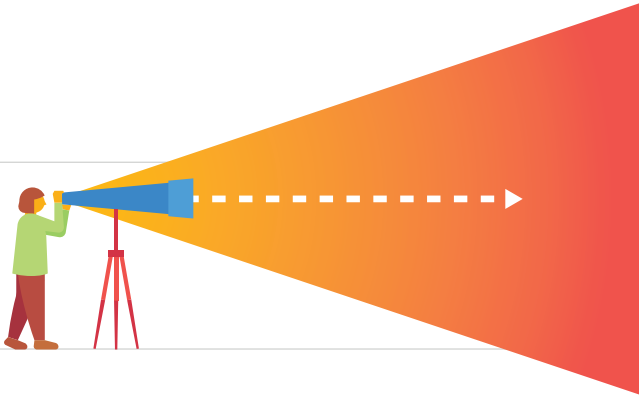
2012

2015

2016

2016





CAPE TOWN

Cape Town in South Africa identifies April 12 as "Day Zero," when it will allegedly run out of water. Putting into place strict water conservation measures allows the city to evade the pending drought grip[27]. Groundwater use and groundwater management play an increasingly critical role in enhancing the city's water security[28].

WATER QUALITY THREATS

While some reversal of negative water quality trends[29] in European aquifers are seen, many aquifers around the world, and in particular in developing countries, are facing pollution threats from conventional sources and increasingly from contaminants of emerging concern[30].

NOW

Abstraction of groundwater improves water and food security for many people, but overexploitation and degradation of the resource may eventually exacerbate droughts and food insecurity. If we take action now to sustainably manage our surface and groundwater resources, we can prevent these problems from becoming worse and potentially irreversible in the future.

2000

1500

1000

500

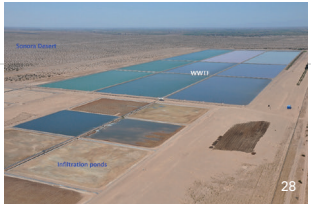
0

Groundwater abstraction [km³/yr]

27

WATER SCARCITY

1.8 billion people globally are coping with water scarcity, partially due to overextraction of renewable and non-renewable groundwater resources[31].



28

MAR AND DEMAND REDUCTION HELP MAINTAIN BUFFER

Managed aquifer recharge, including through use of treated wastewater, is projected to double by 2030, and could ultimately contribute 10% or more of groundwater use in many countries[13].


29

AFRICAN CITIES TO BENEFIT

With half of the Sub-Saharan African cities in 2035 not yet built and the secondary cities of today expected to become the mega cities of tomorrow, a quadrupling in water supply service rates will be required just to maintain current levels (let alone to increase proportional coverage), much of which will need to come from groundwater. Wherever high-yielding aquifers exist within 30 km of an urban demand center in Sub-Saharan Africa, their managed and staged development by water utilities can significantly increase water-supply security[32].


30

AQUIFERS AT STAKE

60% of Indian groundwater aquifers are in a critical condition[33].

FUTURE

Year

2025

2030

2035

2040

SINKING CITIES

The Indonesian capital of Jakarta is home to 10 million people, but it is also one of the fastest-sinking cities in the world. If this goes unchecked, parts of the megacity could be entirely submerged by 2050[34].

FOOD SECURITY RISKS

The Ogallala aquifer in the United States, previously the site of one fifth of the world's wheat, corn, cotton, and cattle production, is severely depleted, making it impossible to grow crops on 35% of previously arable land[35].

PRAY FOR WATER

Groundwater depletion threatens to push this vital resource out of reach for more than 170 million small-scale farmers who are the backbone of India's food security[36].

EMERGING POSITIVE TRENDS AND SOLUTIONS

Long-term groundwater monitoring, innovative research and technology can help understanding and managing impacts of climate change on groundwater resources[37]. It can inform groundwater forecasting[38], tackle groundwater quality threats[39], and create opportunities to explore for new groundwater reserves[40].

Innovative management and business models can also support sustainable water supply from groundwater, through maintenance services for rural water supply infrastructure as trialled in sub-Saharan Africa[41], and through supported community participation in groundwater monitoring and management[42] and access to solar irrigation for smallholder farmers as successfully implemented in India[43].

GROUNDWATER IN SUSTAINABLE DEVELOPMENT
– A juggling act

Water, and by extension groundwater, clearly underpins human development and life and the achievement of the United Nations' Sustainable Development Goals (SDGs).

History teaches us that groundwater development and management need to go hand in hand. Many goals, such as those related to food security, access to safe water and sanitation, cannot be achieved without taking sustainability of groundwater into consideration. However, while many of the SDG targets reinforce sustainable and equitable groundwater use, some, like economic development, may threaten the resource. Hence, going forward, achieving the SDGs will be a balancing act that requires juggling between sometimes difficult and conflicting trade-offs regarding groundwater.

The historical lessons show us that we need a much more informed approach than our previous efforts. Greater emphasis is needed on informing groundwater-dependent communities and the general public about this common pool resource - especially where it is the sole or go-to resource during drought, on monitoring groundwater levels, quality and use, and facilitating equitable and transparent management practices by culturally acceptable means at meaningful scales. It is also important to acknowledge and account for the fact that many decisions with impacts on groundwater are taken outside the sphere of groundwater management. These decisions and trade-offs need to be made explicit in the context of increasing groundwater risks and juggled correctly to achieve the SDGs.[44]

The United Nations' Sustainable Development Goal 17 is on Global Partnerships for Sustainable Development.

As we can see, good global-to-local partnerships are critical for sustainable groundwater management. The Groundwater Solutions Initiative for Policy and Practice (GRIPP) is a network of organizations and experts committed to strengthening and expanding sustainable groundwater practices by embedding them at the heart of natural resource management and the SDGs.

Learn more by visiting:
http://gripp.iwmi.org/

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Images:

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3. Cross-section of a Qanat. Source: https://en.wikipedia.org/wiki/Qanat
4. A Persian Sakia wheel, ca. 1905. Source: https://en.wikipedia.org/wiki/Sakia
5. Donkey at work at Carisbrooke castle during the70's.
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18. Pumping water to different parts of the Azraq Wetland reserve has helped attract a large variety of bird species, especially migrants (Photo courtesy of Royal Society for the Conservation of Nature (RSCN)).
    Source:
    http://www.jordantimes.com/news/local/azraq-wetland-reserve-rehabilitation-helped-attract-variety-birds-%E2%80%94-rscn
19. Forward-thinking farmers in California are abandoning almonds and turning to a nut native to the hot, dry Middle East: the pistachio.
    Source: https://psmag.com/environment/farmers-are-salty-over-soils-saline-levels
20. Seven largest groundwater consuming countries in the world. Source: Taylor, R. (2014) When wells run dry. Nature, 516, 179-180. https://www.nature.com/articles/516179a/figures/1
21. Freshwater about half a foot below the sill level of bed dam in Cuddalore District,Tamil Nadu, India shows the arrest of seawater from the coast.
    Source:
    https://www.deccanchronicle.com/nation/in-other-news/101017/tamil-nadu-fights-sea-intrusion-to-protect-farm-lands.html
22. Adinath Suryawanshi stands by his open well, which once provided water for his family on their 7.5-acre farm in Maharashtra state, India. The well, which was blasted open with dynamite years ago, has gone dry.
    Source:
    https://eu.desertsun.com/story/news/environment/2015/12/10/how-unchecked-pumping-sucking-aquifers-dry-india/74634336/
23. Water pump in the highlands of Ethiopia.
    Source: https://www.agefotostock.com/age/en/Stock-Images/Rights-Managed/X8C-1281206
24. Mbarek Belkadi stands next to the stump of an orange tree on his family's farm in Sebt El Guerdane, Morocco. He said earning a living has been difficult the past several years since their well went dry and the family uprooted their trees.
    Source:
    https://eu.desertsun.com/story/news/environment/2015/12/10/morocco-groundwater-depletion-africa/76788024/
25. People queuing for water in Cape Town (2018).
    Source: https://bedroomfurniture.club/search/africa-town-cape-water-south.html
26. Landfill in Lagos,Nigeria. Source: https://www.independent.co.ug/monetisation-of-garbage/
27. Managing Water Under Uncertainty and Risk cover.
    Source: https://unesdoc.unesco.org/ark:/48223/pf0000215644
28. Managed aquifer recharge scheme in San Luis Río Colorado, north-western Mexico.
    Source: : Jorge Ramírez-Hernández, Universidad Autónoma de Baja California with aerial support from LightHawk.
29. Dar es Salaam, Tanzania is increasingly dependent on groundwater.
    Source:
    https://www.citylab.com/design/2015/02/the-bright-future-of-dar-es-salaam-an-unlikely-african-megacity/385801/
30. The village well in Paldev Ka Purwa village in Banda district of Uttar Pradesh dried up three years ago, bringing cultivation to a virtual halt.
    Source: https://indiaclimatedialogue.net/2016/05/05/heat-dust-water-bundelkhand/
31. Jakarta is sinking at an alarming rate and is implementing infrastructure projects to combat subsidence.
    Source: https://www.todayonline.com/world/jakarta-sinking-so-fast-it-could-end-underwater
32. A field of dead corn affected by drought in Illinois.
    Source
    https://www.nbcnews.com/science/environment/field-bad-dreams-increased-drought-takes-toll-midwest-corn-n94791
33. Indian smallholder farmer praying for rain.
    Source:
    https://www.newsbytesapp.com/timeline/India/8685/49379/problems-with-the-pradhan-mantri-fasal-bima-yojana
    IWMI/Hamish John Appleby

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