063 - Best practices, successes and failures involving groundwater replenishment – Case studies from India

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Abstract

Groundwater is one of the most important sources of water. India relies heavily on it and is the world's largest groundwater consumer, satisfying more than 85% of its drinking water demands with it and uses an estimated 230 million cubic kilometres of groundwater per year. This review is centred on case studies in India, involving both the depletion and replenishment of groundwater. First, the general condition of India's groundwater reserves is presented. Second, the major causes of and factors involved in their rapid depletion are examined. Third, some of the biggest failures and successes in groundwater management and renewal, taking into account the differences between cases in rural and urban areas, are presented. Finally, some of the best practices for the effective managing and replenishment of groundwater, including traditional, age-old practices and community specific practices are discussed. This may be beneficial to understand the severity of the ongoing event and formulate action plans and/or policies to replenish India's steadily depleting reserves. It may also help to understand how better to achieve the United Nations Sustainable Development Goals (SDGs), especially the ones pertaining to water and sustainability among others.

Introduction

India is the seventh-largest country in the world area-wise and is home to almost 16% of the world's population. However, it possesses only 4% of the freshwater resources globally – 1123bcm utilisable water, 690bcm surface water and 433bcm groundwater.

This groundwater distribution is very uneven throughout the country. Higher levels are found in the north and north-eastern parts of the country (corresponding to the basins of the Himalayan origin rivers – Indus, Ganges and Brahmaputra (IGB)), due to the alluvial soils. However, southern peninsula has low infiltration capacity.

The chief source of groundwater replenishment is rainfall but again there is high spatial and temporal variation in rainfall patterns.

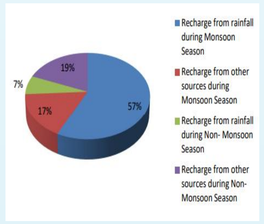

Figure 1: Sources of groundwater recharge. (Source: Dynamic water resources of India, CGWB, 2020)

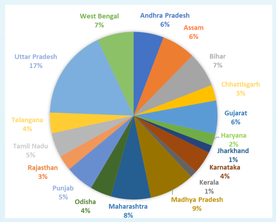

Figure 2: Uneven distribution of groundwater resources. (States with <5bcm not shown; data adapted from CGWB, 2020)

Increasing population/demand and changing rainfall patterns (attributed to climate change) are causing depletion and overexploitation of water. In a report, the Central Ground Water Board (CWGB) mentions that 13% of extractable groundwater (about 398bcm) lies in the overexploited zone. A study published by Science.org also found that sizable areas in north-western and south India will face "critically low groundwater availability" by 2025.

Thus, urgent measures are needed to alleviate the stress on the country's groundwater resources.

Here, 2 different cases are analysed – the techniques they used to replenish their groundwater and whether or not they were successful. Further, with increased interest in sustainability, we will see whether groundwater (and its renewal) as a resource can help to attain the UN SDGs as well.

Case Study 1: Alwar District, Rajasthan

- Rajasthan – located in Northwest India; largest state area-wise (10% of land).
- Characterised by sandy, barren land in the west (the Thar desert), gradually improves on moving eastward.
- One of the driest states, with critical water status – only possesses 1% of India's water resources; average rainfall is 415mm (from Southwest monsoon).
- Precipitation is disproportionate – 1000 100mm in southern and eastern districts; 100-150mm in western, north-western districts on average.

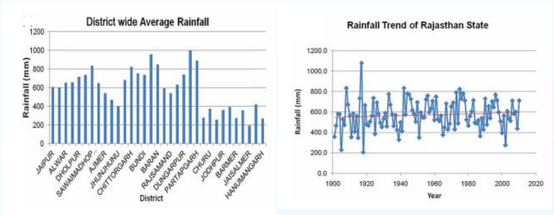

Figure 3: a) Average rainfall across districts of Rajasthan. b) Rainfall across state of Rajasthan
(Source: Gupta et al., 2018)

- Alwar is amongst the driest districts in the state; seasonal rivers with annual rainfall its only renewable water supply.
- Earlier, had a stable water use-to-replenishment ratio. Ruined after British invasion – forests sold for timber use and such.

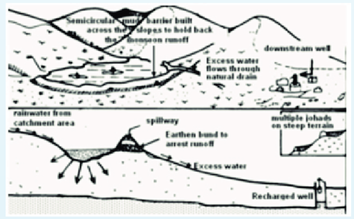

Figure 4: Earlier, the locals used *johads* (earthern dam-like structures) to store rainwater and replenish groundwater.

(Source: Hussain et al, 2014)

- Deforestation resulted in topsoil, debris blocking the *johads*, making them unavailable for use.
- After Independence, new government permitted logging in leftover land; brought in new, diesel-powered technology for water aid.
- Monsoon season dwindled from 101 days in 1973 to 55 days in 1987, deforestation decreased transpiration rates – vicious cycle cycle wherein dry aquifers led to greater reliance on rainfall, and less rain led to greater dependence on underground resources.
- 1985 saw Rajendra Singh (Water man of India) of Tarun Bharat Sangh move to nearby Kishori village to open a clinic. On learning of the water woes of the district, he along with 2-3 others began to dig a johad. Villagers were convinced to help in exchange for grains. In 7 months, dug 15ft.
- The monsoon of 1986, sufficient to refill pond and even renew a long-dry well.
- By 1996, 9 *johads* were constructed, covering area of 2381 acres, with capacity of 162 million gallons.
- Groundwater level rose significantly – from 22ft to 45ft.

Case Study 2: Chennai, Tamil Nadu

- Chennai, capital of southern state of Tamil Nadu, is situated on eastern coast (bordering Bay of Bengal).
- Chennai is one of India's wettest cities with average annual rainfall of 1200-1300mm. 1/3rd occurs during retreat of Southwest monsoon (August-September), 2/3rd during Northeast monsoon (October-December).
- Most of the rainfall occurs on some 'rainy' days. Majority of it is lost to surface runoff, about 8% recharges both surface and groundwater reservoirs.
- In urban areas, municipal agencies maintain surface/groundwater reservoirs; in rural areas primary source is groundwater.

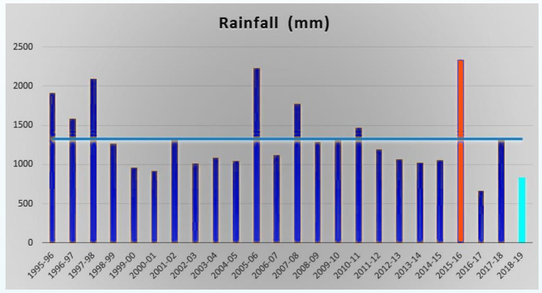

Figure 5: Annual average rainfall in Chennai.
(Source: DownToEarth.org)

- Rainfall deficit in 2000-2001 led to severe droughts.
- Government of the time, passed 'The Tamil Nadu Municipal Laws ordinance' in 2003, making rainwater harvesting (RWH) compulsory for all households, public/private buildings.
- The government took a number of steps to ensure compliance with the law – organized workshops/seminars, held door-to-door campaigns, set up centres for free technical assistance etc.
- In 2015, a survey by an NGO in Greater Chennai area found most people flouted the rule; worst violators were government buildings – reason was most structures being built incorrectly.
- 2015 saw the highest rainfall since 1918 (>2000mm) – 450mm between November 11 and 18. The city was flooded, affecting >4 million people.
- Chennai experiences violent storms frequently, correctly installed RWH structures could have handled a significant portion of excess water.
- In 2018-19, rainfall deficit led to the drying up of both surface and groundwater reserves – Chennai became the first Indian city to declare "Day Zero" on 19th June 2019.
- Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) extracted groundwater from outside the city, supplied it in tankers to meet water needs, worsening the crisis.

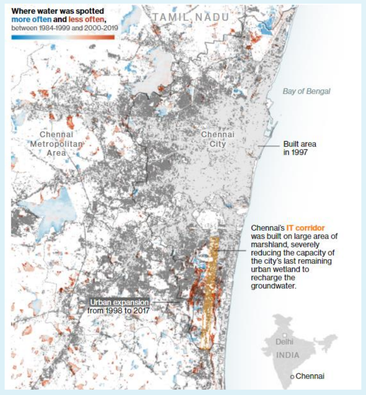

Figure 6: Rapid Urbanization is one of the major reasons for Chennai's water woes; increasing groundwater extraction to unsustainable levels while reducing marshland area required to recharge groundwater.

(Source: Bloomberg.com)

Conclusions

The case studies above show two differing scenarios – one in a rural area of one of India's driest regions and the other in an urban, coastal metro city which experiences one of the highest average rainfalls in the country.

Both situations clearly showed how resuscitating groundwater helped to achieve the SDGs. The results of case 1 showed how it was directly associated with attaining goals 3, 6, 8 and 11. Goals 1, 2, 4, 5, 9 and 10 also indirectly benefited to some extent. Conversely, achieving some of the goals can also boost the water levels. Working toward goals 11, 12 and 13 can aid in reducing usage and depletion of groundwater.

Some recommendations to boost groundwater levels and thus work towards the SDGs:

- Strict governance – case 2 shows no matter how robust the law, negligence on part of authorities/people will result in failure.
- Focus on local customs – India has enormous population, changing physiographic features throughout, so each local community has unique traditions relating to water. Combined with newer techniques (artificial recharge) will be more successful, economical approach.
- Greater community involvement – as seen in case 1, participation of entire village brought about desired results.

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