Depleting Groundwater, Rising Threats: Integrating Community and Policy for Groundwater Sustainability

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Abstract - Groundwater depletion is posing a critical threat to public health, particularly in India, which is most populated and agriculture dominated, where over-extraction and contamination of groundwater is leading to sever health crisis. This article examines the intricate relations between groundwater depletion and its impact on public health, emphasising the need for community participation for sustainable groundwater governance. The article evaluates India's legal and policy framework, including the Mission LiFE and their effectiveness in groundwater conservation. The study integrates theoretical perspective like Ubuntu Principle and Arnstein ladder of citizen participation to assess the role of decentralising governance. The article highlights successful community led groundwater management initiatives advocating inclusive approach for conservation. Concluding with policy recommendation, it underscores the need for collective action to mitigate groundwater depletion and its impact on public health.

I. INTRODUCTION

Groundwater is the major source of freshwater for meeting the needs of population all across the globe, including domestic, industrial and agricultural purposes and it accounts for almost 99 percent of fresh liquid water on Earth.[2] While accommodating 16 percent of the global population, India possesses 4 percent of the world's freshwater resources to fulfil its needs.[3] It is a crucial resource for our country as almost around 230 cubic kilometre of groundwater is extracted each year, more than a fourth of the whole world's total.[4] India, having become the most populated country in the world, and relying on groundwater for more than 60 percent of agricultural irrigation and 85 percent of drinking water needs, there is a mounting pressure on the groundwater quality and quantity. It all makes groundwater depletion an

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[2] 'Groundwater, Making the Invisible Visible | UN World Water Development Report 2022' <https://www.unesco.org/reports/wwdr/2022/en> accessed 14 March 2025.
[3] 'How Is India Addressing Its Water Needs?' <https://www.worldbank.org/en/country/india/brief/world-water-day-2022-how-india-is-addressing-its-water-needs> accessed 4 March 2025.
[4] Faraz Ahmad, 'India's Groundwater Quality Report Underscores Systematic Inertia and Fragmented Efforts Undermining Water Security' [2025] *Down To Earth* <https://www.downtoearth.org.in/water/indias-groundwater-quality-report-underscores-systemic-inertia-and-fragmented-efforts-undermining-water-security> accessed 3 March 2025.

escalating global crisis, with India facing a particularly alarming scenario due to its demographic and geographic realities.

The condition of groundwater in India is a fundamental perspective for the whole world in terms of water scarcity, both quality and quantity. Although India is a home to some rich fluvial aquifers, but over-exploitation of the groundwater resource has resulted in "groundwater drought" in major parts of India.[5] The anthropogenic pressure and other hydrogeological conditions (known as water-rock interaction or WRI) affect the composition of groundwater. Due to depleting groundwater resources, the minerals and components in groundwater gets concentrated. In a similar way, through water-rock interaction, changes in temperatures and physio-chemical condition of surrounding environment, the components in groundwater gets dissolved and colluded and changes the composition of groundwater.[6] Thus through such geogenic and anthropogenic reasons, the nature of groundwater changes from being clean and potable to being contaminated with high content of elements like arsenic, fluorine, iodine etc. The increasing contaminants in groundwater and emerging contaminants coming up due to over-exploitation and other factors is affecting human health, which has been considered as a public health emergency for global society where a study found evidence of the same in more than 100 countries.[7]

II. BENEATH THE SURFACE: UNRAVELING THE GROUNDWATER DEPLETION CHALLENGES

We rely heavily on groundwater resources for our various demands across all seasons throughout the year. Heavy reliance on groundwater for various needs like household consumption, drinking water, industrial use and agricultural purposes, along with over-exploitation, erratic monsoon conditions due to which aquifers do not get replenished, and fast paced urbanization[8] have collectively laid stress on groundwater resources. Together with these factors, increasing temperatures, erratic monsoons and population pressure on limited resources, do not allow the aquifers to get recharged sufficiently.

[5] Abhijit Mukherjee, Soumendra Nath Bhanja and Yoshihide Wada, 'Groundwater Depletion Causing Reduction of Baseflow Triggering Ganges River Summer Drying' (2018) 8 Scientific Reports 2018 8:1 1 <https://www.nature.com/articles/s41598-018-30246-7> accessed 4 March 2025.
[6] Xianjun Xie and others, 'Groundwater Quality and Public Health' [2023] Annual Review of Environment and Resources <https://doi.org/10.1146/annurev-environ-112321->.
[7] Yanxin Wang and others, 'Genesis of Geogenic Contaminated Groundwater: As, F and I' (2021) 51 Critical Reviews in Environmental Science and Technology 2895 <https://doi.org/10.1080/10643389.2020.1807452> accessed 14 March 2025.
[8] Swarup Dangar, Akarsh Asoka and Vimal Mishra, 'Causes and Implications of Groundwater Depletion in India: A Review' (Elsevier BV, 1 May 2021).

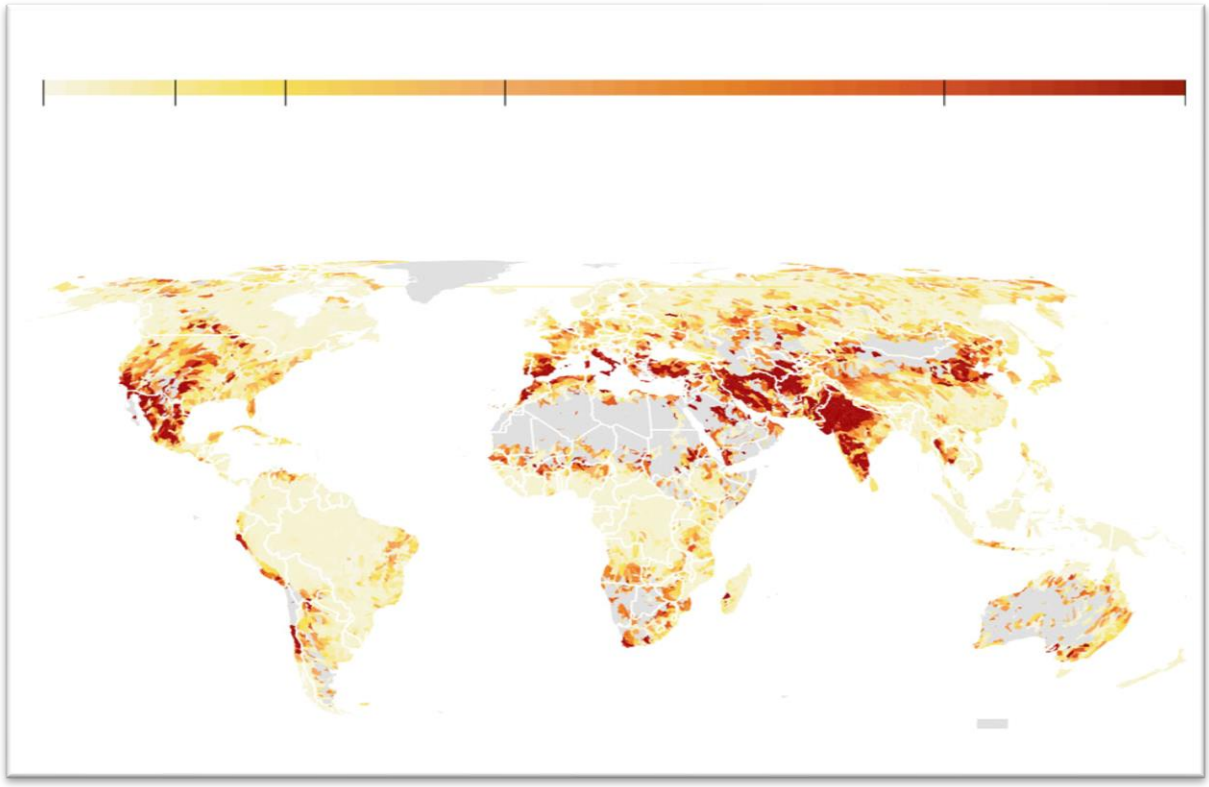
This trajectory of depletion of groundwater in India is alarming, for if this trend is to persist, reports suggest that the rate of groundwater depletion would triple by the year 2080, constituting a hazard to food security in India.[9] Historically, farmers relied on canal-based irrigation for farming, but gradually it shifted to privately owned groundwater extraction systems like well, tube-well, and pumps. A study by University of Michigan identified warming climate as one of the key reasons because of which farmers are relying more and more on groundwater for irrigation purposes.[10] The results of this study were further corroborated by the data from the Central Groundwater Board (CGWB) which stated that states like Rajasthan, Punjab, Haryana and Delhi are over-extracting their groundwater resource as the rate of extraction was overshooting more than 100 percent. The study highlighted that in light of climate change and increasing temperatures, demand for crop water is also increasing and for this reason farmers are relying more on groundwater extraction. However, it was projected in the study that even with anticipated increase in precipitation, the rate of groundwater loss could be thrice as high as usual. On one hand increase in irrigation is essential to alleviate crop water stress, but on the other hand continuing this practice for long term will cost groundwater resources.[11] Thus, it is imperative to come up with robust strategies and policy interventions to ensure sustainable use of groundwater in our country. The darker shade area represents extremely high-water stress level, with India, among other 17 countries, is at urgent risk of running out of water.

[9] Amit Kapoor and Mukul Anand, 'Addressing Groundwater Depletion Crisis in India: Institutionalizing Rights and Technological Innovations Addressing Groundwater Depletion Crisis in India: Institutionalizing Rights and Technological Innovations' (2024).

[10] Nishan Bhattarai and others, 'Warming Temperatures Exacerbate Groundwater Depletion Rates in India' (2023) 9 Science Advances <https://www.science.org> accessed 15 March 2025.

[11] Zumbish, 'India Will Be Losing Groundwater Three Times Faster in 2041-2080, Finds Study' [2023] *Down to Earth* <https://www.downtoearth.org.in/water/india-will-be-losing-groundwater-three-times-faster-in-2041-2080-finds-study-91503> accessed 15 March 2025.

Figure 1- Water Stress Level



Source- *World Bank Document; 2030 Water Resources Group Offerings: Advancing global water security through public-private collaboration*

Groundwater Contamination

The problem does not end here, as with groundwater depletion and its over-exploitation, another significant challenged posed is that of groundwater degradation or contamination.[12] The Groundwater Foundation defined groundwater contamination as when man-made products such as oils, fertilizers, bio-medical wastes, road salts and chemicals leach into the groundwater and makes it unsafe and unfit for human use.[13] Although in some of the northern states of India, data suggests abundance of water resource, but the availability of clean and potable water is restricted due to unregulated discharge of industrial waste and sewage into the rivers and other surface water sources.[14] Such unregulated discharge of waste into water bodies, along with other geogenic activities, the quality of groundwater gets degraded so much so that the

[12] 'Kumar, R., Singh, R.D. and Sharma, K.D. (2005) Water Resources of India. Current Science, 89, 794-811. - References - Scientific Research Publishing' <https://www.scirp.org/reference/referencespapers?referenceid=1320501> accessed 4 March 2025.

[13] 'Groundwater Contamination – The Groundwater Foundation' <https://groundwater.org/threats/contamination/> accessed 15 March 2025.

[14] Abhijit Mukherjee and others, 'Elevated Arsenic in Deeper Groundwater of the Western Bengal Basin, India: Extent and Controls from Regional to Local Scale' (2011) 26 Applied Geochemistry 600.

groundwater contains toxic level of such contaminants and elements, well above the permissible limits as provided by the World Health Organization for drinking water. Getting exposed to such contaminated water over a long period of time, through ingestion or contacting with body has exposed many people to several health hazards.[15]

It is noteworthy that contamination of groundwater is not similar to contamination of surface water, as the recovery of the former is difficult and slow, if not impossible, with the current technologies.[16] The contamination of groundwater is difficult to detect as the contaminants are invisible, odourless and without any colour, and the impact of it on public health is usually not immediately linked to groundwater consumption.[17] Furthermore, once groundwater becomes contaminated, the process of remediation is both difficult and expensive due to presence of aquifers well below the ground. Further, even if the source of contamination is eliminated, the natural purification takes a very long time to restore the quality of groundwater.[18]

Major Contaminants in Groundwater in India

As a positive initiative, the Government of India, through Union Ministry of Jal Shakti, released a report last year on groundwater quality, utilizing a newly developed Standardized Operating Procedure for assessment. The report had an extensive scope covering 15,259 monitoring locations, particularly focusing on shallow aquifers. Sampling of groundwater was conducted during both pre- and post-monsoon seasons, employing 4,982 trend stations in order to evaluate seasonal variations in the contamination levels. The report gave a detailed analysis of groundwater quality across the country, identifying the presence of key contaminants such as arsenic, uranium, fluoride, iron, chloride and high electrical conductivity (EC). [19] Major contaminants that were found across various states in India were-

[15] ibid.
[16] Jacqueline A Macdonald and Michael C Kavanaugh, 'Restoring Contaminated Groundwater: An Achievable Goal ?' (1994) 28 Environmental Science and Technology <https://pubs.acs.org/doi/abs/10.1021/es00057a001> accessed 15 March 2025.
[17] Dipankar Chakraborti and others, 'Groundwater Arsenic Contamination in Bangladesh-21 Years of Research' (2015) 31 Journal of trace elements in medicine and biology : organ of the Society for Minerals and Trace Elements (GMS) 237 <https://pubmed.ncbi.nlm.nih.gov/25660323/> accessed 15 March 2025.
[18] Dongshuang Wang and others, 'Hydrogeochemistry Assessment of Shallow Groundwater and Human Health Threats in the Northwestern Ordos Basin, China' (2021) 80 Archives of environmental contamination and toxicology 92 <https://pubmed.ncbi.nlm.nih.gov/33388838/> accessed 15 March 2025.
[19] 'Annual Ground Water Quality Report, 2024' (2024) <https://cdnbbsr.s3waas.gov.in/s3a70dc40477bc2adceef4d2c90f47eb82/uploads/2024/12/2024123111839566 96.pdf> accessed 15 March 2025.

- ***Nitrate-*** Primarily linked to runoffs from agriculture and excessive use of fertilisers, were found to be prevalent in Rajasthan, Maharashtra, and Tamil Nadu, with over 40 percent samples found to be exceeding the permissible limit.
- ***Fluoride-*** Elevated fluoride concentration was detected in Rajasthan and Haryana in the western belt and Andhra Pradesh, Karnataka and Telangana in southern belt of India, posing serious health concerns. Some improvements were observed in the concentration level of fluoride during monsoon season but overall contamination level remained at a concerning level.
- ***Arsenic-*** A major cause of concern, arsenic, was found in excessive amounts in floodplains of the Ganga and Brahmaputra rivers, in the states of Uttar Pradesh, West Bengal, Bihar, Jharkhand, Punjab, Assam and Manipur.
- ***Uranium-*** Rajasthan and Punjab were identified as major hotspot of high uranium concentration. With over 42 percent of samples exceeding the limit in Rajasthan and 30 percent in Punjab. Areas with excessive over-extraction of groundwater, showed higher concentration of uranium, indicating a link between groundwater depletion and leaching of uranium.
- ***Salinity and Electrical Conductivity (EC)-*** Several states like Rajasthan, Gujarat, Delhi, Punjab and Haryana, exhibited high level of EC values indicating higher groundwater salinity. Again, monsoons recharge showed temporary improvements in some of these areas, but certain areas in Rajasthan like Barmer and Jodhpur showed rising trend in EC level, meaning thereby a long-term salination deposits in the groundwater.

The report will help in establishing a critical baseline for monitoring groundwater quality and form targeted policies to mitigate contamination risks and ensure long-term water security. However, the impact of groundwater contamination on public health is still not addressed, for which interdisciplinary research would help understand the optimal solution for sustainable and safe supply of clean groundwater, as well as to safeguard the ecosystem and human society which is dependent on the groundwater resources.

Table1- States and districts affected by geogenic contamination in groundwater

Geogenic contaminants	Number of affected states	Number of affected districts
Arsenic	10	68

Fluoride	20	276
Nitrate	21	387
Iron	24	297

Source: Central Ground Water Board; PRS.

The Table above shows data regarding the number of states and districts affected by geogenic contaminant namely Arsenic, Fluoride, Nitrate and Iron, examined by the Committee on Estimates for the period of 2014-15.

III. PUBLIC HEALTH RISKS OF CONTAMINATED GROUNDWATER

Sir Donal Acheson defined the term public health in the year 1988 as *"the art and science of preventing diseases, prolonging life and promoting health through the organized efforts of society".*[20] Acheson's definition is one of the most cited definitions by far, and has been used in various studies to lay emphasis on importance of public health. Climate change is one of the factors which is posing imminent threat in this age to public health, as data suggests that almost 13 million die every year due to environmental factors.[21]

Groundwater, contaminated and depleted by climatic and human activities is affecting human health. Groundwater when studied by contrasting its water quality index (WQI) against the human health assessment model, showed to have negatively impact human health.[22] Persistent scarcity of water is proven to impact public health and economic growth and over two billion people across the globe do not have access to clean and potable drinking water, and such deficiencies contribute to spread of diseases like polio, cholera and typhoid.[23]

It is not that groundwater must be devoid of all elements as a healthy human being requires more than a dozen elements essential for the body to function properly, and groundwater acts as a carrier of such micro and macro elements like Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), Fluorine (F), Silicon (Si), Iodine (I), Manganese (Mn), Iron (Fe), Zinc (Zn), etc. Consumption of completely demineralized drinking water for a long time can be

[20] Donald Acheson, 'Public Health in England' (1988).
[21] 'Causes and Effects of Climate Change | United Nations' <https://www.un.org/en/climatechange/science/causes-effects-climate-change> accessed 16 March 2025.
[22] Abhijit Mukherjee, 'Changing Groundwater Landscape of India: Implications to Drinking Water, Food Security, Socio-Economy and Public Health' [2019] Proceedings of the Indian National Science Academy.
[23] Claire Klobucista and Kali Robinson, 'Water Stress: A Global Problem That's Getting Worse' [2023] Council on Foreign Relations.

detrimental to human health, as it may affect hearth health, thyroid function and dental health.[24] Moreover, it is recommended that drinking water sourced from groundwater helps in intake of daily recommended elements essential for human health.[25] Further, when non-contaminated groundwater is used for irrigation, such essential elements are supplied to us through food chain.[26]

But these essential elements can be antagonists for human body if they are in higher concentration than required. For instance, Sodium in higher concentration, especially in coastal areas where the groundwater is usually saline, prolonged consumption of such water increases the risks of cardio vascular diseases and high blood pressure.[27] Infants and children are especially susceptible to the ill effects of contaminated water, for example, infant methemoglobinemia, commonly called as *blue baby syndrome,* is caused by intake of water contaminated by nitrate baby formulae.[28]

Further, consumption of calcium (Ca) and magnesium (Mg) in excess of required limits can cause imbalance and increases the risks of coronary and cerebrovascular diseases, and it also leads to formation of calculi, a common health issue that we have been witnessing for a long time.[29] A significant correlation has been observed between prevalence of urinary and kidney stones in the "global stone belt" (term used for the geographical area where this problem is highly prevalent) and elevated Ca and Mg in drinking water aquifers.[30] Thus, these elements are required in specific amount in human body, as both deficiency and excessive intake can be a pose significant risk to human health.

[24] Ingegerd Rosborg and Frantisek Kozisek, *Drinking Water Minerals and Mineral Balance: Importance, Health Significance, Safety Precautions* (Springer International Publishing 2020).
[25] Mohammad A Hoque and Adrian P Butler, 'Medical Hydrogeology of Asian Deltas: Status of Groundwater Toxicants and Nutrients, and Implications for Human Health' (2015) 13 International Journal of Environmental Research and Public Health 2016, Vol. 13, Page 81 81 <https://www.mdpi.com/1660-4601/13/1/81/htm> accessed 16 March 2025.
[26] Karaj S Dhillon and Surjit K Dhillon, 'Selenium in Groundwater and Its Contribution towards Daily Dietary Se Intake under Different Hydrogeological Zones of Punjab, India' (2016) 533 JHyd 615 <https://ui.adsabs.harvard.edu/abs/2016JHyd..533..615D/abstract> accessed 16 March 2025.
[27] Pauline FD Scheelbeek and others, 'Drinking Water Salinity and Raised Blood Pressure: Evidence from a Cohort Study in Coastal Bangladesh' (2017) 125 Environmental health perspectives <https://pubmed.ncbi.nlm.nih.gov/28599268/> accessed 16 March 2025.
[28] Peiyue Li and others, 'Sources and Consequences of Groundwater Contamination' (2021) 80 1 <https://doi.org/10.1007/s00244-020-00805-z> accessed 16 March 2025.
[29] Yanxin Wang and others, 'Assessment of the Impact of Geogenic and Climatic Factors on Global Risk of Urinary Stone Disease' (2020) 721 The Science of the total environment <https://pubmed.ncbi.nlm.nih.gov/32172122/> accessed 16 March 2025.
[30] ibid.

Fluoride (F) is essential for bone and teeth health and iodine (I) in proper amounts prevents thyroid associated diseases. However, due to contamination of groundwater and excessive accumulation of F and I have become a public health issue, as it is leading to endemic fluorosis and iodism in such areas.[31] More than 66 million people were reported to be exposed to high amount of fluoride through groundwater and states like Gujarat, Rajasthan and Andhra Pradesh were affected the most as per a 2015 study.[32] Higher concentration of fluoride in water can lead to calcification of teeth enamel and a prolonged exposure to even higher concentration can affect bones and ligaments through diseases like skeletal fluorosis.[33]

Arsenic is a geogenic pollutant which falls under the category of metals and metalloids, it is occurs naturally in rock formation and is commonly found in certain parts of South Asia. The US Environmental Protection Agency (EPA) has ranked Arsenic as Group 1 human carcinogen element. It is considered to be amongst most toxic elements, and a prolonged exposure to it, above the minimum contamination level, can lead to health diseases associated with skin like skin lesions, or cardiovascular problems like high blood pressure, heart diseases, neurological dysfunctions, kidney and bladder cancer, respiratory problems like asthma and bronchitis.[34]

In India, data released by the central government in 2016 stated that around 9.6 million people in West Bengal, 1.6 million in Assam, 1.2 million in Bihar, 50,000 and 13,000 in Uttar Pradesh and Jharkhand respectively were at an imminent risk due to contamination of groundwater with arsenic. All these states fall under the region of Ganga basin.[35] Another study, released in 2021, found that groundwater in approximately 20 percent of India's total landmass

[31] Yanxin Wang and others, 'Genesis of Geogenic Contaminated Groundwater: As, F and I' (2021) 51 Critical Reviews in Environmental Science and Technology 2895 <https://www.tandfonline.com/doi/abs/10.1080/10643389.2020.1807452> accessed 16 March 2025.

[32] Neha Mumtaz, Govind Pandey and Pawan Kumar Labhasetwar, 'Global Fluoride Occurrence, Available Technologies for Fluoride Removal and Electrolytic Defluoridation: A Review' [2015] Critical Reviews in Environmental Science and Technology 00 <https://www.tandfonline.com/doi/abs/10.1080/10643389.2015.1046768> accessed 16 March 2025.

[33] SP Sinha Ray and L Elango, 'Water Governance: Challenges and Prospects' in Amarjit Singh, Dipankar Saha and Avinash Tyagi (eds), *Springer Water* (Springer, Singapore 2019) <https://link.springer.com/chapter/10.1007/978-981-13-2700-1_5> accessed 16 March 2025.

[34] Manoj Kumar Yadav and others, 'Status and Management of Arsenic Pollution in Groundwater: A Comprehensive Appraisal of Recent Global Scenario, Human Health Impacts, Sustainable Field-Scale Treatment Technologies' (2021) 9 Journal of Environmental Chemical Engineering <https://www.researchgate.net/publication/349327138_Status_and_management_of_arsenic_pollution_in_groundwater_A_comprehensive_appraisal_of_recent_global_scenario_human_health_impacts_sustainable_field-scale_treatment_technologies> accessed 16 March 2025.

[35] Mimi Roy, 'Arsenic Poisoning: A Silent Killer in India's Villages' [2024] *Down to Earth* <https://www.downtoearth.org.in/health/arsenic-kills-by-stealth-in-indias-villages> accessed 16 March 2025.

has “toxic level of arsenic” to which more than 250 million people are vulnerable across the country.[36]

Further, Cadmium (Cd), lead (Pb), and mercury (Hg) found in groundwater are amongst the most toxic metals, as they accumulate in the human body due their persistent nature, and once absorbed in human body, they can cause damage to body organs or dysfunction among them.[37] Studies have linked prolonged exposure to Cd to cancers of prostate, lungs and liver in certain areas, along with damage to nervous system and pulmonary and testicular. [38] Lead (Pb) is another organic compound which affects kidney and nervous function, and increases the chances of certain types of cancer and mental retardation. Global data shows that around 26 million have been put at risk because of consumption of water contaminated with lead, particularly in developing countries.[39]

Minamata disease and Itai Itai disease were found in Japan during the 1950s, which caused impairment of visual and hearing senses, numbness in hands and feet, pain in spine and joints, and which led to paralysis, insanity and even death in certain cases. This disease was linked to be caused primarily by consumption of contaminated fish and rice. It was excessive toxicity of mercury (Hg) and cadmium (Cd) which caused these diseases[40].

The interaction of natural processes and anthropogenic disturbances complicates groundwater-related exposure to the essential elements present in it and associated health risks. This underscores the need for establishing guidelines for public health vis-à-vis water quality standard for essential elements in drinking water.

IV. LEGAL FRAMEWORK

Groundwater has for a long time been invisible and under-appreciated by the legislators, as it has been seen separately from surface water and often is unregulated. The jurisprudence of

[36] ‘IIT Kharagpur AI Study Finds 20% Toxic Levels of Arsenic in Groundwater of India - Hindustan Times’ <https://www.hindustantimes.com/education/iit-kharagpur-ai-study-finds-20-toxic-levels-of-arsenic-in-groundwater-of-india-101613043639737.html> accessed 16 March 2025.
[37] Xiangyang Wu and others, ‘A Review of Toxicity and Mechanisms of Individual and Mixtures of Heavy Metals in the Environment’ (2016) 23 Environmental science and pollution research international 8244 <https://pubmed.ncbi.nlm.nih.gov/26965280/> accessed 16 March 2025.
[38] Shakhawat Chowdhury and others, ‘Heavy Metals in Drinking Water: Occurrences, Implications, and Future Needs in Developing Countries’ (2016) 569–570 The Science of the total environment 476 <https://pubmed.ncbi.nlm.nih.gov/27355520/> accessed 16 March 2025; Wu and others (n 36).
[39] Marzie Boskabady and others, ‘The Effect of Environmental Lead Exposure on Human Health and the Contribution of Inflammatory Mechanisms, a Review’ (2018) 120 Environment international 404 <https://pubmed.ncbi.nlm.nih.gov/30125858/> accessed 16 March 2025.
[40] Xie and others (n 5).

groundwater governance in India is influenced by English case laws. In one of the first significant judicial pronouncement for addressing the issue of groundwater was addressed in the case of ***Chasemore v Richards***[41], where the court held that the status of groundwater oozing out of soil beneath the ground is not same as that of flowing water in the streams or rivers, and thus, refused to apply same rules on groundwater and flowing water from rivers and streams. Similarly, in the famous tort law case of ***Acton v Blundell***[42]***,*** absolute ownership of landowner was established, where the court stated that the person who owns the surface has the liberty to dig as per his free will.

These English cases impacted Indian legal system, as in India as well groundwater is considered to be property of the owner who own the land above. As per the ***Indian Easement Act, 1992*** the right over groundwater lies with the landowner. Section 7 of this Act has given uncontrolled rights to land owners *"to collect and dispose within his own limits of all water under the land…".* This creates the problem as ownership of groundwater is attached to land ownership, which on one hand is a private ownership, whereas water is public property, to be regulated by the government. The lack of regulation of groundwater extraction leaves a gap in the legal system, as a land owner can extract as much groundwater as they want and may deplete neighbours' resource as well. In such cases, the only remedy left is people keep digging their wells deeper and deeper, depleting the groundwater resource, which is a public resource in the first place.[43]

One of the plausible reasons for this lack of recognition of groundwater as a separate right is that the Constitution of India did not recognize right to water per se, it was only with development of judicial pronouncements that the right to water was recognised, to be a part of Right to Life under Article 21 of the Constitution of India.[44] In the year 1997, the Supreme Court of India upheld ***Public Trust Doctrine***[45]***,*** according to which the State holds natural resources as a trustee of the people and such resources, like water, rivers, etc, are not to be used as to harm others, rather held under the trust for future generations. Thus, we cannot use them to the extent of depleting them and would have to use them sustainably, which explains another principle of ***intergenerational equity.***

[41] (1859) 7 HLC 349
[42] (1843) 152 ER 1223, 123
[43] B B Katiyar (Revised by justice K Shanmukham), Law of Easement and Licences (Universal Publishing, 13 edn, 2010)
[44] *Attokoya Thangal v. Union of India*, 1990(1) KLT 580
[45] *M C Mehta v. Kamal Nath*, (1997) 1 SCC 388

Addressing the need for a separate authority for regulating groundwater and its management, the Supreme Court directed the Central Government in the case of ***Vellore Citizens***[46] to set up a separate authority for better regulation and control of groundwater management, in lieu of which Central Ground Water Authority (CGWA) was established under the provisions of the Environment Protection Act, 1996. The CGWA has penal powers to take necessary measures and pass directions for preservation of groundwater, and it has been notifying regularly areas where groundwater has been over-exploited and regulations are required. However, the CGWA has been facing issues of under-staffing and limited capacity, which affects coordination among different departments working on resource management.[47]

Model Groundwater Bills

Groundwater under the legal framework is inter woven within its federal framework, and falls under the State List, which means that the States have the authority to manage the water resources, but on the other hand, subjects like agriculture and power, which directly affect the groundwater fall under the Union List of the Seventh Schedule of the Constitution of India. Thus, the state policies and regulations play crucial role in managing water resources. The Central Government, in absence of a central legislation, introduced a ***Model Bill for Groundwater*** in ***1970*** which was subsequently revised from time to time. The earlier framework required a strict regime of registration and licencing for wells. However, due to limited enforcement mechanism, these legislations benefited landowner, whereas landless and marginalised communities were disregarded, reinforcing the pre-existing inequalities.[48] Also, the bill failed to adopt practice of community participation, because of which implementation became quite difficult.

Another Model Bill came in ***2011***, which represented a shift towards prioritizing domestic and drinking needs, and introduced groundwater protection zones and security measures which were useful particularly during droughts and floods.[49] The ***2017 Model Groundwater (Sustainable Management) Bill*** showed more progressive shift as it introduced several other innovative provisions like access to safe drinking water and it applied the public trust doctrine

[46] *Vellore Citizen Welfare Forum v Union of India,* (1996) SC 2715
[47] Anjal Prakash and others, 'Navigating India's Groundwater Crisis: Legal and Institutional Perspectives on Regulation and Conservation' (2024) 26 Water Policy 835 <http://iwaponline.com/wp/article-pdf/26/8/835/1469485/wp2024123.pdf> accessed 17 March 2025.
[48] Himanshu Kulkarni, Mihir Shah and PS Vijay Shankar, 'Shaping the Contours of Groundwater Governance in India' (2015) 4 Journal of Hydrology: Regional Studies 172.
[49] Jenny Grönwall, 'Groundwater Governance in India: Stumbling Blocks for Law and Compliance' (2013) <www.watergovernance.org> accessed 17 March 2025.

to groundwater resources.[50] The approach of this bill was towards collective groundwater rights, as opposed to earlier individualistic approach. Further, it also incorporated environmental law principles like polluter pays principle and precautionary principle.

Aligning with the principles of decentralised governance as provided under 73rd and 74th Constitutional Amendment Act, the 2017 Bill facilitated bottom-up approach in water management.[51] The framework delegated responsibilities and decision making to the lower rung of power structure i.e. the gram panchayats, blocks, municipalities and district administrative units. The Bill suggested for formation of district groundwater council entrusted to coordinate water initiatives between panchayat and municipalities and mandates regular assessments of social and environmental impacts, ensuring transparency and accountability.

In more recent development, ***Atal Bhujal Yojana*** was launched by the government in collaboration with the World Bank in 2020. The scheme, extending across the states of Gujarat, Rajasthan, Madhya Pradesh, Maharashtra, Karnatak and Uttar Pradesh, emphasises on supply-side of the measures, and focuses on aquifer recharge, water harvesting and conservation and sustainable management. A key component of the scheme is use of community participation from grassroot level, attempting to enhance capacity building and monitoring networks for groundwater management, formulating budgets and community driven water management plans. For the demand side interventions, the scheme promotes crop diversification, separate electricity feeders for farmers, and micro-irrigation. However, it is indispensable for groundwater management that we recognise the need to separate land ownership from the underneath water resources, which is still missing from our policies and legal framework. Based on the Mission LiFE, this scheme focuses on behavioural change in communication strategies in order to raise awareness and educate stakeholders, through innovative and divers channels like ***Jal Panchayat*** (earlier used to known as ***Paani Panchayat***), exhibitions, and public awareness campaign.

International Commitment

Various international instruments, which recognise fundamental human rights, are premised on ensuring right to life, health and well-being, which implicitly includes within its

[50] Philippe Cullet, 'Model Groundwater (Sustainable Management) Bill, 2017: A New Paradigm for Groundwater Regulation' (2018) 2 Indian Law Review 263 <https://www.tandfonline.com/doi/abs/10.1080/24730580.2019.1565567> accessed 17 March 2025.

[51] Anjal Prakash and others, 'Navigating India's Groundwater Crisis: Legal and Institutional Perspectives on Regulation and Conservation' [2024] Offiicial Journal of the World Water Council- Water Policy accessed 17 March 2025.

ambit the right to clean and potable water. However, there are international treaties and conventions which recognise varying degrees of right to water. ***Stockholm Declaration, 1972*** amongst the earliest environmental instrument, recognises the right that *"[t]he natural resources of the earth including ... water ... must be safeguarded for the benefit of present and future generations..."*[52].

The ***Action Plan from the United Nations Water Conference*** held in ***Mar del Plata*** in 1977 is a key water related instrument, which acknowledged water as a fundamental right, affirming that everyone has the right to access drinking water in sufficient quality and quantity. Then, the ***Dublin Statement on Water and Sustainable Development***, in 1992 also known as Dublin Principles, under its Principle 4, reiterated access to clean water, at an affordable rate to be*" ...the basic right of all human beings."* ***Agenda 21*** of the Earth Summit, 1992, talked about the right of water to include three aspects of *access, quality and quantity,* adopting an integral approach considering water as a natural resource and a socio-economic commodity for the growth and development of people, whose utilization is dependent on its quality and quantity.

As these international instruments recognise water resource as a fundamental human right, emphasising the need for its sustainable management. It is imperative to note that although none of the instruments discussed the role of groundwater per se, however, the depletion of groundwater threatens the accessibility and quality of water, which in turn is affecting public health. It is vital to implement these principles through national policies in order to safeguard public health and ensure water security for present and future generations.

V. SUSTAINABLE SOLUTIONS

Safe and clean water forms basic human right necessary for health and well-being of people, and Sustainable Development Goal under Goal 6.1 target to achieve it by 2030 as billions of people lack access to safe water, sanitation and hygiene.[53] It aims to *"ensure availability and sustainable management of water and sanitation for all".* The efforts to achieve this goal will have to be quadrupled in order to reach the set goal, in the backdrop of increasing population, urbanisation, industrialisation and climate change, which all are affecting the access to safe drinking water. The SDG Report of 2023[54] argued that in order to

[52] Principle 2 of the Stockholm Declaration
[53] 'Water and Sanitation - United Nations Sustainable Development' <https://www.un.org/sustainabledevelopment/water-and-sanitation/> accessed 16 March 2025.
[54] 'The Sustainable Development Goals Report 2023' (2023).

get on track for achieving Goal 6, we would need to boost invest and capacity-building across various sectors, and most importantly collaboration is necessary among stakeholders, adopting an integrated approach for water management. Access to clean water (clean groundwater sources) is necessary for public health, as it is seen depletion of groundwater is a major threat for public health.

Groundwater governance plays a critical role in addressing the problem of water crisis and its impact of public health. A collective approach with engagement of all stakeholders and participation of community, would help in effective groundwater management. The Food and Agricultural Organization of the United Nations defined enabling framework and guiding principles for groundwater governance,[55] which includes-

- An institutional framework characterised by permanent stakeholder engagement, leadership and sound organization and sufficient capacity,
- Articulate regulatory and legal framework,
- Widely available knowledge, along with awareness of the challenges of sustainability, and
- Plans, policies, and incentive structures which align with goals of society.

Implementing these principles in a collaborative and well-formulated approach will ensure sustainable groundwater management, safeguard both water security as well as public health for future generations.

Public engagement in Groundwater governance

Public engagement is a sustainable option viable in groundwater governance as legal regulations at local level are not denied as such and stakes to conserve and manage groundwater are very high, in this view, decisions coming from bottom-up approach would be more acceptable by society and more effective. While employing public engagement in governance of groundwater, the goal is not just outcome-oriented, but process-oriented. In other words, public engagement will ensure participation of the community in decision making, making sure diverse form of knowledge, experience and vision will come on the plate, and the decisions so taken will be more efficiently implemented as they would be backed by sense of ownership

[55] 'Shared Global Vision for Groundwater Governance 2030- A Call-for-Action' (2016).

and trust.[56] In doing so, a deeper awareness of local water needs will be developed along with accountability. Further, this approach centred around bottom-up decision making for groundwater conservation, encourages a sense of ownership and responsibility among the users of groundwater.[57] One example of this is Haryana, where under the Atal Bhujal Yojana, groundwater governance revolutionised by involving experienced NGOs and adopted this community-led approach and established sustainable groundwater management system takin into account the heterogeneity of the society.

The ***Arnstein's Ladder of Participation*** is an often-used framework to understand the community participation, although it was developed in the context of community planning.[58] The concept of Arnstein categorised participation in eight different level or step of ladder; and as one moves above each step of ladder, the extent of public involvement in decision making increases. In her concept she broadly grouped public-involvement from non-participation of citizen, to tokenism, where participation is only in theory and lastly genuine citizen power, where citizens participate fully in decision making.[59]

The Arnstein Ladder has been adopted in climate discourses to discuss the varying degree of involvement of citizens, from information availability, to stakeholder consultation, cooperation and collaboration with the community to empowerment of society. In case of groundwater governance, the role of community participation is essential, as it makes sure that initiatives are viable, effectively adopted and implemented and the communities gets benefited from them in longer run. Additionally, the democratic principle of governance is applied to the very lower rung of decision making with regard to water management.

Ubuntu Ethos for Sustainable Water Management

The African philosophy of Ubuntu which means *"I am because we are"* was developed by Africans and popularised by then President Nelson Mandela and Archbishop Desmond Tutu. The principle emphasises on collectiveness and interconnectedness, where it is believed that well-being of one depends on well-being of whole community, thus promoting sense of

[56] Lorraine Whitmarsh, Åsa Gerger Swartling and Jill Jäger, 'Participation of Experts and Non-Experts in a Sustainability Assessment of Mobility' (2009) 19 Environmental Policy and Governance 232 <https://onlinelibrary.wiley.com/doi/full/10.1002/eet.513> accessed 16 March 2025.
[57] Nitin Bassi, 'Assessing Potential of Water Rights and Energy Pricing in Making Groundwater Use for Irrigation Sustainable in India' (2014) 16 Water Policy 442.
[58] Sherry R Arnstein, 'A Ladder Of Citizen Participation' (1969) 35 Journal of the American Institute of Planners 216 <https://www.tandfonline.com/doi/abs/10.1080/01944366908977225> accessed 16 March 2025.
[59] Livia Fritz and others, 'Public Engagement for Inclusive and Sustainable Governance of Climate Interventions' (2024) 15 Nature Communications.

collectiveness and shares responsibility in betterment and upliftment of community as a whole. In the face of individualism and pro-industry policy making, this principle of indigenous people focuses on interconnectedness and sustainable development with altruism.

The philosophy of Ubuntu is applied in policy formulation with regard to environment and climate change mitigation strategy. In case of groundwater governance, the principle of ubuntu can be invigorated in the community to develop the sense of collectivism and the idea that decisions reached through consensus at local level will benefit the whole community. In the face of long-standing problem of groundwater depletion and its contamination which is posing a threat to public health, it is necessary to understand that promoting groundwater governance and decision making to ensure water justice is necessary. By inculcating the principle of ubuntu among the society will promote sustainable practices for groundwater conservation and management. Another important aspect of ubuntu principle, which is essential to address the threat of groundwater contamination to public health, is raising awareness and education among people. Ubuntu principles emphasise on raising education and awareness among society so that eco-friendly societies can be build with a touch of humanness. The distinctive character of this principle is that no new legislation, regulation or policy will have to be framed, it is a principle that society can adopt and practice themselves, to respond to the health issues and groundwater depletion, collectively.

VI. MISSION LIFE: BEHAVIOURAL APPROACH TO WATER CONSERVATION

The Prime Minister of India, in the 26th Conference of Parties meeting in 2021 gave launched a global mass movement for community action to preserve and protect the environment, which was named ***Mission LiFE*** or ***Lifestyle for Environment.*** The program aimed at mobilising 1 billion Indians, as well as the global society to adopt sustainable practices in their daily life. The movement is also targeted towards industry and government to nudge them towards sustainable consumption and production and practicing environment-friendly actions.

While Ubuntu Principle and Arnstein ladder focus on collective action, the Mission LiFe, launched by the Ministry of Environment, Forest and Climate Change (MoEFCC), focuses on individual and community actions or brining behavioural changes in our actions to conserve environment. The government document lists a number of actions that can be adopted in order to conserve water, which includes, switching away from water intensive crop like millets, creating rain water harvesting structures in localities like home, offices, schools, using

drip irrigation, etc. Although the initiative of the government is laudable one, however, survey reveals that many people are still unaware of this initiative. With proper promotional campaign and awareness, Mission LiFE would bring great result through behaviour changes in the community by adopting pro-environment lifestyle.

Reviving Gujarat's Water: Story of Innovation and Community Effort

Lunidhar, a village in the Amreli district of Gujarat, faced sever water scarcity due to its arid climate and geographical location. Situated between two tehsils (talukas), the water distribution in the village was uneven and insufficient to fulfil the domestic and irrigation needs of the village. The depletion of water table further aggravated the water crisis in the village, threatening the livelihoods of the local farming communities.

The villagers, understanding the urgency of the situation, with the support of government's soil and water conservation department and with financial aid from industrial donors, sought sustainable solution. With the necessary approvals from the village panchayats, the task of deepening and widening the natural streams and small water courses (nalas) was undertaken by government official on collective request of village people. Additionally, the government agency also constructed around 30 talavs (ponds) and check dams in the village, enabling retention of rainwater after monsoon season and helping in diverting runoffs to groundwater wells. This initiative significantly helped in improving groundwater recharge as water was allowed to slowly seep into the ground and facilitated in the replenishment of supply of groundwater.

Encouraged by this success, the village people further expanded their efforts towards agroforestry in collaboration with gram panchayat. The panchayat contributed land for plantation and with financial aid from Surat based business trusts, facilitated the initiative the village green and self-sufficient. Villagers actively engaged in afforestation efforts, which resulted in over-all socio-economic upliftment of the community, as the agricultural productivity increased, better employment opportunity came and education became accessible for children.

The remarkable achievements of the community, spearheaded by ***Mr Bharatbhai Vegad*** of the village, garnered recognition from the Forest Department and Irrigation Department of Gujarat. His efforts and leadership were further acknowledged when he received award from then Chief Minister of Gujarat, Mr Narendra Modi.

The success story of the village Lunidhar, showcases the power of community action and engagement of all stakeholders in rainwater harvesting and sustainable water management. Through collective action, the villagers of Lunidhar not just conserved water in an arid region but also were able to transform their landscape into a greener and prosperous environment.

VII. CONCLUSION

For a country like India, on path of becoming a developed nation, water security is an essential issue in this age when global warming has set in and climate change is the reality of the day. India being most populated country of the world, the pressure on its natural resources is higher and providing accessibility of these resources is imperative for the growth of our society. Water is the lifeline of our social and economic life, especially for India whose economy is agriculture dominated and major irrigation needs are met through groundwater. Over-exploitation of the groundwater resources is leading not just to depletion of it, but at the same time contamination of groundwater resources. It is well documented that contaminated groundwater, when comes in close contact with people, through ingestion or through entering the food chain, impacted their health with diseases like kidney stones, cardio vascular diseases, respiratory and skin diseases, and certain types of cancer. Additionally, pollutants introduced in the groundwater through anthropogenic activities and emerging contaminants are another reason for threat to public health.

Groundwater has long been a hidden resource, underneath surface and absent from clear legislative framework. Its regulation through legislation is also complicated because of its deep connection with land ownership, making groundwater governance elusive and leaving it vulnerable to unchecked exploitation. International principles like Arnstein Ladder and Ubuntu Principle emphasise the importance and positive outcomes of participatory approach. In light of this, following a bottom-up approach for regulating groundwater, with a participatory approach by making behavioural changes in the community has been proven successful in some area. This model of community engagement can be adopted across the nation for better regulation of groundwater resource. Public participation in groundwater governance will ensure that informed decisions are taken that are in favour of the local communities, and decision taken by local communities will make foster a sense of ownership and enhanced accountability. By ensuring the ethos of democracy in groundwater governance is not just an environmental necessity, but a fundamental step towards securing public health sustainable development.