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SUSTAINABLE GROUNDWATER MANAGEMENT: EVALUATING LEGAL FRAMEWORK AND CHALLENGES

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ABSTRACT

Groundwater is an essential resource for agriculture, drinking water, and industrial use, especially in water-scarce regions like India. However, unsustainable extraction, pollution, and a fragmented regulatory framework have resulted in significant groundwater depletion and contamination. This article presents a comprehensive analysis of the legal framework governing groundwater management in India, with a specific focus on its alignment with principles of sustainability and the challenges encountered in achieving Sustainable Development Goal 6 (Clean Water and Sanitation). The paper evaluates national and state-level laws, including the 2017 Model Groundwater Bill, and assesses the effectiveness of institutional mechanisms such as the Central Ground Water Authority (CGWA). The study also explores the role of judicial interventions in shaping groundwater governance and presents policy recommendations aimed at promoting sustainable groundwater use, ensuring equitable access, and protecting groundwater-dependent ecosystems. In doing so, the article emphasizes the need for an integrated approach that combines legal reforms and community-driven initiatives to safeguard groundwater resources for future generations.

Keywords: Groundwater, Groundwater Management, Polluter Pay Principle

1. INTRODUCTION

Water is a fundamental component of the existence of life, as a living body is made of water. Though water is a renewable resource, its availability and quality vary from place to place. Globally, 2 billion individuals (26% of the population) lack access to safe drinking water, and 3.6 billion people (46%) do not have access to safely managed sanitation. Annually, between two and three billion individuals face water shortages for at least one month (UNESCO, 2024). The increasing human population haphazard anthropological activities and climate extreme not only affected the water availability per person but also stressed the entire environmental system. According to the study "Reassessment of Water Availability in India using Space Inputs, 2019" by the Central Water Commission, the projected average annual per capita water availability for the years 2021 and 2031 is 1486 cubic meters and 1367 cubic meters, respectively. An

annual per capita water availability below 1700 cubic meters is deemed a water-stressed condition, while availability under 1000 cubic meters is classified as a water scarcity condition(CWC, 2019).

Groundwater is a valuable resource worldwide, especially in areas where surface water is scarce or inaccessible. Many of the world's largest cities, as well as many smaller towns, depend on groundwater as their primary source of fresh water. This dependence is expected to grow, especially in the swiftly urbanizing regions of developing nations and emerging economies (UNESCO, 2023). The contribution of groundwater is nearly 62% in irrigation, 85% in rural water supply, and 50% in urban water supply (CGWB, 2022). According to National Compilation on Dynamic Ground Water Resources of India 2023, the status of groundwater in 73 percent of blocks in India is safe, 11 percent semi-critical, 3 percent critical, 11 percent over-exploited and 2 percent saline (CGWB, 2023). Groundwater is an annually replenishable resource but its availability is non-uniform in space and time. In the past few decades, human activities have impacted water availability, both indirectly through alterations in rainfall patterns due to anthropogenic climate change, and directly via overconsumption (Scanlon et al., 2023). These impacts include changes in groundwater recharge, discharge, flow, storage, and distribution. The significance of groundwater is often underrepresented in water legislation, which predominantly concentrates on surface water (Cullet, 2018). The existing statutory frameworks for groundwater are confined to laws enacted in the last two decades, which primarily establish a level of top-down regulatory control over groundwater usage but fail to offer a comprehensive regulatory framework. Moreover, these laws do not address the fundamental rights framework governing access to groundwater (Cullet, 2018). Hence, the sustainable development of groundwater resources is needed, this could done through a legal framework.

This article examines the intricate relationship between groundwater management and legal frameworks. Through an analysis of historical context, current laws, and challenges in groundwater management, this article aims to underscore the path toward sustainable groundwater usage.

2. CONCEPT OF SUSTAINABLE GROUNDWATER MANAGEMENT

According to the United Nations Brundtland Commission, sustainable development is defined as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs" (Kono, 2014). Thus sustainable groundwater management may be understood as the regulation of extraction and use of groundwater in such a way that it meets the needs of the present population and also preserves it for the future generation. Sustainable groundwater management involves a balance between extraction and recharge of groundwater, protecting the groundwater from contamination, and equitable access to groundwater

2.1. MEANING OF GROUNDWATER

For the purpose of law, it is important to define the groundwater. The legal systems of different countries define it differently. A narrow definition can limit the scope of the law constraining its reach and an overbroad could complicate the administration of the law.

The groundwater may be defined along several dimensions whether it includes naturally stored water or artificially stored water using managed aquifer recharge or both; whether there is a depth limit of groundwater; whether the definition includes water in the unsaturated zone, as well as in the saturated zone of the soil profile and whether it distinguishes between percolating groundwater and underground streams.

In India, groundwater management is the subject matter of states according to the seventh schedule of the Constitution of India. However, to ensure uniformity of law among all states for groundwater management central government has made a model bill called the Model Groundwater (Sustainable Management) Act, 2017. The Bill defines 'Groundwater" as "water occurring in its natural state, where it exists below the surface in the zone of saturation whereby it can be extracted through wells or any other means or emerges as springs and base flows in streams and rivers. In its natural state, it is a common pool resource" (Model Groundwater Bill, 2017, § 2(1) (f)). According to the Bihar Ground Water (Regulation and Control of Development and Management) Act, 2006, "Ground Water means the water which exists below the ground surface in the zone of saturation and can be extracted through wells or any other means or emerges as springs and base flows in streams and rivers" (Bihar Ground Water Act, 2006, § 2(1) (f)).

2.2. MEANING OF AQUIFER

The term aquifer literally means “water bearer”. Aquifers are the sub-surface underground layers of gravel, permeable rocks, or sand-bearing water. This water has soaked down through the soil until it reaches impermeable or waterproof rock. This underground water can slowly flow through the pores of permeable rock along the impermeable barrier until it reaches a lake’s bed, or seashore, or it may even flow into the shadow of a river. The layer of impermeable rock usually is bowl-like, where the flow of water would be prevented, forcing it off or man underwater lake of saturated stony material (Kalappa & Khan, 2021, p. 90).

2.3. SUSTAINABLE DEVELOPMENT GOAL

Groundwater management is closely tied to Sustainable Development Goal 6 (SDG 6), which aims to "ensure availability and sustainable management of water and sanitation for all. SDG 6 is dedicated to ensuring the availability and sustainable management of water and sanitation for everyone by 2030. Groundwater management is essential for achieving SDG 6. Effective management involves sustainable use, quality monitoring, community participation, and integrated water resources management. Under SDG 6, groundwater sustainability contributes to substantially increasing water-use efficiency and ensuring sustainable withdrawals (Target 6.4); implementing integrated water resources management at all levels (Target 6.5); and protecting and restoring water-related ecosystems, including aquifers (Target 6.6) (*Sustainable Development Goals (SDG 6)*, n.d.).

3. LEGAL FRAMEWORK FOR GROUNDWATER MANAGEMENT IN INDIA

The present legal framework for Groundwater water management includes common laws principles, the Constitution of India, the national and state level statutes, national water policy and environmental law principles.

3.1. COMMON LAW PRINCIPALS

According to Article 372 of the Constitution of India, all the pre-constitutional laws are enforced in the territory of India until altered, repealed or amended by a competent legislature or authority. The State legislatures in India are the competent authority to make laws related to groundwater. Some states have enacted laws to regulate groundwater and the common law is still applicable in states where specific statutes are not made. Under the Common Law principle, groundwater is considered as chattel attached to the land (Roath v. Driscoll, 1850). Furthermore, groundwater is considered distinct from surface water, so the principles and doctrines regarding surface water do not apply to groundwater (Acton v. Blundell, 1843). Common law has subsequently acknowledged the landowner's inherent rights to groundwater, or water located beneath the surface of their land. Under this doctrine, the right to extract groundwater is not separate but is considered incidental to the right of ownership of the land above. The common law doctrine that grants a landowner the right to extract groundwater does come with certain obligations and liabilities towards the interests of neighbouring owners. This right must be exercised according to a "reasonable test," which is less stringent than that for surface water. Thus, the principle of reasonable use is an integral part of the common law doctrine (Chasemore v. Richards, 1859).

The ownership of groundwater is a highly emotional issue: it is intimately linked to land ownership, yet it is also crucial for public water supply systems and for sustaining ecosystems that have significant public importance. In certain areas, groundwater has traditionally been subject to different ownership and allocation rules compared to surface water. This is due to its less apparent flow path, which is sometimes considered "secret" and "unknowable" (Nelson & Quevauviller, 2016, p. 176). Groundwater is subject to different treatment than surface water. Traditionally, groundwater rights have been closely linked with land ownership rights. This principle was founded on the common-law concept of "absolute dominion," which holds that groundwater is an integral part of the land, not subject to separate ownership. Historically, landowners had the right to manage, control, and utilise the groundwater beneath their property.

The Indian Easements Act of 1882, still active in India, grants landowners the right to collect and dispose of water found beneath their land, provided it does not flow in a defined channel (Indian Easements Act, 1882, § 7(g)). However, the Act only specifies "user" or "easementary" rights concerning groundwater, without conferring ownership rights (Koonan, 2022, p. 48). These rights are also supported by other legislation, such as the Transfer of Property Act of 1882,

which acknowledges a landowner's rights to groundwater under the principle of absolute dominion. Due to the inherent nature of groundwater, its rights cannot be transferred separately from the land.

Consequently, landowners possess unconditional and exclusive rights to extract and utilize groundwater, despite the absence of formal ownership rights. These user rights are extensive, permitting unrestricted use of groundwater and excluding others. For instance, a landowner is entitled to construct a well and solely use its water. Additionally, there are no restrictions on the volume of water one can extract, allowing a landowner to draw significant quantities from their property without repercussions, even if it disrupts the water supply to neighbouring areas.

Linking land ownership directly to groundwater rights exacerbates social and economic disparities in India by denying landless individuals access to groundwater. This privatization of user rights undermines the protection of groundwater as a shared public asset, contravening the fundamental right to water, which is integral to the right to life as enshrined in the Indian Constitution. Moreover, these rights are antiquated when viewed against contemporary environmental law principles such as public trust, the "polluter pays" rule, and the precautionary principle (Cullet, 2019).

3.2. CONSTITUTIONAL PROVISIONS

The Constitution of India, 1950 designates "Water" as a state subject, with states having the authority to legislate on water-related issues. According to Entry 17 of the State List, states have the power to regulate water supplies, irrigation, canals, drainage, embankments, water storage, and water power. However, the central government does have a role in regulating, developing, and using inter-state rivers. Entry 56 of the Union list grants the centre the authority to regulate and develop inter-state rivers and river valleys in the public interest as declared by Parliament.

While India's Constitution does not explicitly recognize a human right to water. The fundamental right to life, as guaranteed by Article 21, has significantly broadened over recent decades. The higher judiciary in India has interpreted Article 21 expansively to encompass new rights, including the right to livelihood, food, and health. These interpretations are particularly pertinent to groundwater rights. The acknowledgement of the fundamental right to water and the right to a pollution-free environment are key developments that directly impact the legal framework governing groundwater. These human rights are crucial in re-evaluating the traditional view that the right to groundwater is an extension of land rights.

In the famous case *of Subhash Kumar v State of Bihar*, the Right to live was recognized as a fundamental right. Along with this, the right to live in a pollution-free environment and the right to full enjoyment of one's life was also recognized as part of Article 21 (Subhash Kumar v. State of Bihar, 1991).

Since 1996, the Supreme Court started applying the Public Trust Doctrine in deciding disputes having environmental importance. The doctrine is of Roman origin and is based on the basic principle that the Government is the proprietor of certain important resources like rivers, shores, etc. in trusteeship for the citizens. In *M C Mehta v. Kamal Nath*, the Supreme Court of India applied this doctrine in the year 1996 and held that the trustee cannot convert the resources for private use as it is a public trust. It was further held that the State is a trustee and has a legal duty to protect natural resources for the public good (M.C. Mehta v. Kamal Nath, 1997).

In pursuance of Supreme Court's orders in a number of cases since 1996, the court directed for establishment of a separate Central Groundwater Authority under the provisions of the Environment

Protection Act 1986. The purpose of setting up such a separate authority was to better regulate and control groundwater management. Further, in a landmark decision of *Vellore Citizens*, the Supreme Court directed the Central Government to constitute CGWA under the provision of the Environment Protection Act 1996. (Vellore Citizen Welfare Forum v. Union of India, 1996)

Additionally, Article 47 requires the state to enhance nutrition and living standards, which includes improving public health through the provision of potable water. Citizens also have a fundamental duty under Article 51A, clause (g), to preserve and improve the natural environment and show compassion for living creatures.

3.3. LEGISLATIVE PROVISIONS

The origins of India's environmental law can be traced back to the Stockholm United Nations Conference on Human Environment of 1972, in which India participated. There was a growing realization within the political establishment that a legal framework was required to address environmental hazards, especially as India was undergoing rapid economic development. Prior to this, India's environmental law was primarily based on tortious actions such as nuisance or negligence. The law concerning the environment has developed through legislative and judicial initiatives (Manjula & Kabra, 2021, p. 82). The Water (Prevention & Control of Pollution) Act, 1974, is relevant as its main aim is to prevent and control water pollution, encompassing groundwater pollution. It provides for the establishment of central and state pollution control boards to lay down standards of effluent discharge and perform other functions. The Environment (Protection) Act of 1986 authorizes the central government, via the Ministry of Environment, Forest & Climate Change, to enact measures for environmental protection and enhancement. This encompasses establishing criteria for releasing domestic and industrial effluents into aquatic ecosystems, including groundwater. Additionally, the Ministry has implemented the Environmental Impact Assessment Notification of 2006 and the Coastal Regulation Zone Notification of 2011, which both include guidelines for the treatment and discharge of effluents into groundwater (Cullet et al., 2017). The Environment (Protection) Act of 1986 authorizes the central government, via the Ministry of Environment, Forest & Climate Change, to enact measures for environmental protection and enhancement. This encompasses establishing criteria for releasing domestic and industrial effluents into aquatic ecosystems, including groundwater. Additionally, the Ministry has implemented the Environmental Impact Assessment Notification of 2006 and the Coastal Regulation Zone Notification of 2011, which both include guidelines for the treatment and discharge of effluents into groundwater. It also set up the Central Ground Water Authority (CGWA), a key institution for groundwater management (Cullet et al., 2017).

3.1.1. IMPORTANT PROVISIONS IN THE MODEL GROUNDWATER (SUSTAINABLE MANAGEMENT) BILL, 2017

The Central Government prepares Model Bills related to groundwater management for enactment and implementation by the state governments. The first Model Bill was passed in 1970 and was updated in 1992, 1996, 2005 and 2011. The initial Bill aimed at empowering state governments to restrict the installation of new groundwater extraction methods. It was unsuccessful due to a lack of cooperation from the state governments and a top-down regulation system that introduced control on groundwater usage by individual owners but did not account for the need for aquifer-level protection measures. The subsequent revisions focused on including groundwater used for drinking and domestic purposes, exempting small and marginal farmers from obtaining permits, rainwater harvesting for groundwater replenishment, and mandating the creation of groundwater authorities under the state governments. Even with these revisions, the Bill failed to achieve the targets (CGWB, 2008).

The Model Groundwater (Sustainable Management) Bill, 2017 aims at integrating surface and groundwater management, aquifer conservation and developing a bottom-up regulation framework. It addresses issues such as the nexus between water management and food security, different regulations for different groundwater use, and the right to water, health and environment of the citizens. This Bill is a first step in the right direction for groundwater management, as it has a more holistic approach to groundwater conservation and would give more power to the local authorities to choose groundwater preservation techniques. The latter feature can boost the participation of local authorities in groundwater conservation (Cullet, 2018).

3.3.1.1. REGULATION OF THE EXTRACTION OF GROUNDWATER.

As previously mentioned, the management of groundwater falls under the jurisdiction of states in India. However, the Groundwater (Sustainable Management) Bill of 2017, drafted by the Ministry of Water Resources, River Development & Ganga Rejuvenation, presents a new framework for states to create laws addressing the rapidly growing groundwater crisis. The objective of the Bill is to establish a framework for regulating groundwater at the state level, tailored to the needs of a nation heavily dependent on groundwater. The 2017 Bill strengthens existing institutions and introduces a framework based on decentralization and subsidiarity. It mandates that all local authorities, including panchayats and municipalities, set up a dedicated committee for groundwater management. In rural areas, this committee operates as an extension of the Village Water and Sanitation Committee, while urban areas are required to form a Municipal Water Management Committee (Model Groundwater Bill, 2017). The 2017 Bill establishes a multi-tier institutional framework

at the Block, District, and State levels. Higher-level institutions are responsible for coordinating actions taken at lower levels and making decisions on issues that require coordination among more localized institutions. For instance, the District Groundwater Council is tasked with integrating groundwater security plans from panchayats and municipalities into a comprehensive District Groundwater Security Plan. Chapter IX specifically addresses the use of groundwater for industries and infrastructure. The 2017 Bill mandates that such usage requires authorization from the relevant government authority, which is valid for a period of five years.

3.3.1.2. INCORPORATION ENVIRONMENT LAW PRINCIPLES IN THE MODEL BILL OF 2017

The 2017 Groundwater Bill expands the public trust doctrine to encompass groundwater, reflecting a worldwide movement. For more than twenty years, the higher judiciary has set forth the principles governing surface water rights, starting with a pivotal ruling in 1996. Currently, the notion of granting groundwater the same recognition is fundamentally uncontested. The Supreme Court has acknowledged groundwater as part of the public trust doctrine in at least one case, despite the case not being centred on water issues.

The acknowledgement of groundwater as a public trust marks a significant shift in a scenario where, for many years, it has been regarded as a private domain of landowners. Concurrently, this acknowledgement will not affect land rights as such, and landowners will continue to have primary control over groundwater access. The principal change in practice will be that regulations will initially consider the aquifer's conservation needs rather than solely the separate needs of each landowner. Moreover, this will allow for the incorporation of a community aspect into the management and utilization of aquifers, an element that has been entirely absent until this point (Cullet, 2018). Groundwater is deemed a shared heritage, intended for communal use. It is not subject to private ownership by states, communities, or individuals in its natural form. This embodies the public trust doctrine, ensuring groundwater is preserved for public use and safeguarded by reasonable limitations to uphold the essential right to water for life.

The Groundwater Bill of 2017 introduces protection principles that have long been applied in environmental law for the first time. This includes the prevention principle, which states that foreseeable environmental damage should be prevented rather than remedied through compensation after the fact. This principle was previously not standardized in water law. Additionally, the Bill explicitly incorporates the precautionary principle and the polluter pays principle, thereby providing groundwater regulation with a robust environmental framework.

The Bill seeks to logically integrate core elements into its regulatory framework, proposing that groundwater regulation be based on the subsidiarity principle, as advocated by the Draft National Water Framework Bill of 2016. This approach aligns with the concept of groundwater as a public trust, resulting in a regulatory framework that revolves around a bottom-up institutional structure. In this structure, each governmental level is expected to serve as a trustee, managing groundwater at their respective level (Cullet, 2018). The Bill of 2017 explicitly states that drinking water is to be given the highest priority over other competing uses of groundwater (Model Groundwater Bill, 2017). The Bill advances the cause by linking the right to water with the fulfilment of other fundamental rights, specifically the rights to food, health, and the environment.

The government should guarantee fair distribution and utilization of groundwater in the public's interest, with an emphasis on fostering environmental principles and acknowledging that sustainable practices are vital for the resource's longevity (Model Groundwater Bill, 2017). The government is also responsible for ensuring that groundwater usage by any individual does not violate the rights of others, particularly those reliant on the same aquifer for their basic water needs. This clause underscores the importance of meticulous management to avert excessive withdrawal or inequitable allocation that could impede others' groundwater access (Model Groundwater Bill, 2017).

3.3.1.3. PRIORITIZATION OF GROUNDWATER USE

The prioritization of groundwater use emphasizes that the highest priority for groundwater allocation is to meet the fundamental right to water for life. After meeting this need, groundwater should be used to achieve food security, support sustainable agriculture, and livelihoods, and maintain ecosystem needs. The appropriate government is responsible for allocating groundwater among these priorities, taking into account local conditions such as climate, land and soil characteristics, water availability and quality, existing activities, livelihoods, and land-use patterns. Any remaining groundwater, after addressing these essential priorities, should be allocated for other uses in a manner that

promotes conservation and efficient use of the resource. These uses must also be consistent with the objective of sustaining aquifers and ecosystems, which are vital for the long-term maintenance of groundwater resources (Model Groundwater Bill, 2017).

3.3.1.4. GROUNDWATER SECURITY PLAN

The Bill 2017 outlines a comprehensive framework for the preparation and implementation of Groundwater Security Plans. The government is responsible for developing these plans in consultation with local bodies and relevant institutions, ensuring a collaborative approach. The primary objectives of these plans are to guarantee sufficient safe water for all individuals, maintain water security during emergencies such as droughts and floods, and improve groundwater quality. These plans are to be prepared at the lowest administrative level, integrating inputs from all relevant authorities, especially when an aquifer spans multiple jurisdictions. Additionally, plans are required for every watershed or administrative unit, particularly those within designated groundwater protection zones. Once prepared, the Groundwater Security Plans must be formally adopted and notified by the government. These plans become binding upon notification and remain valid for five years, after which they must be revalidated or amended. This structured and inclusive approach ensures sustainable groundwater management, adapting to changing conditions and securing water resources for future generations (Model Groundwater Bill, 2017).

3.3.1.5. INSTITUTIONAL FRAMEWORK UNDER THE MODEL BILL OF 2017

The Groundwater Model Bill of 2017 sets out a detailed framework for managing and safeguarding groundwater resources at different levels of administration. It requires the establishment of Groundwater Sub-Committees at the Gram Panchayat level, with responsibilities such as assessing the minimum water quantity needed for sustenance, creating and obtaining approval for the Panchayat Groundwater Security Plan, and ensuring that groundwater use respects the rights of others. These sub-committees are also responsible for well registration and collecting data on local water-related activities (Model Groundwater Bill, 2017).

At the Block Panchayat level, the integration of groundwater management occurs within existing water-related committees. Their duties include consolidating the groundwater security plans of Gram Panchayats into an overarching Block Groundwater Security Plan, facilitating planning among panchayats sharing aquifers, and overseeing plan execution to ensure efficient groundwater management. (Model Groundwater Bill, 2017)

Municipalities establish a Municipal Water Management Committee to integrate groundwater management into city planning. The committee is responsible for allocating water resources, developing and implementing a Municipal Groundwater Security Plan, and designating groundwater conservation areas. (Model Groundwater Bill, 2017)

The District Groundwater Council, led by the District Magistrate, plays a key role in combining rural and urban plans into a unified District Groundwater Security Plan. The council's duties involve harmonizing plans from various panchayats and municipalities, identifying cross-jurisdictional protection zones, and ensuring a coordinated and supportive approach to groundwater management throughout the district. (Model Groundwater Bill, 2017)

At the state level, the State Groundwater Advisory Council is established, either as a new entity or by expanding the existing State Groundwater Authority or Water Board. (Model Groundwater Bill, 2017)

3.3.2. STATE-LEVEL GROUNDWATER LEGISLATION:

The Central Government prepares Model Bills related to groundwater management for enactment and implementation. Several states in India have enacted their own groundwater legislation to regulate the extraction and management of groundwater. Bihar has enacted its own legislation to address groundwater management. The Bihar Groundwater (Regulation and Control of Development and Management) Act, 2006 serves as the primary legal instrument for regulating groundwater resources in the state. The Act aims to regulate and control the development and management of groundwater in Bihar. The Act establishes a groundwater authority, which is responsible for regulating and controlling the development and management of groundwater in Bihar. The authority has the power to grant permits to extract and use groundwater in notified areas, register existing users in notified areas, register drilling agencies, alter, amend or vary the terms of permits/certifications of registration, cancel permits/certifications of registration, and more. The Act also includes provisions for rainwater harvesting for groundwater recharge.

4. CHALLENGES IN GROUNDWATER MANAGEMENT

4.1. OVER-DEPENDENCE AND EXPLOITATION OF GROUNDWATER

In several regions, the limited availability of groundwater is a significant challenge. The excessive extraction of groundwater for agriculture, industry, and domestic purposes is depleting aquifers at a faster rate than they can naturally replenish. Out of a total of 6,553 assessment units (Blocks/Mandals/Talukas) in the country, 736 units across various States/UTs (11.23%) are classified as 'Over-exploited,' indicating that groundwater extraction surpasses the annually replenishable groundwater recharge. Additionally, 199 units (3.04%) are at a groundwater extraction stage of 90-100% and are categorized as 'Critical.' Furthermore, there are 698 (10.65%) 'Semi-critical' units, where groundwater extraction is between 70% and 90%(CGWB, 2023).

4.2. CONTAMINATION OF GROUNDWATER

Groundwater contamination from both geogenic and anthropogenic sources is reported in various parts of the country. Geogenic contamination, especially that caused by high fluoride and high arsenic, is widely reported. Arsenic contamination is especially critical due to its carcinogenic nature and the dense population in the affected areas. Fertilizers used in agriculture, along with insecticides and pesticides, are additional factors that pollute groundwater. The Public Health Engineering Department of the Bihar Government has reported that drinking water sources in rural areas are not safe for consumption, leading to dire health consequences for the rural populace. Thirteen districts along the Ganges River suffer from arsenic contamination, which is severe in Bihar. Excessive arsenic in drinking water is linked to various health problems, including cancer and reproductive issues. The National Green Tribunal has discovered that groundwater in approximately 40% of Bihar's districts contains arsenic, primarily due to natural geological conditions, exacerbated by excessive groundwater extraction (Manu, 2021).

4.3. CLIMATE CHANGE

Groundwater is typically managed and regulated at the local level, as it is usually accessed directly from the aquifer and utilized locally. However, climate change has a direct impact on groundwater, as the rainfall that recharges most aquifers is becoming increasingly unpredictable. The increasing exploitation of groundwater leads to the depletion of aquifers and increases the vulnerability of dependent ecosystems to the adverse effects of climate change (Cullet et al., 2017).

4.4. INSTITUTIONAL AND LEGAL GAPS

The effectiveness of groundwater management can be hindered by insufficient legal frameworks, lack of enforcement, and limited institutional capacity. Strong legal frameworks and governance structures are necessary for effective groundwater management. The existing laws of states, which are mostly based on the model bill for groundwater regulation of 2005, propose a top-down approach that emphasizes new controls on groundwater usage by individual landowners. However, these laws completely overlook the necessity for measures that protect aquifers at the aquifer level (Cullet, 2018, p. 269). The approach overlooks the fact that the term 'users' includes almost every individual in an area, not just landowners, and therefore doesn't consider the fairness of groundwater usage. Additionally, it doesn't take into account the difficulty of regulating over 30 million mechanized water extraction devices only through centralized state-level actions. The Central Ground Water Authority (CGWA), established under the Environment (Protection) Act of 1986, has emerged as the most prominent entity for groundwater regulatory interventions in India. This prominence is not due to a broad mandate for protecting and regulating water but largely because there has been minimal activity at the state level (Cullet, 2018, p. 270).

4.5. PUBLIC AWARENESS AND ENGAGEMENT

Involving the community and raising awareness about sustainable groundwater usage is essential. Encouraging public participation in decision-making processes can result in more effective management strategies. It's vital to link groundwater usage to user responsibilities, acknowledging that all users, particularly large-scale ones, have an obligation to prevent waste and contamination, conserve resources, and support replenishment efforts, for instance, through afforestation or reforestation.

5. CONCLUSION

Groundwater is vital for the existence of life, yet it is a frequently neglected resource. The evaluation of the legal framework and challenges associated with sustainable groundwater management reveals a complex interplay of regulatory, environmental, and socio-economic factors. The existing legal provisions, while comprehensive in scope, often fall short in practical implementation due to inadequate enforcement mechanisms and limited community engagement.

There is a need for the integration of traditional knowledge with modern legal frameworks for effective groundwater management strategies. Policymakers must prioritize adaptive legal measures that can respond to the dynamic nature of groundwater resources and the impacts of climate change. There is also a need to limit the unrestricted right to extract groundwater of landowners. There is also a need for an integrated plan for groundwater and surface water management. By doing so, we can move towards a more sustainable and equitable management of groundwater resources, ensuring their availability for future generations. The state government should adopt the provisions of the Model Bill of 2017. To achieve sustainable groundwater management, it is essential to adopt a holistic strategy that aligns regulatory mechanisms with local realities. This includes incentivizing conservation practices, strengthening enforcement mechanisms, and promoting public awareness about the importance of groundwater preservation.

CONFLICT OF INTERESTS

None.

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