A CRITICAL REVIEW OF INDIA'S LATEST GROUNDWATER POLICY: IMPACTS ON GROUNDWATER RESOURCE PLANNING AND MANAGEMENT

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ABSTRACT

Groundwater policy is widely considered an essential element for building effective groundwater use and carrying out the country's groundwater resources planning and management. This review first of its kind which gives extensive information about groundwater policy at the national and state level in India. This review focuses on the new national-level groundwater policy of India and discusses the salient features of groundwater policy for selected countries. Based on the ongoing challenges of groundwater issues in India, the benefits and drawbacks are described, making the future decision-making process easier and more efficient when contemplating regulation and known groundwater challenges. Considering the new provisions and the ongoing challenges, this paper discusses gaps in policy and its effects on the overall sustainability of groundwater resources. Our findings provide insight into the new national-level groundwater policy and outline limitations in areas such as the agricultural sector, land subsidence, cross-border conditions, climate change, information dissemination, groundwater and surface water connectivity, etc. that need urgent attention.

Keywords: Groundwater; Groundwater policy; India; Planning and Management; Sustainable development.

INTRODUCTION

Groundwater is the main source of water in India for domestic, industrial, and agricultural sectors. India is the largest groundwater user globally which comprises 239 km^3 per year approximately. Out of the total groundwater use in India, the agriculture sector uses 222 km^3 (89.15 %) of groundwater (CGWB, 2021). Based on the status of groundwater extraction, the Central Ground Water Board (CGWB), an apex agency that regulates and manages groundwater in India, classifies four types of assessment units in India. The CGWB classifies the groundwater assessment unit into four categories that include "safe", where the development of groundwater is possible; "Semi-critical" units, where groundwater development is allowed which is subject to caution; " Critical" area; and "Over-exploited" units, where there should be intensive monitoring and evaluation, and where any future groundwater development should be linked to water conservation measures. In a recent report by CGWB (2022), 1006 units in India constitute nearly 14 % of the total assessed units

in India fall under the Over-exploited category. These Over-exploited units are located in the northwestern part of the country including parts of Punjab, Haryana, Delhi, and western Uttar Pradesh, the western part of the country, particularly in states of Rajasthan and Gujarat, and the southern parts of peninsular India cover portion of the states of Karnataka, Tamil Nadu, Telangana, and Andhra Pradesh. As the groundwater extraction scenario will continue for a long time, the issue of groundwater sustainability will be a major concern in several regions of India. Therefore, groundwater management strategies in those regions of India must balance water with effective regulation policy to achieve sustainable groundwater goals.

The central government agencies under the Ministry of Jal Shakti (Ministry of Water Resources), Government of India are primarily responsible for groundwater planning and management. To balance the use of groundwater and the sustainability of groundwater in the country, the government has introduced several schemes from time to time. Some of those ongoing schemes comprise Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Har Khet Ko Pani (HKKP), Ground Water Irrigation (GWI), etc. The Ministry of Jal Shakti (Ministry of Water Resources), Government of India manages the groundwater components of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) including other schemes. The Ministry of Jal Shakti initiated the "Jal Kranti Abhiyan", and "Jal Jeevan Mission" which aim to coordinate national water management and conservation. To manage sustainable groundwater resources in India, CGWB is implementing a nationwide framework called the National Aquifer Mapping and Management Program (NAQUIM). In addition, Amrit Sarovar, a Rainwater Harvesting scheme, and a managed aquifer recharge (MAR) program which is one of the most deliberate ways to recharge aquifers are some of the ongoing programs in many parts of India.

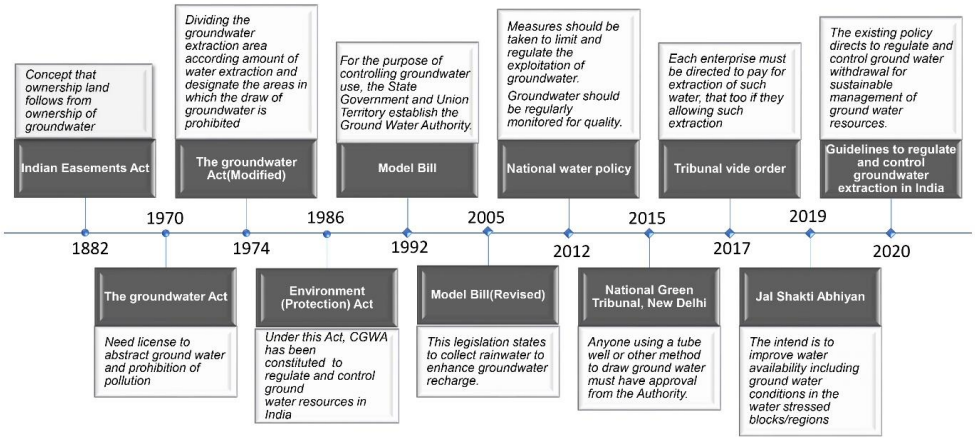
To regulate groundwater in India, some policies were made but were not feasible given the rate of demand and utilization. The Indian Easements Act of 1882 was probably the first documented policy that mentioned groundwater regulations. The Indian Easement Act of 1882 gave the landowner the right to use water on and below the surface of the land (MLJ, 1882). From 1882 to 1970 there were negligible changes in groundwater regulation policy in India. Since 1970 there has been a series of policy changes, including the Ground Water Act 1970, which was further amended in 1974, the Environment (Protection) Act 1986, the Model Bill 1992, and other policies (Fig. 1). The model bill was the threshold point that gave states in India powers to control and regulate groundwater. After the Model Bill 1992, some states and union territories of India like Tamil Nadu, Lakshadweep, Kerala, Goa, Puducherry, Himachal Pradesh, Jammu and Kashmir, Karnataka etc. came up with groundwater policies. To better regulate and control groundwater in India, the Ministry of Jal Shakti under the government of India issued a new groundwater policy in September 2020.

Previous policies have focused on regulating groundwater but have been limited to a few states and union territories. Despite the good provisions, the policies have failed to provide implementation strategies in the industry, domestic, and agricultural sectors. This paper is a review of new Groundwater policy of India and its implications on groundwater resources planning and management. Based on the growing groundwater challenges in India and the inception of a new groundwater policy, the objective of this research is to review the existing policy and new groundwater policy in India. How did policies in India evolve over a period of time? What knowledge gap exists when considering regulation and sustainable groundwater resources?

METHODS

A systematic review of groundwater policy documents within the 100-year time frame of 1882 to the present was employed to know about groundwater policies in India (Fig. 1). The review summarized all previous policies and new policies of 2020. However, the emphasis is given to new policy with the aim to summarize the key points and identify the research gaps considering the regulation and sustainability of groundwater resources in India. The central theme of the review was based on three sectors that comprise agriculture, domestic, and Industries. This theme has been selected for comparative analysis because these sectors would be the main categories based on groundwater utility and dominant from the policy-makers perspective.

Fig. 1: Timeline map which shows a year-wise revolution of groundwater law in India by corresponding authority. (CGWA, 1970, 2020; Dubbal, 2017; Govt. Ind, 1974, 1986; Jairaj, 2012; MHUA, 2019; MLJ, 1882; MWR, 2005, 2012; NGT, 2015)



In this study, groundwater policy review is classified into three broad categories. The first category comprises of policies in selected countries based on best management practices and a high percentage of groundwater withdrawals globally. The second category consists of union territories and state-level policies of India that also include core issues considering key stakeholders. The third category includes the new national-level policy of 2020 which is based on key stakeholders from the agriculture, domestic, and industrial sectors. By including all these policies in this review, it helps in providing extensive comparisons about ongoing policies considering the negative consequences of groundwater exploitation, increasing food demand, and changing climate, and summarizing the advantages and disadvantages of ongoing policies to recommend a more robust groundwater policy for India.

To ensure high-quality literature, we conducted a series of systematic searches on various web pages to access documents, reports, and peer-reviewed articles. First, we searched Google Scholar, Springer Link, and ScienceDirect using the following keywords: Groundwater policy in India, groundwater policies in Indian states and Union Territories, modified groundwater policy, previous groundwater policies, gaps in policies, etc. Second, we visited the website managed by groundwater agencies under the Centre, Union

Territories, and the State Government of India to find policy documents. Third, we explored the year-wise groundwater reports provided by the Government of India and the existing policy on groundwater given by the CGWB and state groundwater departments. In addition, country-wise policies were searched where the percentage of groundwater withdrawals was higher globally. All documents, reports, and peer-reviewed articles were screened and reviewed in full based on the groundwater policies at (1) Selected countries where groundwater withdrawals were higher globally (2) State and Union Territories of India, and (3) national level (India)

RESULTS

This section presents the results of the systematic review of policy at the State level, National level, and policy of selected countries with a prime focus on new groundwater policy. Most of the results are presented as sector-wise groundwater policies, which help to determine the relevance of different provisions for regulating and controlling groundwater use and to shed light on sectors and policies that need substantial development.

Overview of groundwater policies in selected countries

This section describes an overview of groundwater policies in selected countries based on best management practices and a high percentage of groundwater withdrawals globally (Table 1). These selected countries include the USA, China, Pakistan, Mexico, Italy, Bangladesh, and Japan. Fig. 2 shows sector wise of groundwater word wide that involves agriculture, industry, and domestic sector. A brief description of their policies is discussed in a subsequent section.

Fig. 2: Sector-wise of groundwater worldwide. ***Raw data source:*** **(IGRAC, 2020)**

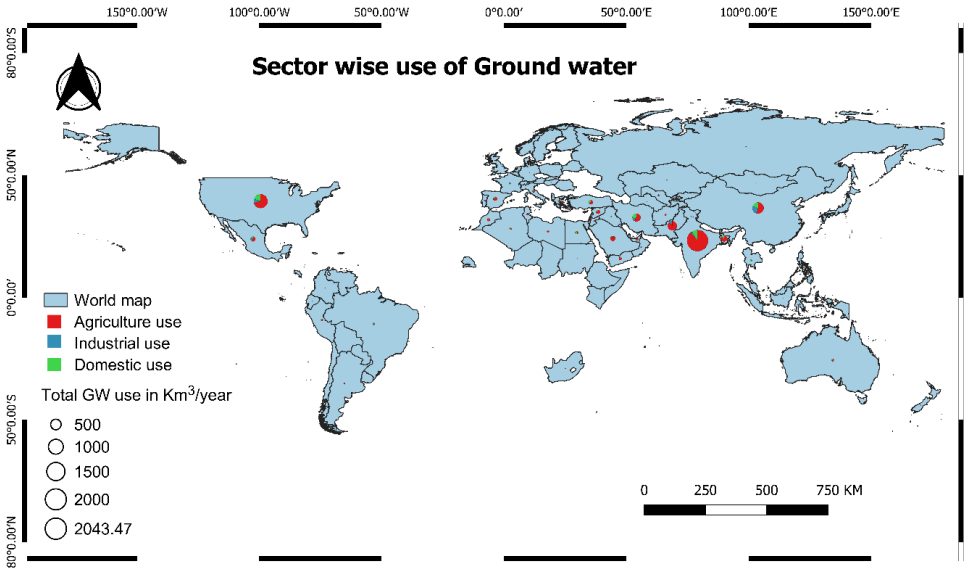


Table 1: Overview of groundwater policies in selected countries

Sr No	Country	Year	Act	Highlight	References
1	USA	2014	SGMA	Intends to limit the exploitation of groundwater.	(USGS, 2014)
2	China	2002	Water Law	Development of groundwater function zoning system to control groundwater use.	(ROC, 2002; Yu et al., 2018)
3	Pakistan	2018	National Water Policy, Pakistan	Participatory groundwater management.	(MWR, Pak, 2018)
4	Mexico	1972	Federal law	Install flow meter in agriculture supply and supply-demand ratio for sustainable groundwater use.	(Espinosa et al., 2016; Spring, 2014)
5	Italy	1933	Groundwater protection act	Divided the country into different water zones according to their water use, and available and natural water resources for sustainable GW use.	(Sappa & Vitale, 2001)
6	Bangladesh	1999	National Water Policy	Gives direction to water rights and quality issues.	(MWR, 1999)
7	Japan	1999	The river law	Nationwide groundwater law not available. National river law control groundwater in Japan	(Ministry. of Cons, 1999)

USA

The United States is the second largest groundwater extraction user after India (Fig. 2) (IGRAC, 2020) Federal government has the primary responsibility of managing and regulating the quantity and quality of groundwater and gives research and development support (OECD, 2015). The State government is responsible for the design and implementation of groundwater extraction policies in private land including state and agricultural land. Recently, the state of California, the highest groundwater extraction state in the US, passed the Sustainable Groundwater Management Act (SGMA) 2014. The SGMA Act 2014 is a landmark act that aims to reduce the several consequences of over-groundwater extraction such as a fall in groundwater level, change in groundwater storage, groundwater quality, seawater intrusion, land subsidence, and surface-water depletions (USGS, 2014)

China

Unlike other countries such as India and the United States, China is also one of the largest users of groundwater worldwide with an annual withdrawal of 111 km^3/year (Table 1). China does not have a separate national groundwater policy regulation while China has a Water Law-2002 to plan and manage groundwater (ROC, 2002). However, the Water Law 2002 did not provide clear policy directions to regulate groundwater at the national level. Policies exist

at the local government level to control the excess use of groundwater. As per the literature, the existing local-level policy faces two potential issues such as 1) monitoring and regulation of excessive groundwater and 2) implementation of existing policy, especially in agricultural regions (Aarnoudse *et al*., 2019). In addition, Shanghai Municipality in China enforced the Land Subsidence Policy 2013 to control and prevent land subsidence due to excessive use of groundwater withdrawal (He *et al*., 2019). This policy allows for demarcating the area prone to land subsidence prone zone and monitoring of land subsidence and groundwater. Overall, no separate groundwater policy exists in China and the existing policy is limited to local government authorities which means that the policy is not consistent at the national level.

Pakistan

Pakistan is the fourth most groundwater extraction country globally, with extraction being about 62 km^3 every year (Fig. 2 and Table 1). The Ministry of Water Resources of Pakistan published the National Water Policy 2018, aimed at sustainable planning and management of water resources (MWR, Pak, 2018). The National Water Policy 2018 provides priority to manage groundwater. Recently, other state-level policies came up such as Punjab Water Act-2019, Khyber Pakhtunkhwa Act-2020, and a draft policy for Sindh State (Gazet. of K. P, 2020). One of the key provisions of the National Water Policy 2018 is that the central government will form the groundwater authority and mandate state government and key stakeholders to coordinate and participate in the management of groundwater resources. However, it is challenging to fill the provision of sustainability of groundwater resources as there is an inadequate monitoring network and dedicated team.

Mexico

In terms of groundwater use in agriculture, Mexico ranks second among the Organization for Economic Co-operation and Development (OECD) countries after the United States (OECD, 2013). In 2012, following a constitutional amendment in Mexico, the government granted its citizens a basic human right to access water (Hoogesteger & Wester, 2017). As a result of changes in basic human rights, the Water Law -1992 has been amended in the year 2014. The new water law aims to safeguard the socio-economic conditions by controlling and regulating the overuse of surface water, including groundwater. However, the new water law failed to provide a solution to the inconsistent access and regulation of water in the highly exploited area (Spring, 2014).

Italy

The first water policy, known as the Water Abstraction License, of Italy came in 1933 under the Royal Decree 1775 (Pasqualetto *et al*., 2019). This law mandated users to obtain abstraction licenses for both surface water and groundwater. Since the inception of the law in 1933, several amendments have been made from time to time. Decentralization of water abstraction was a popular reform that gave power to state, province, and local authorities. In 2006, other reforms mandated license holders to withdraw specific amounts of water and enforce fines against violations (Santato *et al*., 2016). In general, the use of water without a license is illegal. Overall, all the surface and groundwater resources are owned by the federal and state governments and managed by local authorities.

Bangladesh

The Ministry of Water Resources under the Government of Bangladesh released the National Water Policy in 1999 (MWR, 1999). The policy aims to give direction to water

rights and quality issues. The policy mandates users to limit the use of groundwater as per the provisions. The government of Bangladesh has given several provisions related to groundwater use in industrial and agricultural sectors. Some of the provisions include recharge of groundwater aquifers, government regulating overuse of groundwater in deficient areas, financial incentives to users who are responsible for preventing groundwater exploitation and quality, etc. However, regulation in Bangladesh is not strict due to budgetary constraints and excessive dependence on the livelihood of people, especially in rural areas (Qureshi, 2015).

Japan

Japan is one of the largest users of groundwater worldwide which uses nearly 14 km^3 each year (Hori, 2016). Japan does not have a nationwide groundwater law. Groundwater control and regulation fall under Japan's national river law (Ministry. of Cons, 1999). (Hori, 2016) reported that Japan has a strong groundwater policy at the local level as compared with the national level law. The overall national and local groundwater policy is divided into four parts which involve policies related to groundwater hydrology, volumetric assessment, quality, and research and development. Most of the problems related to groundwater are solved by the local government on a case-by-case basis as per the local-level policy. In addition, Japan has local regulations to deal with land subsidence issues that are linked to excessive groundwater extraction (Daito, 2017).

Overview of groundwater policies in State and Union Territories of India

The government of India passed a model bill in 1992 aimed at the management and control of groundwater in Indian States. The Model Bill, of 1992, directed all states to formulate a state-level policy to regulate and control groundwater. Tamil Nadu formulated its first State Policy after the Model Bill, 1992 in 1996. Other States and Union Territories have also formulated policies such as Lakshadweep (2001), Kerala (2002), Goa (2002), Telangana (2002), Puducherry (2003), Himachal Pradesh (2005), Jammu and Kashmir (2010), Karnataka (2011), Uttar Pradesh (2020), and Punjab (2020). Table 2 gives the highlights of each state policy in chronological order. However, States like Karnataka and Tamil Nadu formulated laws before 1992 and amended the existing laws after the Model Bill, of 1992.

Table 2: Overview of groundwater policies in various states in India

Sr No	State	Year	Act	Highlight	References
1	Tamil Nadu	1996	The Chennai Metropolitan Area Ground Water (Regulation) Act, 1987	Maintain the ratio of groundwater extraction and recharge	(CHGW, 1987)
2	Lakshadweep	2001	Lakshadweep Ground Water Development and Control Regulation, 2001	Existent groundwater long-term use and quality monitoring.	(Laks., 2001)
3	Kerala	2002	The Kerala Ground Water (Control and Regulation) Act, 2002	Conservation of groundwater and control of usage.	(KeGW, 2002)
4	Goa	2002	The Goa Groundwater Regulation Bill, 2002	Establish groundwater cells to monitor groundwater quantity and quality.	(GOWRD, 2002)
5	Telangana	2002	The Telangana Water, Land and Trees Act (Chapter-3), 2002. (ACT NO. 10 OF 2002)	Protect groundwater for future resources	(TWLD, 2015)
6	Puducherry	2003	The Puducherry Groundwater (Control and Regulation) Act, 2002	Existent groundwater long-term use and quality monitoring.	(PGW, 2003)
7	Himachal Pradesh	2005	Himachal Pradesh groundwater regulation, control and Management Act, 2005	Groundwater recharge methods	(HPGW, 2005)
8	Jammu and Kashmir	2010	Regulation and Management) ACT, 2010	Management of groundwater.	(J&KWRD, 2010)
9	Karnataka	2011	Karnataka Act No 25 Of 2011	Regulates and controls the development and management of groundwater, as well as incidental activities.	(KGW, 2011)
10	Uttar Pradesh	2020	The Uttar Pradesh Ground Water (Management and Regulation) Rules, 2020	Fixing the limit of groundwater for commercial purposes.	(UPGW, 2020)
11	Punjab	2020	The Punjab Water Resources (Management and Regulation) Act, 2020	Develop a water plan for sustainable use.	(PuWD, 2020)

New National level policy in India

The new national groundwater policy came in the year 2020 to regulate groundwater withdrawal and sustainable management of groundwater resources in the country. This guideline was notified in September 2020 and replaced previous guidelines formulated by the Central Ground Water Authority (CGWA). The Central Ground Water Authority (CGWA) is the apex agency in the country responsible for regulating, planning, and managing groundwater (CGWA, 2020). At present, India has 28 states and 8 union territories. Out of the total states and union territories, New National level policies apply to 22 states and 2 union territories. Fig. 3 shows detailed information about the groundwater policies in the state and union territories of India. The new guideline gives flexibility to states and union territories to include additional guidelines that are based on the specific requirements and hydrogeological setup. This inclusion of additional guidelines will be subject to approval from competent authorities.

To control groundwater withdrawal, Industrial and domestic sectors have to take a No Objection Certificate (NOC) from CGWA and other competent authorities. The process of applying for NOC can be made through the online process. The process of levying charges and issuing is based on the groundwater assessment unit identified by central and state groundwater authorities. Ensuring that groundwater extraction is carried out responsibly and has no detrimental effects on the surrounding ecosystems or water table is the main goal of NOC. The guidelines have created opportunities for bureaucratic corruption even if their goal is to support sustainable groundwater management. The government implemented capacity-building and training programs that can encourage moral behavior and lessen reliance on discretionary power in order to lessen the possibility of bureaucratic corruption connected to the NOC issuance procedure. Apart from this, the process can be made more equitable and efficient, guaranteeing that the goals of groundwater conservation are achieved without placing an excessive burden on authorized users, by putting in place measures for openness, independent audits, and robust accountability systems.

After a systemic review of the new national groundwater policy, we plotted a word cloud of this policy. Fig 4 shows the word cloud based on the new national groundwater policy in India. First, we sorted the technical words from the new groundwater policy document. Then we plotted it using the Python tool considering technical terms to see the maximum use of words and their frequency. Fig.4 shows the size of the ‘NOC’ word that represents its frequency or importance in the new groundwater policy document. The other larger words that appear in the word cloud are ‘abstraction’, ‘assessment’, ‘industries’, ‘domestic’ ‘project’ etc. also used many times. This word cloud shows that the new national-level policy on groundwater in India only bounded to the industrial sector and mining sector for NOC. There is no such provision for agriculture as in the word cloud agriculture or this same synonym word is not there.

Fig. 3: Groundwater policies in States and union territories of India

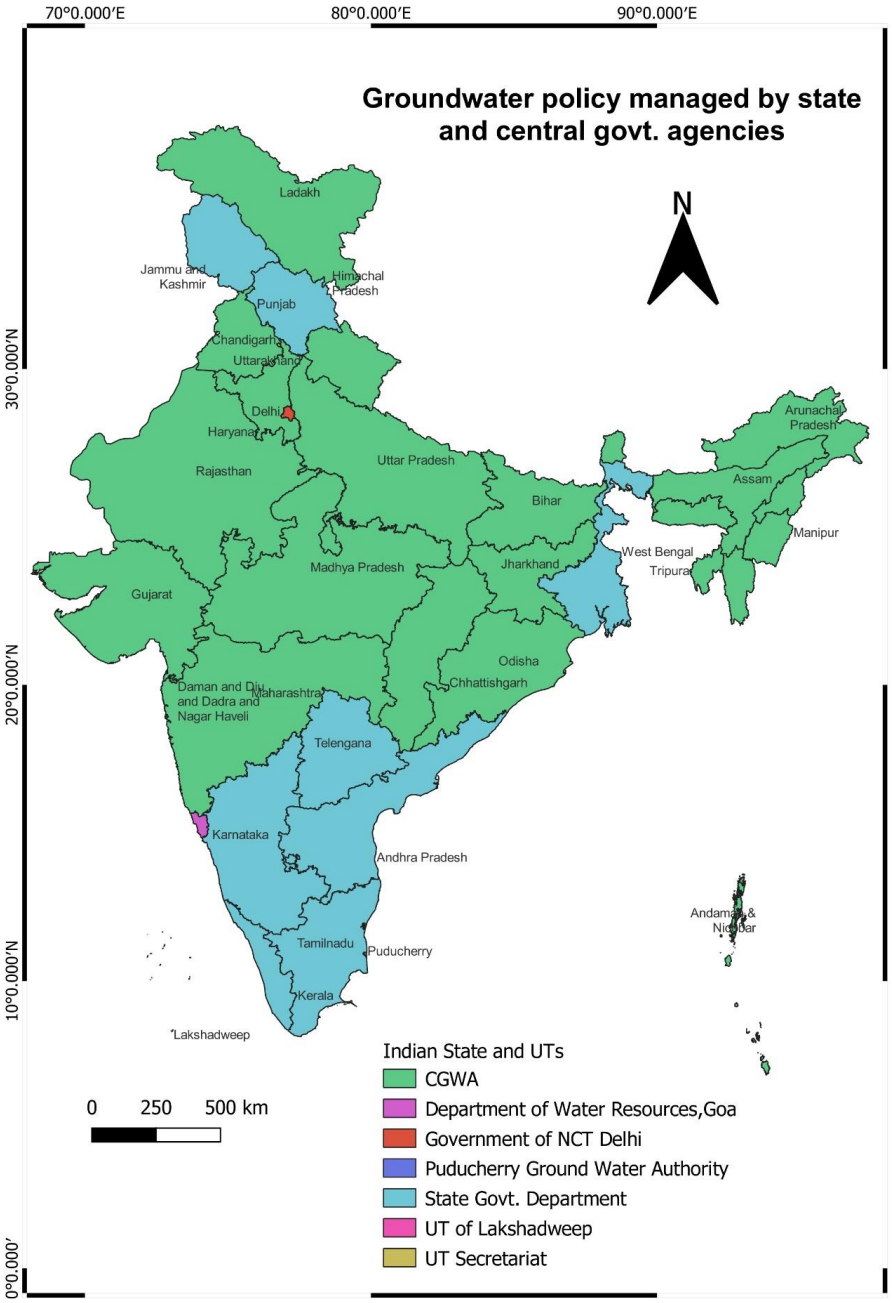
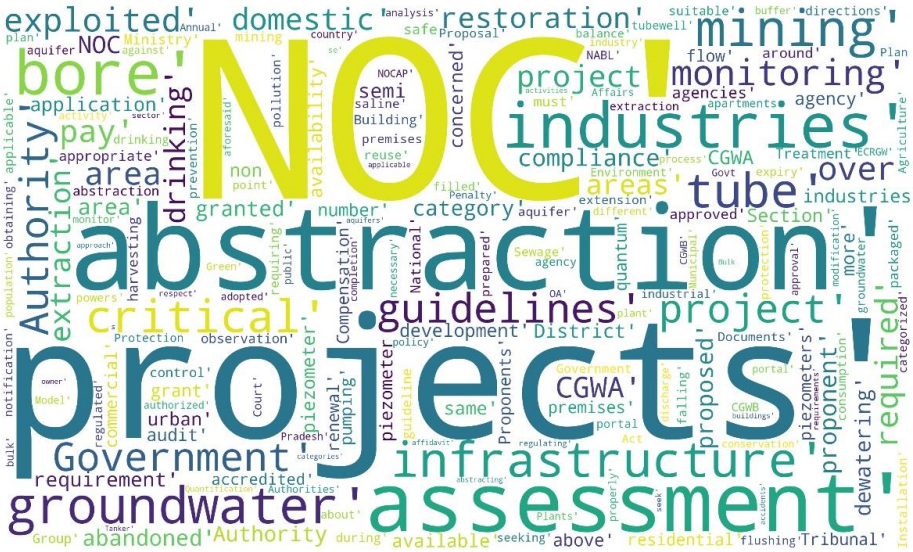


Fig. 4: World cloud of New National level policy in India (CGWA, 2020)



Industry, Packaged drinking, and mining

The new policy categorized the Packaged drinking industry, Infrastructure project, Mining project, and other Industries into a commercial type that uses groundwater for commercial purposes. The policy gives detailed guidelines to issue NOC for different sectors based on groundwater abstraction. The process of granting NOC depends on the status of groundwater assessment units which are managed by CGWA and Central Groundwater Board (CGWB). The CGWB demarcated the groundwater assessment units (GAUs) considering watershed and administrative boundaries (CGWA, 2020). The status of groundwater abstraction in GAUs depends on the ratio of annual groundwater abstraction and annual groundwater available. The status of groundwater abstraction is expressed in percentage. In general terms, the status of groundwater abstraction in GAUs further categorized as 'Safe (<=70 %)', 'Semi-critical (>70 % and <=90 %)', 'Critical (>90 % and <=100 %)', and 'Over-exploited (>100 %)' (CGWA, 2020).

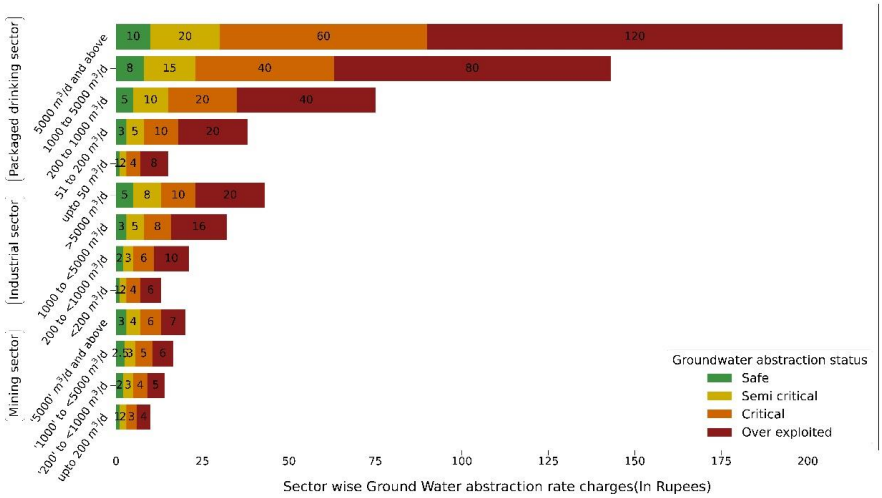
The policy for granting NOC varies with the category of industry. As per the policy, no NOC will be granted for extracting groundwater to a new industry in an over-exploited region, Micro, Small, and Medium Enterprises (MSME) will be given an exemption. The employees of industries in over-exploited regions have been given exemptions to use groundwater for drinking and other domestic purposes. However, No NOC will be granted to the packaged drinking water sector in the over-exploited region, despite such an industry being affiliated with MSME.

Fig. 5 shows the sector-wise groundwater abstraction rate for mining, packaged drinking, and other industrial sectors. The groundwater abstraction charges have been fixed by considering the groundwater abstraction rate and the status of groundwater use such as 'Safe', 'Semi-critical', 'Critical', and 'Over-exploited'. The new charges are applicable with effect from September 2020. The extent of groundwater abstraction varies between 50 m^3/day to 5000 m^3/day for various sectors depending on the status of groundwater use (Fig. 4). For example, the packaged drinking industry will have to pay Rs. 120 if the industry

falls under the overexploitation category and the groundwater abstraction rate rises above 5000 m^3/day.

The guideline exempted Mining projects from groundwater abstraction in an overexploited region. However, all previous and existing mining projects need to obtain NOC. Grant of NOC for groundwater abstraction will be subjected to certain terms and conditions. Those specific conditions include treatment of groundwater, construction of observation wells, monitoring of groundwater level, excess water to be used for irrigation, and recharge purposes. In addition, all mining industries have to pay the groundwater abstraction charges fixed by considering the groundwater abstraction rate and groundwater use status such as 'Safe', 'Semi-critical', 'Critical', and 'Over-exploited' (Fig. 5).

Fig. 5: Sector groundwater abstraction rate as per the new groundwater policy of India. ***Raw data source:*** **(CGWA, 2020)**



Agriculture

The agriculture sector in India plays an important role in economic development. Considering the socioeconomic conditions of farmers in India, the new policy does not apply to the agriculture sector. The agriculture sector has been exempted from obtaining NOC for groundwater abstraction. About 70 % of India's population directly depends on agriculture and other allied sector. India has 82 % of small farmers who own less than 2 hectares of land and fall under the small and marginal category (FAO, 2018). Imposing extra charges or penalties on marginal farmers may likely impact their socioeconomic conditions. Further, the policy states that it would be difficult to monitor groundwater abstraction in the agricultural sector given the vast number of wells and groundwater abstraction status. The current policy also directs Indian states and Union Territories to review the ongoing policies and proposes to formulate a new policy to promote a participatory approach to the regulation and control of groundwater to reduce excess use of groundwater.

Infrastructure projects

In the new guideline, infrastructure projects have been exempted from groundwater abstraction in the over-exploited area. Nevertheless, all earlier and new infrastructure projects need to obtain a no-objection certificate for groundwater abstraction. Unlike mining projects, granting no-objection certificates to infrastructure projects will be subject to specific conditions. Those specific conditions include monitoring the groundwater withdrawal rate and the construction of a sewage treatment plant if the groundwater withdrawal exceeds 20 m^3/d. Fig. 5 shows the charges for groundwater abstraction of infrastructure projects in 'safe', 'semi-critical', 'critical', and 'over-exploited' assessment units. Further, a strict provision has been made in the new policy and the authorities have been directed not to provide NOCs to water and amusement parks for groundwater abstraction.

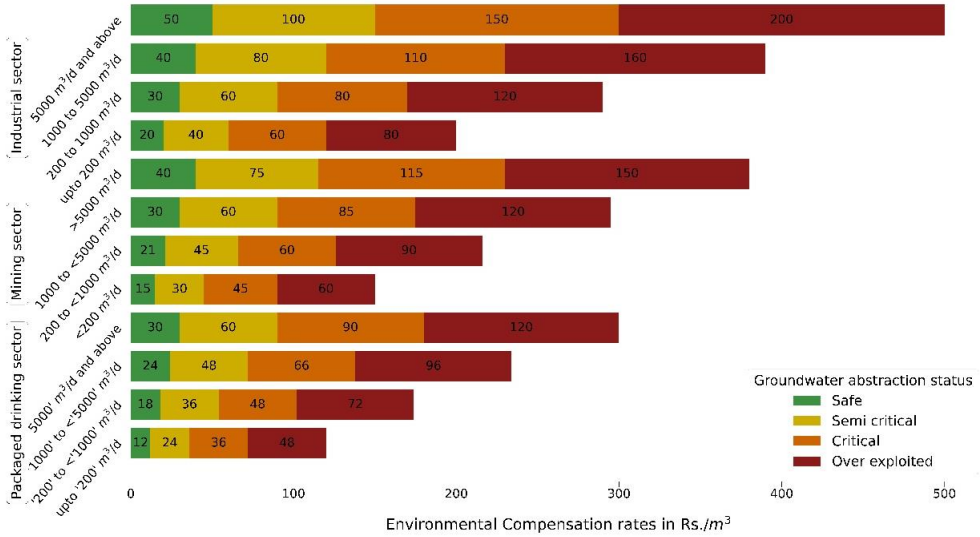
Water Supply using a private tank

The new guideline mandated private tankers to obtain NOCs for groundwater abstraction. Private tankers that will use groundwater in a 'safe', 'semi-critical', 'critical', and 'over-exploited' assessment unit will have to pay a fee of Rs. 10, 20, 25, and 35 per m^3 respectively for groundwater abstraction. Apart from this, private tankers have also been instructed to install GPS devices on the tank to monitor movement and groundwater supply. However, no clear guidelines have been given for the grant of NOC, monitoring, and management of groundwater abstraction. The new guideline suggests States and Union Territories for granting NOCs to private tankers.

Other provisions in policy

Other provisions of the policy comprised Groundwater extraction in Saline environments, Wetland areas, Environmental Compensation, and Ground Water Level Monitoring. Industries located in areas where saline groundwater is present have been exempted from taking groundwater and no pricing has been imposed on such industries. No provision was made to protect wetland areas despite wetlands directly related to groundwater recharge. However, there are separate guidelines for the conservation of wetland ecosystems under the Ministry of Environment, Forest and Climate Change. All users extracting groundwater greater than 10 m^3/day must set up observation wells to monitor groundwater levels. In addition, all industries must obtain a valid NOC to extract groundwater for commercial use, otherwise, they will have to pay environmental compensation fees determined by considering the groundwater abstraction rates and groundwater use status such as ‘Safe’, ‘Semi-critical’, ‘Critical’, and ‘Over-exploited’ (Fig. 6).

Fig. 6: Environmental compensation rates in new groundwater policy. *Raw data source:* (CGWA, 2020)



DISCUSSIONS AND GAPS IN POLICY

The present study conducted a systematic review of groundwater policy in India which aimed at identifying a sector-wise potential challenge to controlling and regulating the groundwater resource in India. The review initially summarized previous groundwater policies in India and other selected countries and then focused primarily on the nationwide new groundwater policy in India. State governments and union territories in India managed the previous groundwater policies in India. The review also looked broadly at groundwater policies outside India, which has the highest annual groundwater withdrawal globally. Particular attention is paid to sector-wise policies that include agriculture, industry, and domestic sectors. As the demand for groundwater withdrawal continues to grow in the future, it is important to look ahead and analyze new and existing groundwater policies that can facilitate groundwater sustainability.

The new groundwater policy has come with provisions that did not exist in the current state-level policy of groundwater. The new groundwater policy replaced the previous policies formulated by CGWA and other competent authorities. Out of 28 states in India, this new policy applies to 22 states, and it also allows amendments to existing state-level policies. The new provisions made to control the excessive use of groundwater include issuance of NOCs to industry and domestic sector, imposition of charges for groundwater use focusing on limiting groundwater extraction rate to a certain extent, and many others. The provision for issuing NOCs has been restricted to a specified area in different sectors as described in Figs. 4 and 5. However, the previous state government's policy like the new policy has a larger goal of achieving groundwater sustainability. For example, states like Jammu and Kashmir, Karnataka, Uttar Pradesh, Telangana, Tamil Nadu, Punjab, Puducherry, Lakshadweep, Kerala, Himachal Pradesh and Goa incorporated measures to regulate groundwater in their respective states. Some of those measures consist of limiting

groundwater for commercial purposes, maintaining the ratio of groundwater extraction and recharge, monitoring the quality and quantity of groundwater, managing aquifer recharge techniques, etc. Nevertheless, there are still some relevant problems of groundwater regulation to be addressed in state policy.

The provisions of the new groundwater policy have created a nationwide framework for achieving groundwater sustainability, though little attention has been paid to the agriculture sector. A major limitation of this policy is that it does not address the problem of agricultural groundwater use. As the agriculture sector in India uses the highest groundwater in the country, which is about 89 %, regulation is certainly necessary in the agriculture sector along with industry and domestic sector. After the inception of the new groundwater policy, most of the states in India come under the jurisdiction of CGWA (Fig. 3). The agricultural sector uses 171 km^3 of groundwater among the CGWA-regulated states (Fig. 7).

Fig. 7: Groundwater policy managed by CGWA and other Indian UTs/state agencies. ***Raw data source:*** **(CGWA, 2020; CGWB, 2021)**

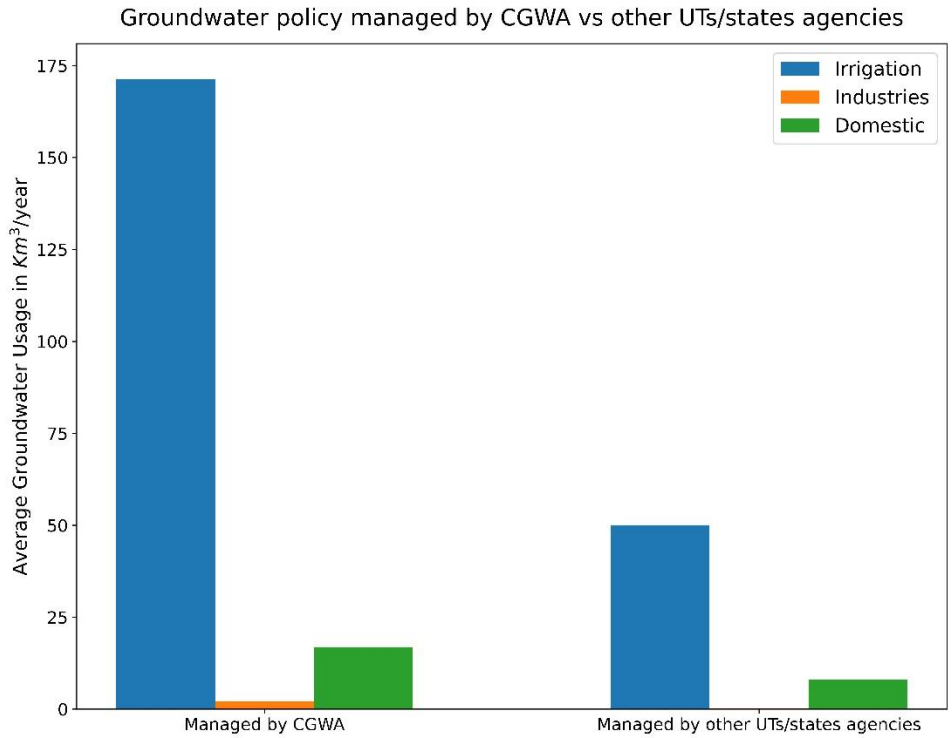
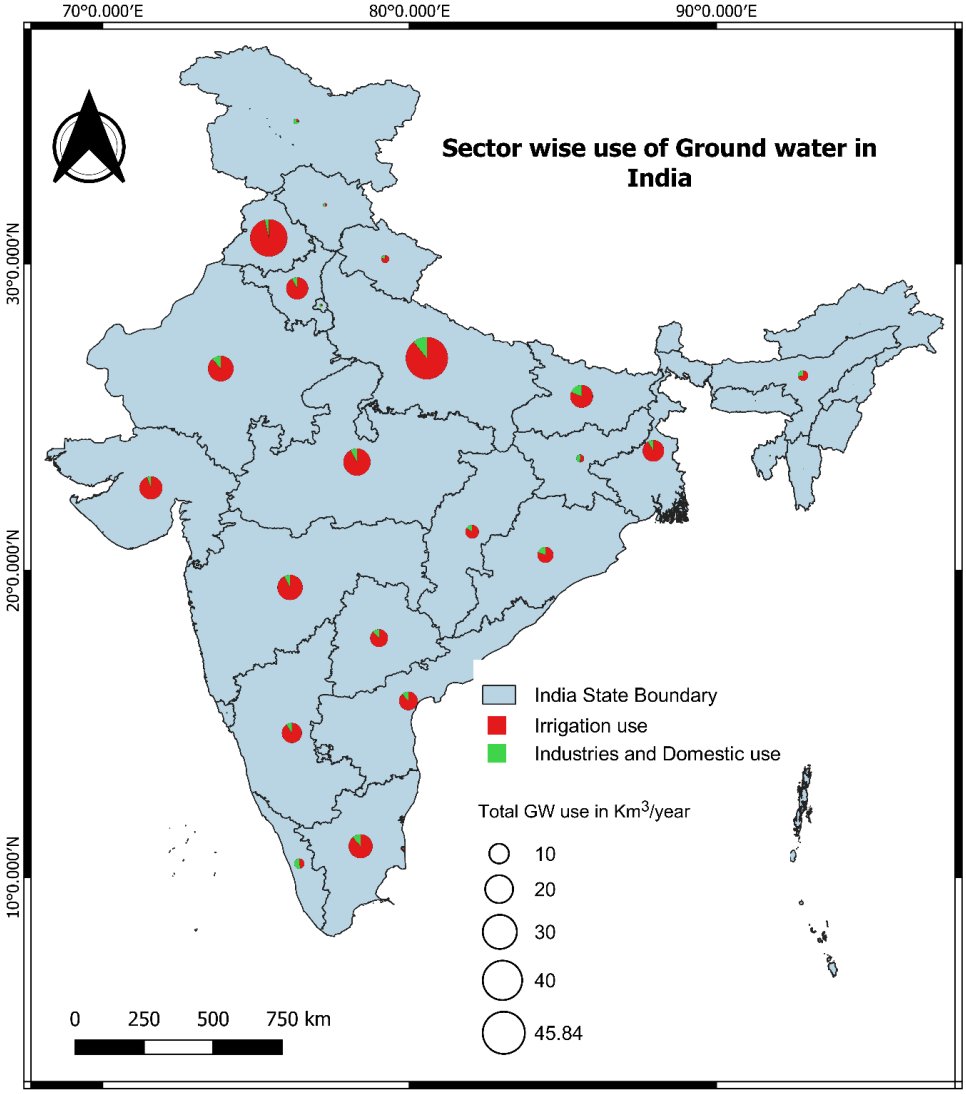


Fig. 8 shows the sector-wise use of groundwater in Indian states. The total groundwater use in Indian states ranges between 10 km^3/year to nearly 46 km^3/year. The majority of the groundwater users belong to the agriculture sector as compared to industries and the domestic sector. Even though the use of groundwater in the agricultural sector is much higher than that of industries and the domestic sector, therefore, it directly means that the new policy will not directly control and regulate groundwater use for a very large sector of agriculture in the country. (Fig. 9). As a consequence, it will not be possible to regulate groundwater use in the agricultural sector, especially in the overexploited unit which accounts for about 14 % of

the total assessment units in India. Due to the fact that no new provision exists for the agricultural sector, achieving overall groundwater sustainability will be a major challenge.

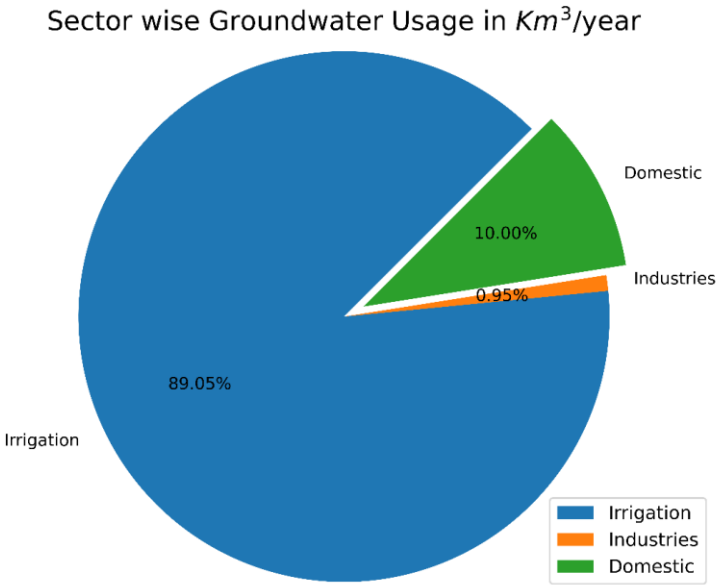
Fig. 8: Sector-wise use of groundwater in Indian states. *Raw data source:* (IGRAC, 2020)



The major use of groundwater in India in agricultural sector. It's very important to control the use of groundwater in the agricultural sector for sustainable development. The CGWB maintains a specialized network of over 25,000 monitoring stations known as "National Hydrograph Network Stations (NHNS)" for the purpose of monitoring groundwater levels. These stations include open-pit wells and specially designed bore/tube wells known as piezometers. In addition, as part of the National Hydrology Project (NHP), CGWB installed

Digital Water Level Recorders (DWLR) with telemetry systems to start automatic high frequency monitoring. This will not only measure the groundwater level but the real time ground water level and supply of ground water level, ground water temperature also (National Hydrology Project, 2019). This DWLR and telemetry have begun to deploy only 13 states in India including Andhra Pradesh, Delhi, Gujarat, Haryana, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Telangana, and Uttar Pradesh. As part of the Public Investment Board (PIB) initiative, CGWB plans to build 7000 piezometers; under the Ground Water Management and Regulation (GWMR) Scheme, another 2000 piezometers are to be built. A telemetry system and digital water level recorders (DWLR) will be installed on these piezometers. The water level data are ultimately shared with end users through India-WRIS, a web-based public platform created by NWIC and available nationally. This accurate measuring system will definitely help to control the groundwater usages based on their availability.

Fig. 9: Sector-wise use of groundwater usage in India. ***Raw data source:*** **(CGWB, 2021)**



Apart from the major limitation of the new policy that does not consider agricultural groundwater use, it is plausible that some other limitations in the policy may impact the overall planning and management of groundwater in the country. For example, the policy does not mention consequences that may be directly related to groundwater extraction such as poor groundwater quality, land subsidence, transboundary conditions, climate change, groundwater models, information dissemination, and others. No provision has been given about groundwater and surface water interaction as it is critical to have a better policy for the overall planning and management of groundwater. It may be important to consider land subsidence in policy in alluvial aquifers as the major cause of land subsidence is excessive groundwater extraction. The policy mandates users to observe and monitor groundwater that

extracts groundwater more than 10 m^3/day. Yet, the policy has given less attention to monitoring groundwater levels as it is not clear how the competent authority will monitor groundwater sharing by two or more adjoining users. There may be a conflict of interest in assessment units that come under overexploitation or critical conditions. Users in those regions that are not responsible for overexploited conditions have to pay higher charges despite low usage. However, more emphasis has been laid on issuing no-objection certificates and volumetric assessments. Based on limitations and gaps in the new groundwater policy, it is evident that the policy needs revision for effective planning and management of groundwater resources.

CONCLUSIONS AND RECOMMENDATIONS

In this paper, we reviewed new groundwater policy of India and its implications on groundwater resource planning and management. The main purpose of this review was to analyze the new provisions and gaps in policy when considering the regulation and control of groundwater in India. The results of the present review have important implications for the overall implementation and planning of groundwater resources, particularly in the agricultural sector. Our findings suggest that incorporating the agriculture sector directly into new policy can significantly improve the larger goal of the sustainability issue of groundwater with the necessary provision of incentives to marginal farmers. This has important implications for policymakers, as groundwater use for agriculture in the country is about 89 %. Furthermore, this review highlights the importance of continued research into the ongoing issue of groundwater to understand the role of technology and to inform policies and best management practices globally. In conclusion, our study provides valuable insights into new and existing state groundwater policy in India. Through a comprehensive analysis of the existing worldwide policy on groundwater and literature, we have found that technology-driven effective policy can play a significant role in the planning and management of groundwater resources. Our findings will have an important impact on stakeholders and policymakers and provide evidence for future amendments to existing groundwater policy.

Based on the findings of the present study, we recommend the following:

Agriculture sector

Keeping in view the socio-economic status of smallholder farmers, subsidies and incentives should be included to encourage farmers to use recent technologies in irrigation, regulatory, and participatory management approaches with an aim to increase water use efficiency.

Participatory approach

A robust policy should be introduced that should encourage farmers, key stakeholders, and local agencies in participatory groundwater management. For example, countries like the USA, Australia, and the European Union (EU), have incorporated groundwater management policies through stakeholder participation such as ‘Sustainable Groundwater Management Act 2014 (Moran & Wendell, 2015), ‘Water Framework Directive-2000’ (Jager *et al*., 2016), and ‘Natural Resources Management Act-2004’ (Cuadrado-Quesada & Gupta, 2019), respectively.

Surface water and groundwater interaction

In addition to focusing only on groundwater resources, all the essential units of hydrological components, including surface water and groundwater interaction should be considered as the fundamental part of overall planning and management. However, it will be challenging to include surface water and groundwater interaction in policy.

Land subsidence

An area prone to land subsidence will require strict regulation of groundwater extraction to control future land subsidence.

Information dissemination

For effective management and implementation of the policy, it is necessary to have strong mechanisms to share information and make the database accessible to the targeted stakeholders.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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