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# Overview of Ground Water Situation in India

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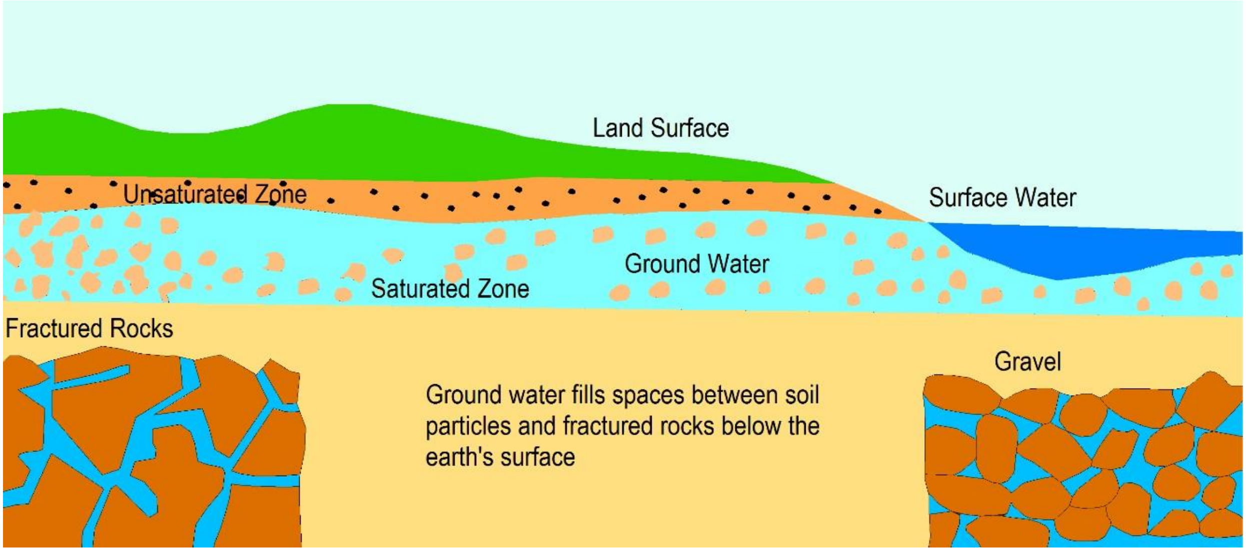
## Introduction

Ground water is the water that seeps through rocks and soil and is stored below the ground. The rocks in which ground water is stored are called aquifers. Aquifers are typically made up of gravel, sand, sandstone or limestone. Water moves through these rocks because they have large connected spaces that make them permeable. The area where water fills the aquifer is called the saturated zone. The depth from the surface at which ground water is found is called the water table. The water table can be as shallow as a foot below the ground or it can be a few hundred meters deep. Heavy rains can cause the water table to rise and conversely, continuous extraction of ground water can cause the levelto fall. Figure 1 illustrates the major definitions used in the context of groundwater.

**Figure 1: Graphical representation of ground water and associated terms**




The underground (hydrogeological) setting of ground water defines the potential of this resource and its vulnerability to irreversible degradation.[1] This setting in India can be divided into following categories, which are described below:

- **Hard-rock aquifers of peninsular India:** These aquifers represent around 65% of India's overall aquifer surface area. Most of them are found in central peninsular India, where land is typically underlain by hard-rock formations. These rocks give rise to a complex and extensive low-storage aquifer system, where in the water level tends to drop very rapidly once the water table falls by more than 2-6 meters. Additionally, these aquifers have poor permeability[*] which limits their recharge through rainfall. This implies that water in these aquifers is non- replenishable and will eventually dry out due to continuous usage.

[*] Permeability refers to the ability of a rock to transmit water.

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- **Alluvial aquifers of the Indo-Gangetic plains:** These aquifers, found in the Gangetic and Indusplains in Northern India have significant storage spaces, and hence are a valuable source of freshwater supply. However, due to excessive ground water extraction and low recharge rates, these aquifers are at the risk of irreversible overexploitation.

## Ground water availability

As of April 2015, the water resource potential or annual water availability of the country in terms of natural runoff (flow) in rivers is about 1,869 Billion Cubic Meter (BCM)/year.[2] However, the usable water resources of the country have been estimated as 1,123 BCM/year. This is due to constraints of topography and uneven distribution of the resource in various river basins, which makes it difficult to extract the entire available 1,869 BCM/year.

Out of the 1,123 BCM/year, the share of surface water and ground water is 690 BCM/year and 433 BCM/year respectively. Setting aside 35 BCM for natural discharge*, the net annual ground water availability for the entire country is 398 BCM.[3]

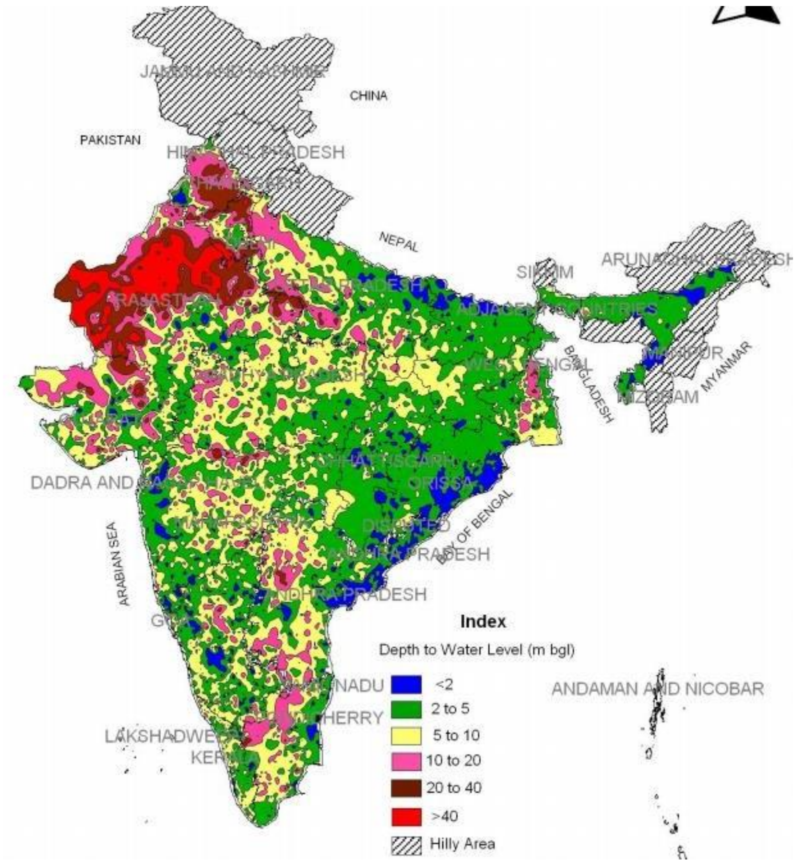
**Table 1: Statistics regarding water resources in India**

| Parameter | Unit (Billion Cubic Meter/Year) |
|---|---|
| Annual water availability | 1,869 |
| Usable water | 1,123 |
| Surface water | 690 |
| Ground water | 433 |

Sources: Water and Related Statistics, April 2015, Central Water Commission; PRS.

The overall contribution of rainfall to the country's annual ground water resource is 68% and the share of other resources, such as canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together is 32%.[4] Due to the increasing population in the country, the national per capita annual availability of water has reduced from 1,816 cubic metre in2001 to 1,544 cubic metre in 2011.[2] This is a reduction of 15%.

**Figure 2: Depth to water level (pre-monsoon, 2014)**




Note: m bgl denotes meters below ground level.Sources: Central Ground Water Board; PRS.

The figure indicates that ground water is available at a lower level in the north-western region of the country. There are other significant pockets across the country where the depth of the water level is more than 10 metres. This implies that one has to dig deeper to reach the water table in these regions. When the ground water level crosses 10 metres, sophisticated equipment is required to extract it.

* Natural discharge occurs as seepage to water bodies or oceans in coastal areas and as transpiration by plants whose roots extend up to the water table.

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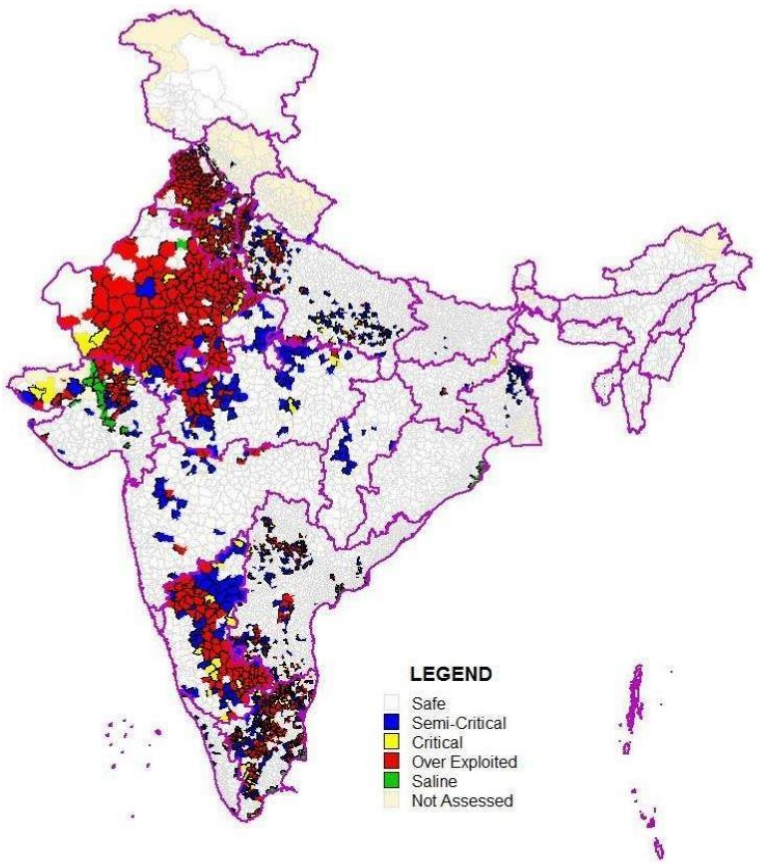
Ground water resources in the country are assessed at different scales within districts, such as blocks/mandals/talukas/watersheds. Ground water development is a ratio of the annual ground water extraction to the net annual ground water availability. It indicates the quantity of ground water available for use. Table 2 below compares the level of ground water development in the country over the past two decades.

**Table 2: Comparative status of level of ground water development in India in the past 20 years**

| Level of ground | Explanation | % of districts in | % of districts in 2004 | % of districts in 2009 | % of districts in 2011 |
|---|---|---|---|---|---|
| **0-70% (Safe)** | Areas which have ground water potential for development | 92 | 73 | 72 | 71 |
| **critical)** | water development is | | | | |
| **90-100% (Critical)** | Areas which need intensive monitoring and evaluation for ground water development | 1 | 4 | 4 | 4 |
| **>100% (Over-exploited)** | Areas where future ground water development is linked with water conservation measures | 3 | 14 | 14 | 15 |

Sources: Central Ground Water Board; PRS.

**Figure 3: Categorization of ground water assessment units**




Note: Data as of 2011.
Sources: Ground water scenario in India, November 2014, Central Ground Water Board; PRS.

| State | Ground water development in 2011 (%) |
|---|---|
| Andhra Pradesh | 37 |
| Arunachal Pradesh | 0 |
| Assam | 14 |
| Bihar | 44 |
| Chhattisgarh | 35 |
| Delhi | 137 |
| Goa | 28 |
| Gujarat | 67 |
| Haryana | 133 |
| Himachal Pradesh | 71 |
| Jammu & Kashmir | 21 |
| Jharkhand | 32 |
| Karnataka | 64 |
| Kerala | 47 |
| Madhya Pradesh | 57 |
| Maharashtra | 53 |
| Manipur | 1 |
| Meghalaya | 0 |
| Mizoram | 3 |
| Nagaland | 6 |
| Odisha | 28 |
| Puducherry | 90 |
| Punjab | 172 |
| Rajasthan | 137 |
| Sikkim | 26 |
| Tamil Nadu | 77 |
| Telangana | 55 |
| Tripura | 7 |
| Uttar Pradesh | 74 |
| Uttarakhand | 57 |
| West Bengal | 40 |
| Total * | 62 |

Note: *Total includes union territories.

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The level of ground water development is very high in the states of Delhi, Haryana, Punjab and Rajasthan, where ground water development is more than 100%. This implies that in these states, theannual ground water consumption is more than annual ground water recharge. In the states of Himachal Pradesh, Tamil Nadu and Uttar Pradesh and the Union Territory of Puducherry, the level ofground water development is 70% and above. In rest of the states, the level of ground water development is below 70%. Over the years, usage of ground water has increased in areas where the resource was readily available.[2] This has resulted in an increase in overall ground water developmentfrom 58% in 2004 to 62% in 2011, as illustrated in Figure 3.

## Ground water extraction and use

Experts believe that India is fast moving towards a crisis of ground water overuse and contamination.[5] Ground water overuse or overexploitation is defined as a situation in which, over a period of time, average extraction rate from aquifers is greater than the average recharge rate.

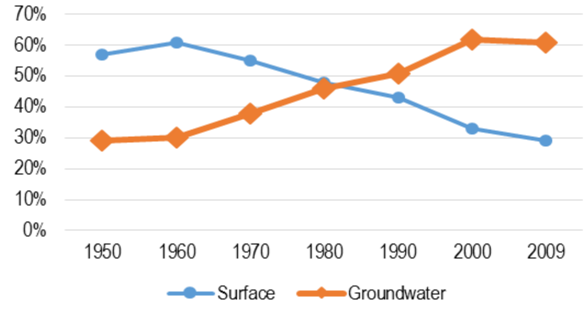
In India, the availability of surface water is greater than ground water. However, owing to the decentralised availability of groundwater*, it is easily accessible and forms the largest share of India's agriculture and drinking water supply. 89% of ground water extracted is used in the irrigation sector, making it the highest category user in the country.[6] This is followed by ground water for domestic use which is 9% of the extracted groundwater. Industrial use of ground water is 2%. 50% of urban water requirements and 85% of rural domestic water requirements are also fulfilled by ground water.[1]

## Irrigation through ground water

The largest component of ground water use is the water extracted for irrigation. The main means of irrigation in the country are canals, tanks and wells, including tube-wells. Of all these sources, ground water constitutes the largest share. Wells, including dug wells, shallow tube-wells and deep tube wells provide about 61.6% of water for irrigation, followed by canals with 24.5%.

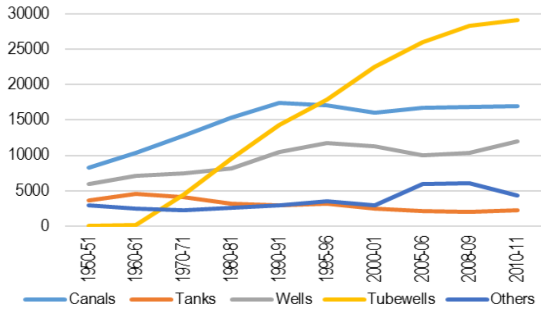
Over the years, there has been a decrease in surface water use and a continuous increase in ground water utilisation for irrigation. Figure 5 illustrates the pattern of use of the main sources of irrigation. As can be seen, the share of tubewells has increased exponentially, indicating the increased usage of ground water for irrigation by farmers. The dependence of irrigation on ground water increased with the onset of the Green Revolution, which depended on intensive use of inputs such as water and fertilizers to boost farm production.[7] Incentives such as credit for irrigation equipment and subsidies for electricity supply have further worsened the situation.[8] Low power tariffs has led to excessive water usage, leading to a sharp fall in water tables.[8]

**Figure 4: Increase in ground water utilization for irrigation**




Sources: Agricultural Statistics at Glance 2014, Ministry of Agriculture; PRS.

**Figure 5: Tubewells increasingly being the main source of irrigation**




Note: Irrigated area is in '000 hectares.
Source: Agricultural Statistics at Glance 2014, Ministry of Agriculture; PRS.

* Decentralised availability of ground water implies that the owner of a piece of land has the right to the water under it according to the Easement Act of 1884.

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### Ground water contamination

Ground water contamination is the presence of certain pollutants in ground water that are in excess of the limits prescribed for drinking water.[9] The commonly observed contaminants include arsenic, fluoride, nitrate and iron, which are geogenic[*] in nature. Other contaminants include bacteria, phosphates and heavy metals which are a result of human activities including domestic sewage, agricultural practices and industrial effluents.[10] The sources of contamination include pollution by landfills, septic tanks, leaky underground gas tanks, and from overuse of fertilizers and pesticides. It has been pointed out that nearly 60% of all districts in the country have issues related to either availability of ground water, or quality of ground water, or both.[10]

Table 3 shows the number of states and districts affected by geogenic contaminants as on July 2014.

**Table 3: 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 Committee on Estimates 2014-15 that reviewed the occurrence of high arsenic content in ground water observed that 68 districts in 10 states are affected by high arsenic contamination in groundwater.[11] These states are Haryana, Punjab, Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh, West Bengal, Assam, Manipur and Karnataka.

## Legislative and Policy Framework

Currently, the Easement Act, 1882 provides every landowner with the right to collect and dispose, within his own limits, all water under the land and on the surface.[12] This makes it difficult to regulate extraction of ground water as it is owned by the person to whom the land belongs. This gives landowners significant power over ground water. Further the law excludes landless ground water users from its purview.

Water falls under the State List of the Constitution. This implies that state legislative assemblies can make laws on the subject. In order to provide broad guidelines to state governments to frame their own laws relating to sustainable water usage, the central government has published certain frameworklaws or model Bills. In 2011, the government published a Model Bill for Ground Water Management based on which states could choose to enact their laws. In addition, it outlined a National Water Policy in 2012 articulating key principles relating to demand management, usage efficiencies, infrastructure and pricing aspects of water. As recommended in this policy, the government publisheda National Water Framework Bill in 2013.

The Model Bills and National Water Policy address the governance of ground water under the public trust doctrine. The concept of public trust doctrine ensures that resources meant for public use cannot be converted into private ownership.[13] Government being the trustee has the responsibility to protect and preserve this natural resource for and on behalf of the beneficiaries, that is, the people.[14] Additionally, they allow every person the fundamental right to be provided water of acceptable quality. It may be noted that the fundamental right to water has been evolved by the Supreme Court and various High Courts of the country as part of 'Right to Life' under Article 21 of the Constitution. Courts have delivered verdicts on concerns such as access to drinking water and on the right to safe drinking water as a fundamental right.[15]

[*] Geogenic contaminants occur as a result of geological processes that happen within the crust of the earth.

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The Bill, along with prioritising needs of rural and urban households, also specifies other primary andsecondary uses. Primary uses include water for agriculture, non-agriculture based livelihoods and municipal water supply and secondary use includes water for commercial activities. The Bill also seeks to implement the principle of subsidiarity which involves giving communities the power to regulate groundwater at the aquifer level.[13,16] For example, an aquifer situated entirely within a village will be under the direct control of the Gram Panchayat.

In response to the Model Bill, so far, 11 states and four union territories (UTs) have adopted and implemented ground water legislation. These are: Andhra Pradesh, Assam, Bihar, Goa, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, West Bengal, Telangana, Maharashtra, Lakshadweep, Puducherry, Chandigarh and Dadra & Nagar Haveli.[17] Further, the Central Ground Water Authority issued advisory to Chief Secretaries of all states and UTs to take necessary measuresfor adopting rainwater harvesting in all government buildings. So far, 30 states and UTs have made rain water harvesting mandatory through laws, rules and regulations and including provisions in building bye-laws.[18]

In addition, in the Draft Model Building Bye-laws, 2015, the Ministry of Urban Development has included a provision related to rain water harvesting. It mandates rain water harvesting structures in all buildings having a plot size of 100 sq. m or more.[18]

In order to promote efficient use of water and incentivise its conservation, the National Water Policy outlines the necessity for pricing of water beyond basic needs. The policy proposes fair pricing for different uses through the establishment of a Water Regulatory Authority (WRA) in each state. WRA will fix and regulate the water tariff, to be determined on volumetric basis and reviewed periodically. It may be noted that the implementation of the part of the policy that aims at providing basic access to water while establishing economic value and full cost recovery is a conflicting intention. In the absence of a suitable financial model, it remains to be seen how water will be allocated to users with limited capacity to pay for the cost. Additionally, it has been noted that the lack of clear guidelines and legally enforceable mechanisms make the policy ambiguous and not effective.[7]

**Plachimada Coca-Cola Case**

The Plachimada panchayat in Palakkad district of Kerala granted a license to the Coca-Cola Company in March 2000 to use groundwater for the production of its beverages. However, in 2003, the panchayat ordered the closure of the plant as it caused lowering of the water table and deterioration of the water quality. This order was challenged by the company before the High Court of Kerala.

The issue is the conflict in the right of a landowner to extract groundwater and the power of the panchayat to regulate the use of groundwater by private individuals. The High Court observed that even without groundwater regulation, the existing legal position was that groundwater is a public trust and the state has a duty to protect it against excessive exploitation. Additionally, it observed that groundwater exploitation by landowners can result in negative environmental consequences. However, on appeal, the two Judge Bench of the High Court asserted the primacy of landowner's control over groundwater in the absence of a specific law prohibiting extraction. The case is now pending in the Supreme Court.

Source: Hindustan Coca-Cola Beverages (P) Ltd. *vs.* Perumatty Grama Panchayat, 2005(2)KLT554.

## Institutional Framework

Within the central government, the Ministry of Water Resources, River Development and Ganga Rejuvenation is responsible for the conservation and management of water in the country. The Ministry of Rural Development also implements certain programmes related to ground water management. In addition, the Ministry of Environment, Forests and Climate Change is partially responsible for the prevention and control of pollution, including water pollution, and ground water contamination. In addition, there are four major central institutions that address issues related to ground water. The main roles of these institutions are summarized in the table below:

**Table 4: Major central level water institutions responsible for ground water management**

| Institution | Role |
|---|---|
| Central Water Commission | Initiating and coordinating schemes for the conservation and utilisation of water resources in the country in collaboration with state governments; and monitoring water quality |
| Central Ground Water Board | Developing and disseminating technology related to sustainable use of ground water; monitoring and implementing policies for the sustainable management of ground water resources; estimating ground waterresources |
| Central Ground Water Authority | Constituted under Section 3(3) of the Environment (Protection) Act, 1986 to regulate and control development and management of ground water resources; can resort to penal actions and issue necessaryregulatory directives |
| Central Pollution Control Board | Implementation of the Water (Prevention and Control of Pollution) Act, 1974 which seeks to restore water quality |

Sources: Ministry of Water Resources; Lok Sabha Question 2157, March 10, 2015; PRS.

The District Collector in every state is the point of contact for the Central Ground Water Board. The Collector has the powers to implement the suggestions or corrective measures provided by the Central Ground Water Board.

## Some Issues

This section highlights key issues related to the ground water sector. The major challenges include:

### Estimation of ground water resources

The current assessment methodology uses 15,640 observation wells for over 30 million ground water structures, which makes the available data indicative and not representative. It has been noted that a clearer understanding of the state of aquifers in India will help in their management and governance at the local level.[19] The Planning Commission Working Group on Sustainable Ground Water Management made the following recommendations to improve assessment:[19]

- Strengthening the database management by central and state governments,
- Adopting alternative techniques for recharge assessment where the estimates do not match the situation on the field,
- Mapping aquifers effectively for a complete assessment of ground water resources.

Following these recommendations, the CGWB in 2012 started the National Project on Aquifer Management (NAQUIM) to identify and map aquifers, and quantify the available ground water potential. This project highlighted the need for a shift in ground water sector from development to management. It aims to increase ground water resource management by (i) identifying and mapping aquifers, (ii) quantifying the available ground water potential, and (iii) proposing plans appropriate to the scale of demand, aquifer characteristics and the institutional arrangements for management. In order to establish a methodology for NAQUIM, the CGWB has undertaken a pilot study of 6 areas in different hydrogeological terrains.[20] These areas are in the states of Bihar, Karnataka, Maharashtra, Rajasthan and Tamil Nadu.

### Agricultural crop pricing and water intensive crops

In the last four decades, roughly 84% of the total addition to the net irrigated area has come through ground water.[1] The primary cause of over-exploitation has been the rising demand for ground water from agriculture. Further, decisions such as cropping pattern and cropping intensity are taken independent of the ground water availability in most areas.[8]

The High-Level Committee on restructuring of the Food Corporation of India in 2014, chaired by Mr. Shanta Kumar observed that even though Minimum Support Prices (MSPs) are currently announced for 23 crops, the effective price support is for wheat and rice.[21] This creates highly skewed incentive structures in favour of wheat and paddy, which are water intensive crops and depend heavily on ground water for their growth. Table 5 below shows the average amount of water (in cubic meters/tonne) needed to grow different crops. It indicates India’s efficiency in the usage of water for

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agriculture as compared to other countries. As can be seen, India uses almost twice the amount ofwater to grow crops as compared to China and United States.

**Table 5: Water use for crop production in different countries (in cubic metres/tonne)**

| Crops and Crop Products | Average amount of wat :r needed to grow crops in | | | |
|---|---|---|---|---|
| | Brazil | India | China | United States |
| Rice | 3,082 | 2,800 | 1,321 | 1,275 |
| Sugarcane | 155 | 159 | 117 | 103 |
| Wheat | 1,616 | 1,654 | 690 | 849 |
| Cotton | 2,777 | 8,264 | 1,419 | 2,535 |

Sources: National Water Footprint Account, UNESCO-Institute for Water Education, May 2011; PRS.

That High-Level Committee suggested that cropping pattern needed to be diversified by providing better price support for pulses and oilseeds.[22] This would also incentivize the production of these food grains.

Other experts have suggested the use of demand management in agriculture to address excessive ground water exploitation.[1] This will reduce dependence of agriculture on groundwater. These measures include:

- Dry-season crop planning for a specific area depending on the aquifer type, ground water extraction, monsoonal rainfall and the water table level. This would include some degree of shift towards higher-value and less-water consumption crops.
- Adoption of modern precision irrigation technologies such as drip and sprinkler systems which will help reduce evaporation and other non-beneficial, non-recoverable fractions of water use in agriculture.
- Restrictions to control ground water abstraction or use through regulatory measures. These may include restricting the depth of irrigation water wells, establishing and enforcing minimum distances between irrigation.

## Energy subsidies and ground water extraction

The practice of providing power subsidies for agriculture has played a major role in the decline of water levels in India. In 2009, of the total amount of ground water extracted, 89% was for irrigation, and 11% was for domestic and industrial uses.[6] Since power is a main component of the cost of ground water extraction, the availability of cheap/subsidised power in many states adds to the greater extraction of this resource.[8] Moreover, electricity supply is not metered and a flat tariff is charged depending on the horsepower of the pump. The Draft National Water Framework Bill, 2013 also suggested that over extraction of ground water should be curtailed by regulating the use of electricity needed for its extraction.[23]

The challenge is to find a balance between the needs of farmers and the need to ensure sustainable use of ground water. In this regard, the National Water Policy, 2012 recommends that the over extraction of ground water should be minimized by regulating the use of electricity for its extraction. Separate electric feeders for pumping ground water for agricultural use could address the issue.

**Ground water governance through electricity supply management: A case of Gujarat, India**

During 2003-2006, the government of Gujarat launched the *'Jyotigram'* (lighted village) scheme and invested Rs 1,450 crore to, (i) separate agricultural electricity feeders from non-agricultural ones, and (ii) established a tight regime for farm power rationing in the countryside. By 2006, the state had covered almost all of its 18,000 villages under the scheme of rationalized power supply. This led to two major changes: (i) villages receive 24 hour three-phase power supply for domestic uses, in schools, hospitals, village industries, all subject to metered tariff, and (ii) tubewell owners receive eight hours/day of power of full voltage and on a pre-announced schedule.

Source: Jyotigram Yojana, Department of Petrochemicals Department, Government of Gujarat; http://guj-epd.gov.in/epd_jyotiyojna.htm

The Commission on Price Policy for Kharif Crops (2015-16) has recommended rationed water use inagriculture by fixing quantitative ceilings on per hectare use of both water and electricity.[22] Also, if farmers are able to use water or electricity less than the ceilings fixed for them, they should be rewarded by cash incentives equivalent to unused units of water/power at the rates of their domestic resource costs. This will encourage farmers to use drip irrigation and other on-farm water management techniques to enhance production per drop of water.

## Inadequate regulation of ground water law

The government, from time to time has stated that ground water needs to be managed as a community resource. However, Section 7(g) of the Easement Act, 1882 states that every owner of land has the right to collect and dispose within his own limits all water under the land and on its surface which does not pass in a defined channel. The legal consequence of this law is that the owner of the land can dig wells in his land and extract water based on availability and his discretion.[24] Additionally, landowners are not legally liable for any damage caused to the water resources as a result of over- extraction. The lack of regulation for over-extraction of this resource further worsens the situation and has made private ownership of ground water common in most urban and rural areas.

The CGWB identifies over-exploited and critical areas within states. However, the Board does not have the power to stop ground water extraction in such areas and can only notify the owners. Additionally, because of a very large number of small users, it becomes increasingly difficult for the Board to identify and penalise the offenders.

## Quality of ground water

The Comptroller and Auditor General (CAG) of India in its Performance Audit of Water Pollution in India, 2011-12 observed that despite increasing pollution of ground water sources and presence of contaminants like arsenic, nitrate, fluoride, salinity, etc., no programme at the central or state level is being implemented for control of pollution and restoration of groundwater.[25] Additionally, the Central Pollution Control Board and the CGWB do not carry out real-time monitoring of water pollution in rivers, lakes and ground water sources.

The CAG has made the following recommendations with regard to the prevention and control of pollution of groundwater: (i) the Ministry of Environment, Forests, and Climate Change needs to establish enforceable water quality standards for lakes, rivers and ground water to help protect ecosystem and human health, (ii) penalties need to be levied for violations of water quality standards, and (iii) states need to take measures for source control of pollutants through sewage and agriculture runoff entering water bodies in projects for conservation and restoration of lakes

In response to the ‘Committee on Estimates’ which reviewed the occurrence of high arsenic content in groundwater, the Ministry of Water Resources constituted an ‘Inter-Ministerial Group’ for arsenic mitigation.[26] The group recommended the formation of a ‘National Arsenic Task Force’ to coordinate arsenic related matters between the central ministries and state governments and other institutions. In addition, it has worked out a project funding of Rs 3,839 crore for five states, namely Assam, Bihar, Jharkhand, Punjab and West Bengal.[26]

## Local management of ground water

The phenomena of local water users successfully managing their water resources has been observed in only a few areas. The Planning Commission recommended that local planners take the following steps while planning for ground water management:[10]

- Determining the relationship between surface hydrological units such as watershed or river basins, and hydrological units below the ground such as aquifers,
- Identification of ground water recharge areas,
- Maintaining ground water balance at the level of the village or the watershed, and
- Creating regulatory options at the community level such as panchayat. Examples of activities that could be regulated at the local level include drilling depth, distance between wells, cropping patterns to ensure sustainability of aquifers and participatory ground water management.

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