1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 04 (Class XII, Semester - 2)
Module Name/Title	Water Resources – Part 1
Module Id	legy_20601
Pre-requisites	Uses of water, sources of water
Objectives	After going through this lesson, the learners will be able to understand the following: • Water Resources of India • Water Demand and Utilisation • Emerging Water Problems
Keywords	Cyclic Resource, Surface and Ground Water Resources

2. Development Team

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Water Resources

Do you think that what exists today will continue to be so, or the future is going to be different in some respects? It can be said with some certainty that the societies will witness demographic transition, geographical shift of population, technological advancement, degradation of environment and water scarcity. Water scarcity is possibly to pose the greatest challenge on account of its increased demand coupled with shrinking supplies due to over utilisation and pollution.

Water is a cyclic resource with abundant supplies on the globe. Approximately, 71 per cent of the earth's surface is covered with it but freshwater constitutes only about 3 per cent of the total water. In fact, a very small proportion of freshwater is effectively available for human use.

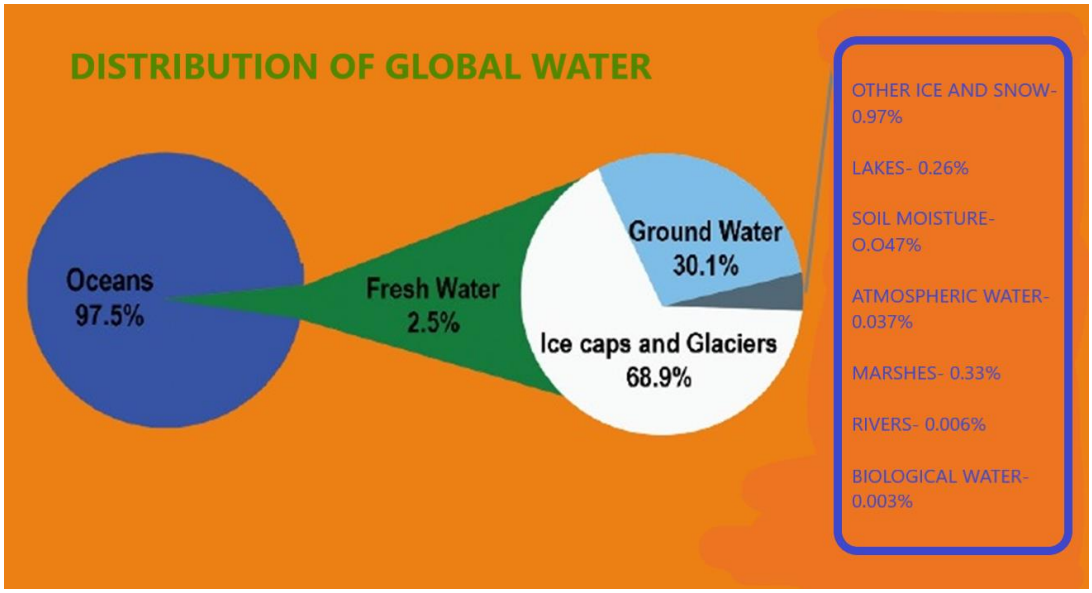


Image 1: Distribution of Global Water

Source- Self modified

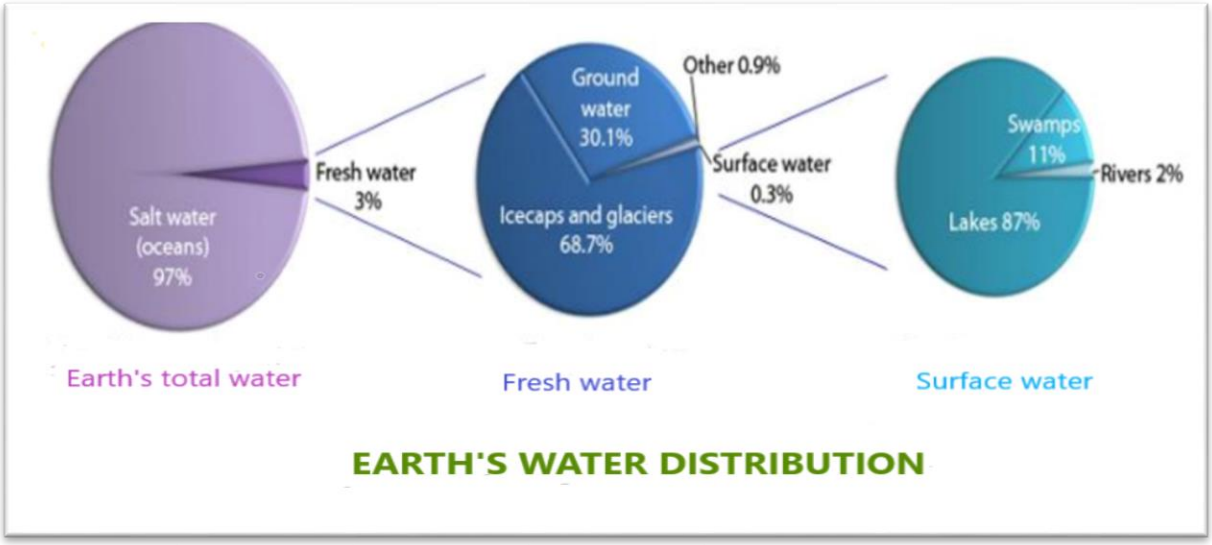


Image 2: Earth's water distribution

Source- Self modified

The availability of freshwater varies over space and time. The tensions and disputes on sharing and control of this scarce resource are becoming contested issues among communities, regions, and states. The assessment, efficient use and conservation of water, therefore, become necessary to ensure development.

In this chapter, we shall discuss water resources in India, its geographical distribution, sectoral utilisation, and methods of its conservation and management.

Major Water Repositories

Source- self created

Water Resources of India

India accounts for about 2.45 per cent of the world's surface area, 4 per cent of the world's water resources and about 16 per cent of the world's population. The total water available from precipitation in the country in a year is about 4,000 cubic km. The availability from surface water and replenishable groundwater is 1,869 cubic km. Out of this, only 60 per cent can be put to beneficial uses. Thus, the total utilisable water resource in the country is only 1,122 cubic km. Surface Water Resources. There are four major sources of surface water. These are rivers, lakes, ponds and tanks. In the country, there are about 10,360 rivers and their tributaries longer than 1.6 km each. The mean annual flow in all the river basins in India is estimated to be 1,869 cubic km. However, due to topographical, hydrological and other constraints, only about 690 cubic km (32 per cent) of the available surface water can be utilised. Water flow in a river depends on size of its catchment area or river basin and rainfall within its catchment area. The precipitation in India has very high spatial variation, and it is mainly concentrated in Monsoon season.

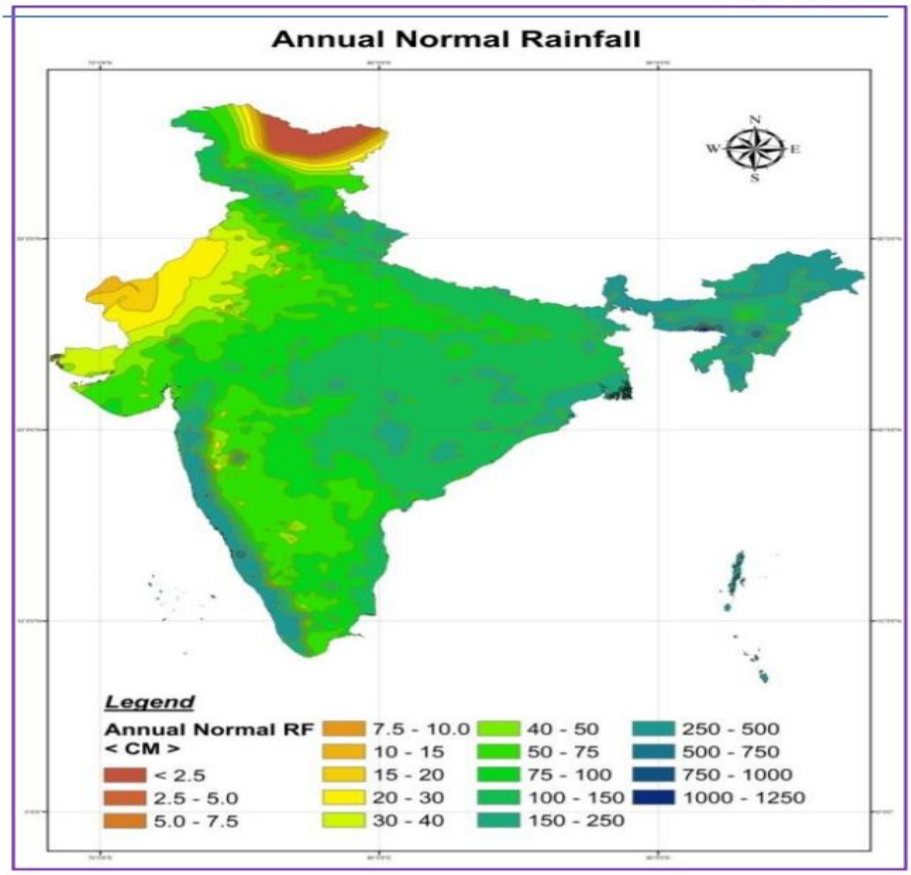


Image 3: Annual annual range rainfall

Source- http://cgwb.gov.in/Ground-Water/Groundwater%20Year%20Book%202017-18.pdf

Year	Population	Per Capita Fresh Water Availability (in cubic meter/annum)
1951	361	5177
1955	395	4732
1999	846	2209
2001	1027	1820
2025	1394 (Projected)	1341
2050	1640 (Projected)	1140

Image 4: Fresh Water Availability in India (Decadal trend cubic meter per capita per annum)

Source- http://cwc.gov.in/sites/default/files/arcwc2018-19.pdf

The rivers in the country like the Ganga, the Brahmaputra, and the Indus have huge catchment areas. Given that precipitation is relatively high in the catchment areas of the Ganga, the Brahmaputra and the Barak rivers, these rivers, although account for only about one-third of the total area in the country, have 60 per cent of the total surface water resources. Much of the annual water flow in south Indian rivers like the Godavari, the Krishna, and the Kaveri has been harnessed, but it is yet to be done in the Brahmaputra and the Ganga basins.

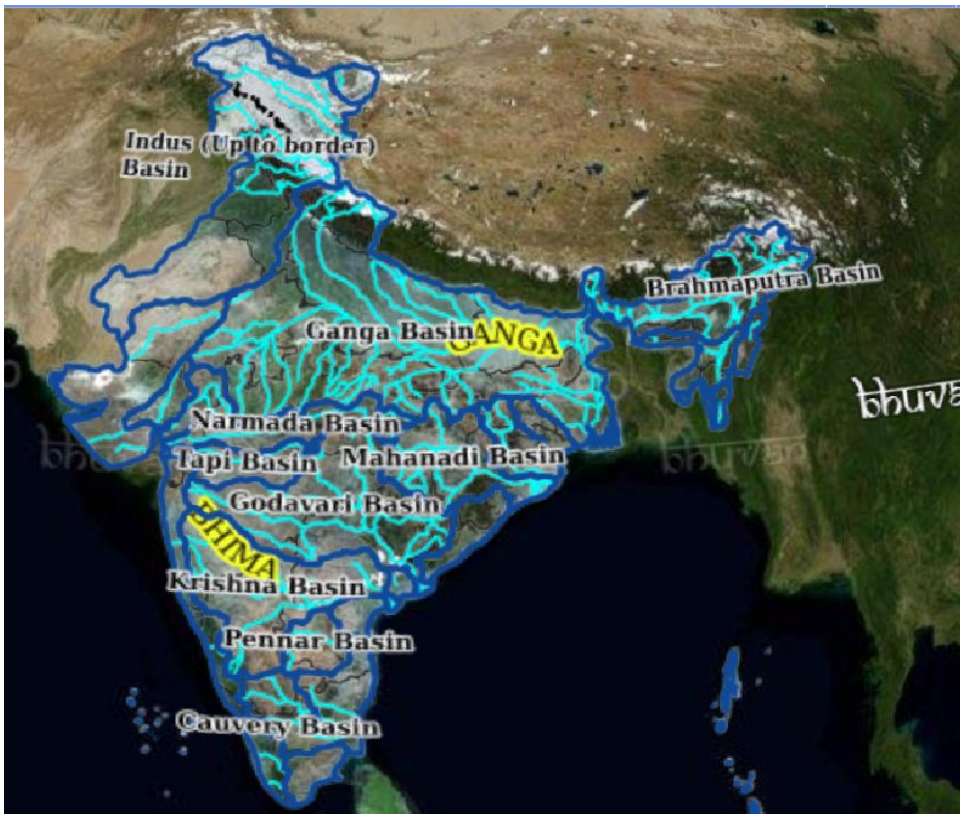
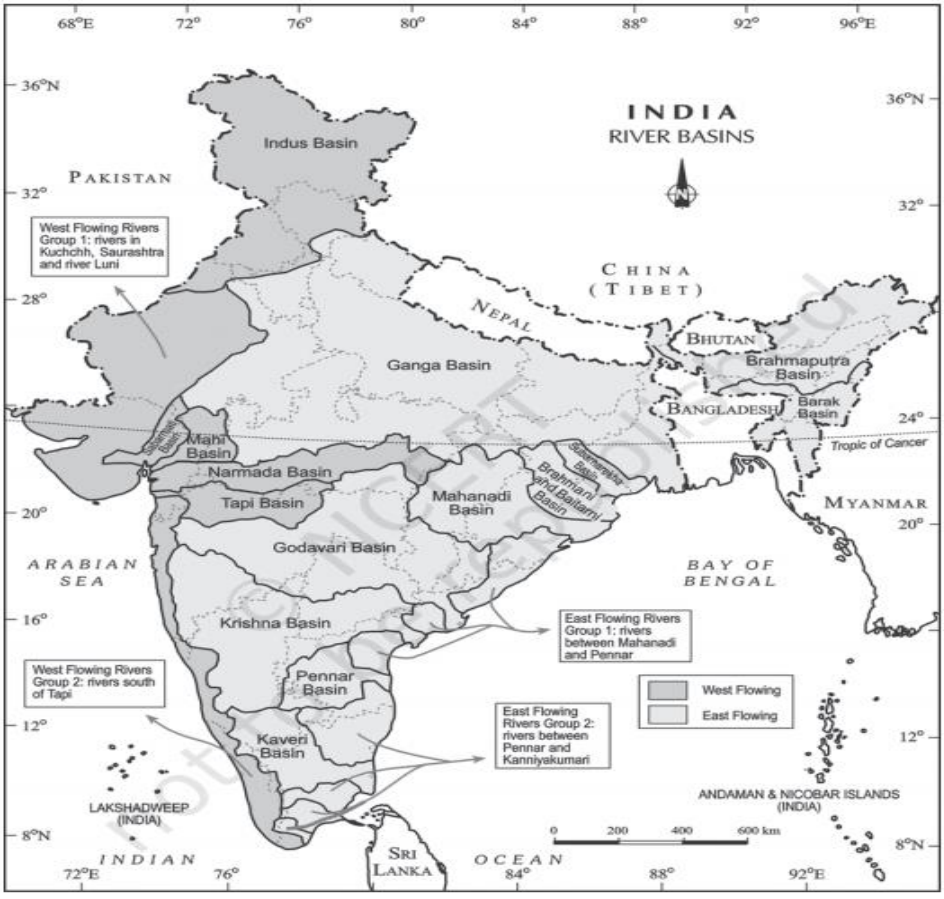


Image 5: Rivers of India and its basin

Source- Bhuvan portal



Pic-6 India – River Basins

Source- NCERT

Surface and Groundwater Uses

1. **Consumptive Use:** - In such uses, water is completely utilized and cannot be reused. Examples: Domestic, Industrial and Irrigation.

2. **Non-Consumptive Use:** In such uses, water isn't completely utilised and is re-used. Ex: Hydropower plant.

3. **Other Uses:**
    - Water is used for domestic purposes like drinking, bathing, cooking, washing. Etc.
    - Water is used in commercial establishments like hotels, theatres, educational institutions, offices, etc.
    - Almost 60-70% of fresh water is used for irrigation.
    - 20-30% of water is used for industrial operations by refineries, iron and steel industries, paper and pulp industries, etc.
    - Water plays a crucial role in sculpting the earth's surface, moderating climate and diluting pollutants.

Ground Water Resources

Rainfall is the major source of groundwater recharge in India, which is supplemented by other sources such as recharge from canals, irrigated fields and surface water bodies. A major part of the groundwater withdrawal takes place from the upper unconfined aquifers, which are also the active recharge zones and holds the replenishable groundwater resource. The replenishable groundwater resource in the active recharge zone in the country has been assessed by Central Ground Water Board jointly with the concerned State Government Authorities.

The Indian Sub-continent has a large area under metamorphic rocks of the pre-Cambrian period, Igneous rocks represented by basaltic rocks of Cretaceous- Eocene Period, Gondwana and Vindhyan rocks which are overlain by quaternary to recent sedimentary deposits. The distribution of these rock types can be seen in the geological map.

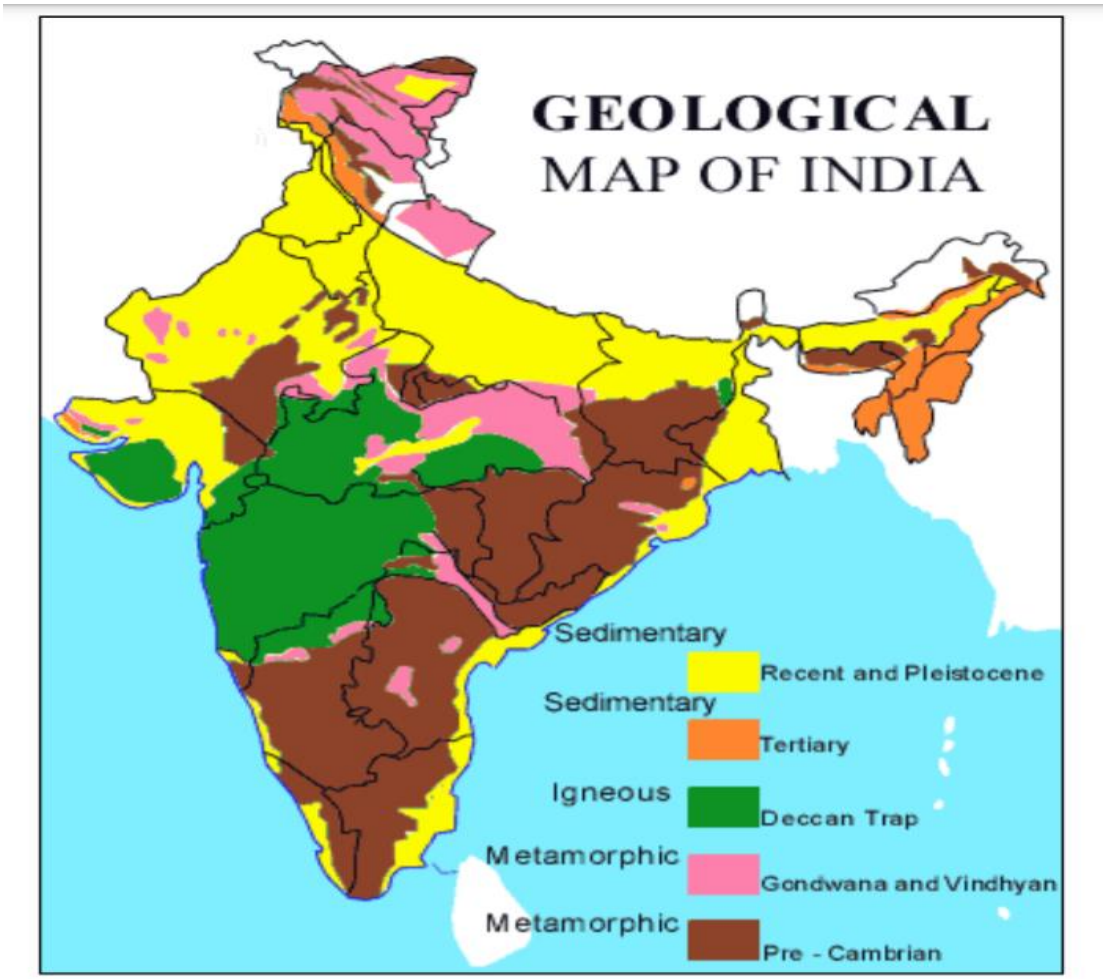


Image 7: Geological map of India (source- GIS)

Source- https://www.flickr.com/photos/hindiwater/27014705092/in/photostream/

Based on the formation characteristics and hydraulic properties to store and transmit groundwater, geologically. all the lithospheric units can be placed under two broad groups of water-bearing formations. These are: 1. Porous Formations which can be further classified into unconsolidated and semi consolidated formations having the primary porosity and 2. Fissured Formations along with their yield prospects. Physiographic and geomorphologic settings are among the important factors that control the occurrence and distribution of groundwater.

Based on these factors, the country has been broadly divided into 5 distinct regions as given below:

1. **Northern Mountainous Terrain and Hilly Areas**

   The highly rugged mountainous terrain in the Himalayan Region in the northern part of the country extending from Kashmir to Arunachal Pradesh is characterised by steep slopes and high runoff. This region is underlain mostly by rocks such as granites, slate, sandstone and limestone ranging in age from Palaeozoic to Cenozoic. The yield potential ranges from 1-40 lbs (liters per second). Though this area offers very little

scope for groundwater storage. It acts as the major source of recharge for the vast Indo-Gangetic and Brahmaputra alluvial plains.

2. Indo- Gangetic- Brahmaputra Alluvial Plains

This region encompasses an area of about 850,000sq km. covering states of Punjab, Haryana, Uttar Pradesh, Bihar, Assam and West Bengal accounting for more than one-fourth of country's land area, comprises the vast plains of Ganges and Brahmaputra rivers and are underlain by thick piles of sediments of Tertiary and quaternary age. This vast and thick alluvial fill, exceeding 1000m at places, constitute the most potential and productive groundwater reservoir in the country. These are characterised by regionally extensive and highly productive multi-aquifer systems. The groundwater development in this region is still sub-optimal, except in the states of Haryana and Punjab. The deeper aquifers available in these areas offer good scope for further exploitation of groundwater. In Indo-Gangetic-Brahmaputra plain, the deeper wells have yield ranging from 25-50lps (litres per second).

3. Peninsular Sheild Area

These are located south of Indo-Gangetic-Brahmaputra plains and consist mostly of consolidated sedimentary rocks, Deccan Trap basalts and crystalline rocks in the states of Maharashtra, And Tamil Nadu, Andhra Pradesh, Orissa and Kerala.

Occurrence and movement of groundwater in these formations are restricted to weathered residuum and interconnected fractures at deeper levels and they have limited groundwater potential. The rocks are commonly weathered to a depth of 30m, under the tropical conditions in the central and southern part of the peninsular region. Groundwater occurs mainly in the weathered and fractured zones of rocks, within the depth of less than 50m, occasionally down to 100m, and rarely below this depth.

4. Coastal Area

Coastal Areas have a thick cover of alluvial deposits of Pleistocene to Recent age from potential multi-aquifer systems in the states of Gujarat, Kerala, Tamil Nadu, Andhra Pradesh and Orissa. However, inherent quality problems and the risk of seawater ingress impose severe constraints in the development of these aquifers. In addition, the groundwater overdevelopment in these areas entails the risk of saline water ingress. Groundwater prospects in these aquifers vary widely depending on the local conditions and may range from 5-25lps (litres per second).

5. Cenozoic Falut Basin and Low Rainfall Areas

This region has been grouped separately owing to its peculiarity in terms of the presence of three discrete fault basins, The Narmada, The Purna and Tapti Valley, all of which contain extensive valley-fill deposits. The fill ranges in thickness from about 50-150m. The aquifer systems in arid and semi-arid tracts of this region in parts of Rajasthan and Gujarat receive negligible recharge from the scanty rains and the groundwater occurrence in these areas is restricted to deep aquifer systems tapping fossil water. For example, in parts of Purna valley, the groundwater is extensively saline and unfit for various purposes. The yield potential of the wells varies from 1-10lps.

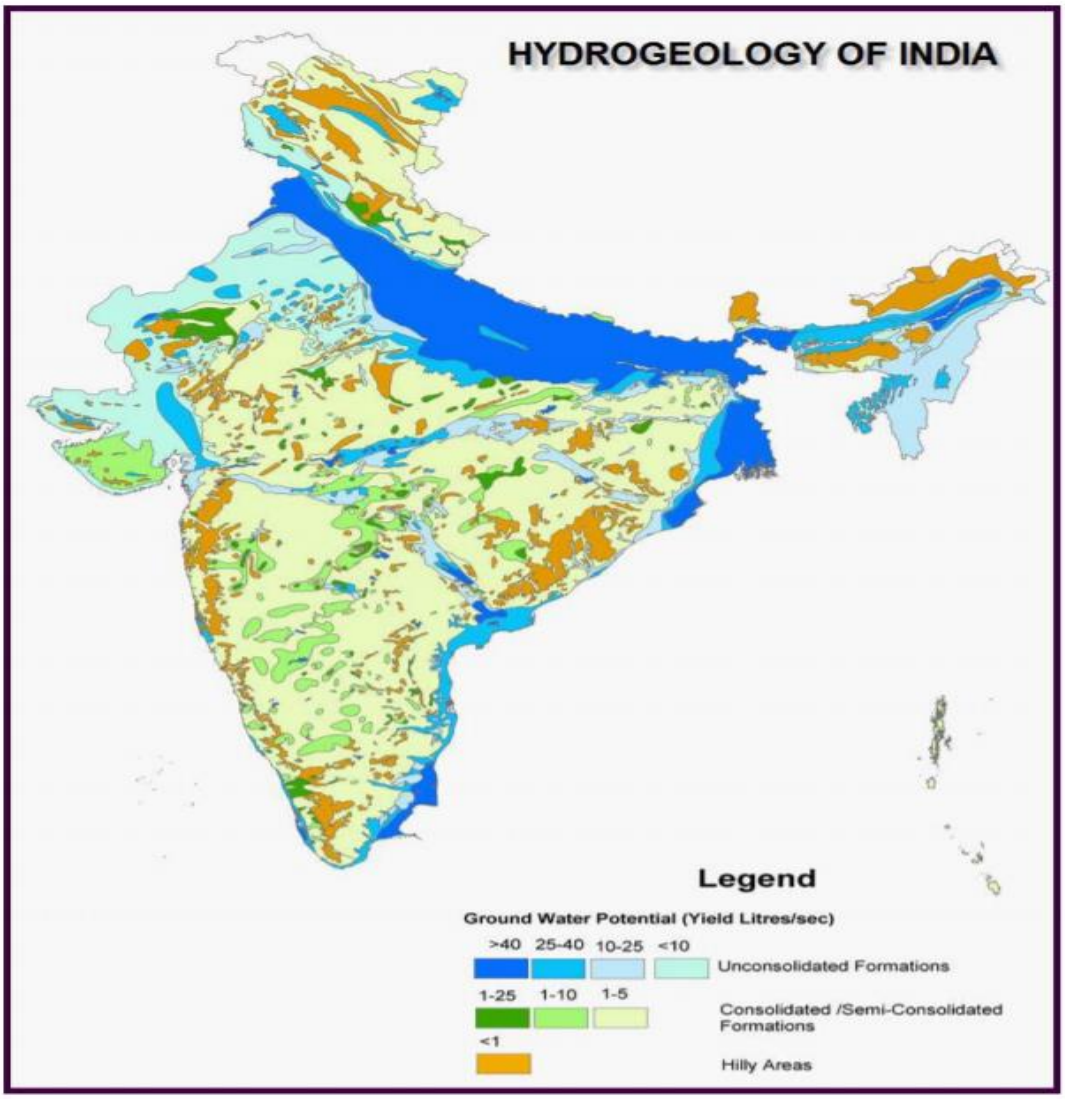


Image 8: Hydrology of India

Source: https://www.flickr.com/photos/hindiwater/26834935000/in/photostream/

Groundwater has emerged as the primary democratic water source and poverty reduction tool in India's rural areas. On account of its near-universal availability, dependability and low capital cost, it is the most preferred source of water to meet the requirements of various user

sectors in India. Groundwater has made significant contributions to the growth of India's Economy and has been an important catalyst for its socio-economic development. Its importance as a precious natural resource in the Indian context can be gauged from the fact that more than 85% of India's rural domestic water requirements, 50%of its urban water requirements and more than 50% of its irrigation requirements are being met from groundwater resources. The increasing dependence on groundwater as a reliable source of water has resulted in its large-scale and often indiscriminate development in various parts of the country, without due regard to the recharging capacities of aquifers and other environmental factors.

Access to groundwater allows farmers to intensify and diversify their cropping system, improve household food security and incomes, and shield against droughts. Over the past half century, groundwater has boosted agricultural production and underpinned agrarian transformation in large parts of Asia, North Africa and the Middle East.

Unsustainable use of ground water, can have severe and long-lasting consequences for ecosystems and societies. Today, groundwater and its socio-economic benefits in both rural and urban areas are threatened due to pollution and overexploitation caused by indiscriminate land use and countless unregistered private wells.

The total replenish able groundwater resources in the country are about 432 cubic km. The level of groundwater utilisation is relatively high in the river basins lying in north-western region and parts of south India. The groundwater utilisation is very high in the states of Punjab, Haryana, Rajasthan, and Tamil Nadu. However, there are States like Chhattisgarh, Odisha, Kerala, etc., which utilise only a small proportion of their groundwater potentials. States like Gujarat, Uttar Pradesh, Bihar, Tripura and Maharashtra are utilising their groundwater resources at a moderate rate. If the present trend continues, the demands for water would need the supplies. And such situation, will be detrimental to development, and can cause social upheaval and disruptions. Lagoons and Backwaters India has a vast coastline and the coast is very indented in some states. Due to this, a number of lagoons and lakes have formed. The States like Kerala, Odisha and West Bengal have vast surface water resources in these lagoons and lakes. Although, water is generally brackish in these water bodies, it is used for fishing and irrigating certain varieties of paddy crops, coconut, etc. In the map given below we can observe water level fluctuation in India.

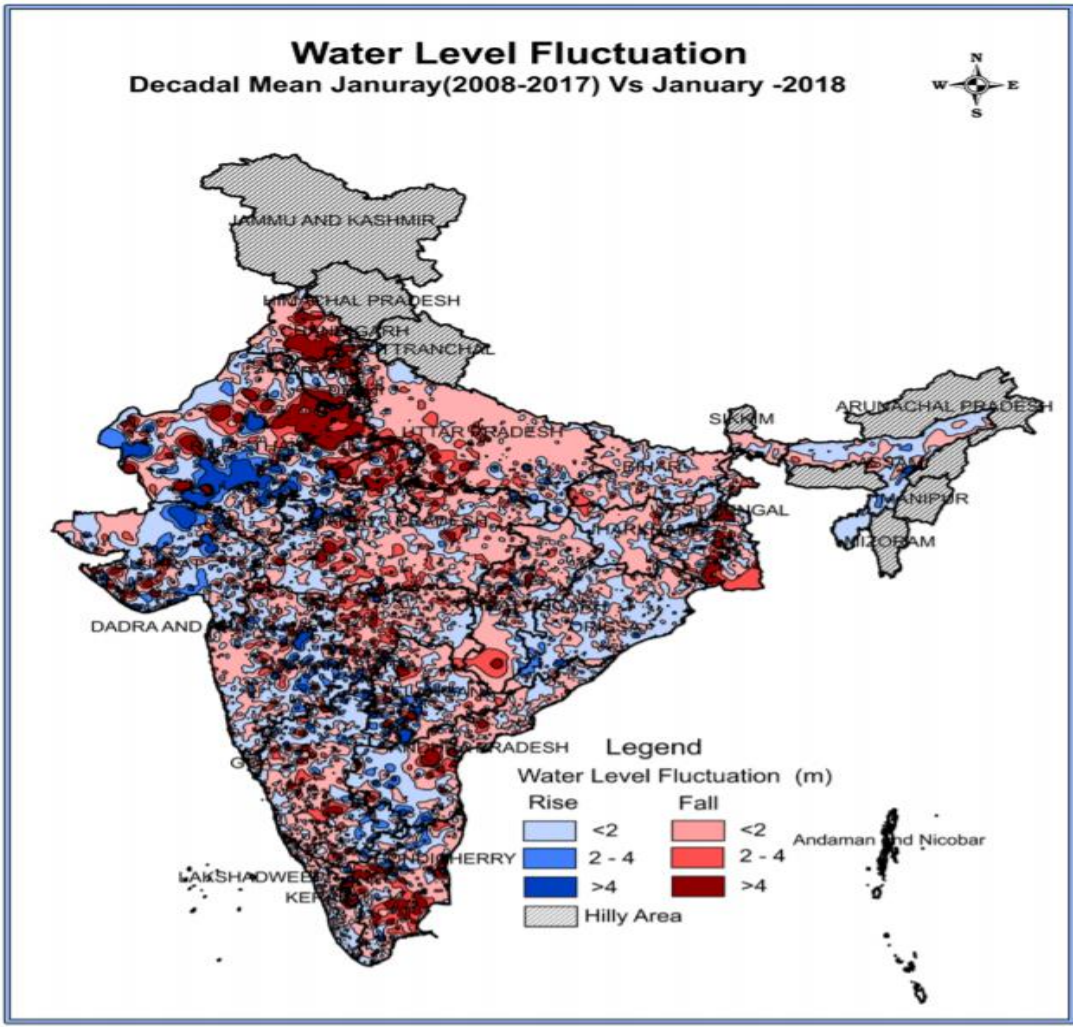


Image 9: Water Level Fluctuation

Source- http://cgwb.gov.in/Ground-Water/Groundwater%20Year%20Book%202017-18.pdf

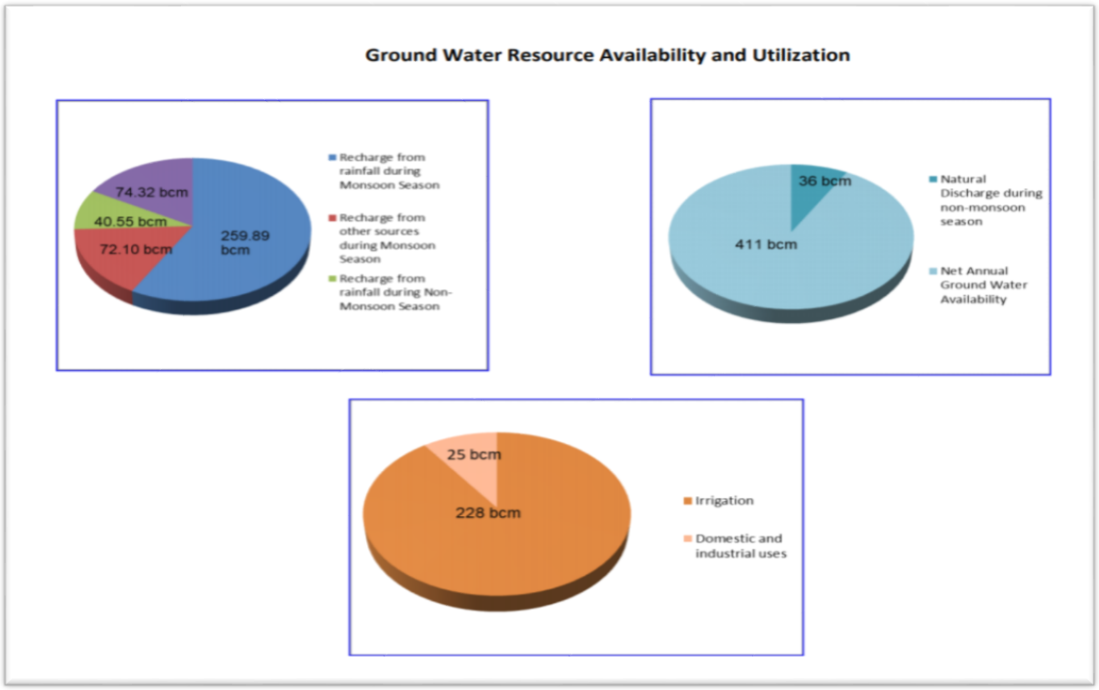


Image 10: Ground water resources availability and utilisation

Source- http://cgwb.gov.in/Ground-Water/Groundwater%20Year%20Book%202017-18.pdf

Water Demand and Utilisation

India has traditionally been an agrarian economy, and about two-third of its population have been dependent on agriculture. Hence, development of irrigation to increase agricultural production has been assigned a very high priority in the Five-Year Plans, and multipurpose river valleys projects, like the Bhakra-Nangal, Hirakud, Damodar Valley, Nagarjuna Sagar, Indira Gandhi Canal Project, etc., have been taken up. In fact, India's water demand at present is dominated by irrigational needs.

Agriculture accounts for most of the surface and groundwater utilisation, it accounts for 89 per cent of the surface water and 92 per cent of the groundwater utilisation. While the share of industrial sector is limited to 2 per cent of the surface water utilisation and 5 per cent of the ground-water, the share of domestic sector is higher (9 per cent) in surface water utilisation as compared to groundwater. The share of agricultural sector in total water utilisation is much higher than other sectors. However, in future, with development, the shares of industrial and domestic sectors in the country are likely to increase.

Demand of Water for Irrigation

In agriculture, water is mainly used for irrigation. Irrigation is needed because of spatio-temporal variability in rainfall in the country. The large tracts of the country are deficient in rainfall and are drought prone. North-western India and Deccan plateau constitute such areas. Winter and summer seasons are more or less dry in most part of the country. Hence, it is difficult to practise agriculture without assured irrigation during dry seasons. Even in the areas of ample rainfall like West Bengal and Bihar, breaks in monsoon or its failure creates dry spells detrimental for agriculture. Water need of certain crops also makes irrigation necessary. For instance, water requirement of rice, sugarcane, jute, etc. is very high which can be met only through irrigation. Provision of irrigation makes multiple cropping possible. It has also been found that irrigated lands have higher agricultural productivity than unirrigated land. Further, the high yielding varieties of crops need regular moisture supply, which is made possible only by a developed irrigation system. In fact, this is why that green revolution strategy of agriculture development in the country has largely been successful in Punjab, Haryana and western Uttar Pradesh. In Punjab, Haryana and western Uttar Pradesh, more than 85 per cent of their net sown area is under irrigation. Wheat and rice are grown mainly with the help of irrigation in these states. Of the total net irrigated area 76.1 per cent in Punjab and 51.3 per cent in Haryana are irrigated through wells and tube wells. This shows that these states utilise large

proportion of their groundwater potential which has resulted in groundwater depletion in these states.

Building construction activities seal permeable soil Zone and reduce the area for percolation of rainwater thereby increase runoff.

Impact of over utilisation of surface and ground water resources

The rapid increase in population and industrial growth led to severe demand on water resources. After using all available surface water resources to the maximum, human beings began using groundwater to meet their needs.

1. The over-use of groundwater resources has led to decline in groundwater table in these states.
2. In fact, over withdrawals in some states, like Rajasthan and Maharashtra, has increased fluoride concentration in groundwater, and this practice has led to increase in concentration of arsenic in parts of West Bengal and Bihar.
3. Intensive irrigation in Punjab, Haryana and western Uttar Pradesh is increasing salinity in the soil and depletion of groundwater irrigation.
4. The increased extraction of groundwater far in excess of the natural recharge led to decreased groundwater level. The erratic and inadequate rainfall caused reduction in storage of water in reservoirs. This also led to decrease of groundwater.
5. Over utilization of groundwater in coastal areas leads to rapid intrusion of salt water from the sea thereby rendering it unusable for drinking and agriculture.
6. Over-utilization of groundwater leads to drying-up of dug wells as well as bore wells.
7. Human activities for infrastructure development like creation of dams, land conversion, etc. are responsible for this loss of integrity of freshwater ecosystems. Water quality and quantity, fisheries, habitats, etc. are at risk due to this loss of integrity.
8. Due to excess use of groundwater near agricultural fields, agricultural water that contains nitrogen as a fertilizer percolates rapidly and pollutes the groundwater thereby rendering the water unfit for potable use by infants.
9. If groundwater withdrawal rate is higher than recharge rate, sediments in aquifers get compacted resulting in sinking of overlaying land surface. The is called land subsidence which leads to structural damage in buildings, fracture in pipes and reverses the flow of canals leading to tidal flooding.
10. Over-utilization of groundwater leads to decrease in water level thereby causing earthquake, landslides and famine.

11. Over-utilization of groundwater in arid and semi-arid regions for agriculture disturbs equilibrium of reservoir in the region causing problems like lowering of water table and decreased pressure in aquifers coupled with changes in speed and direction of water flow.

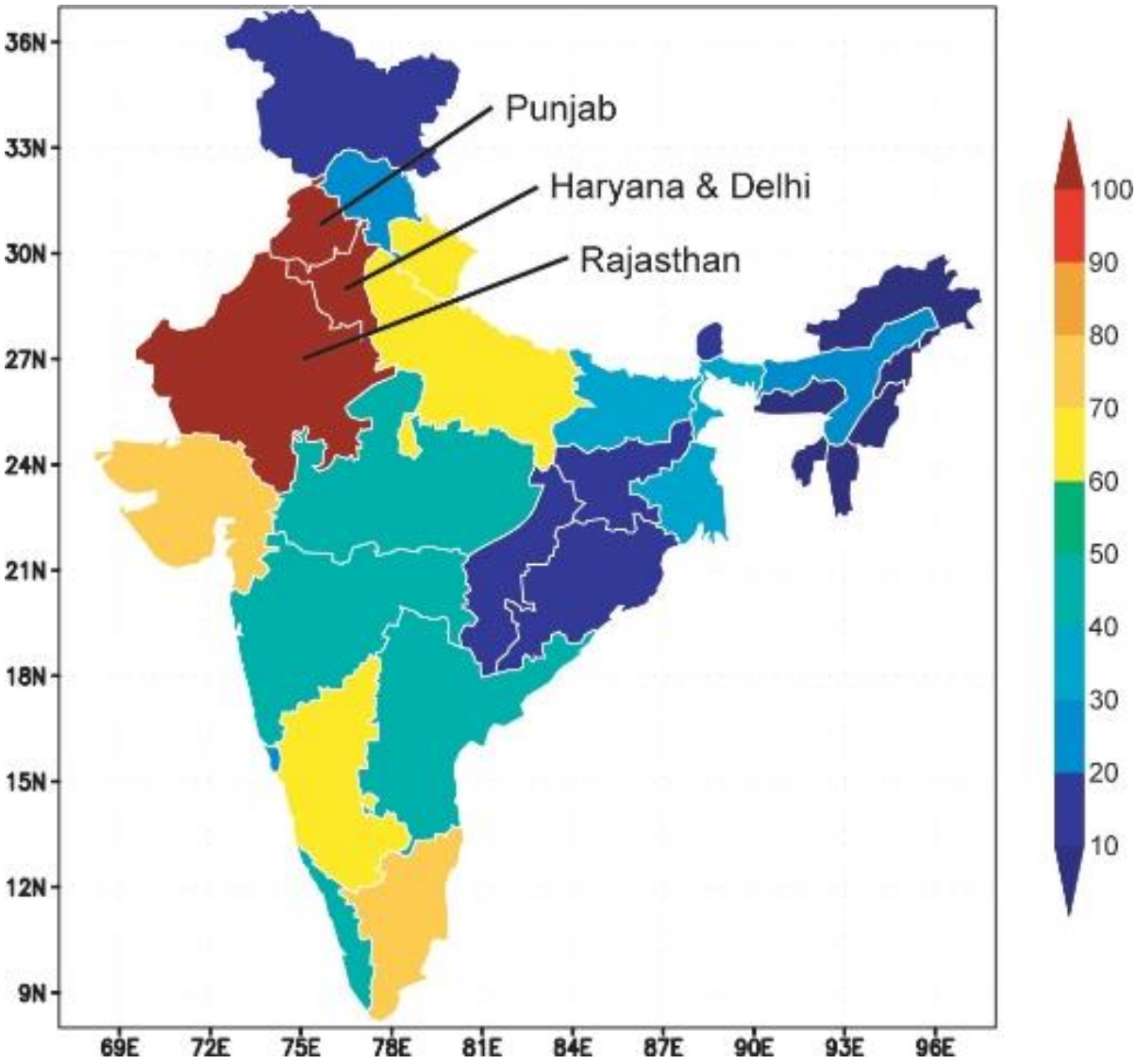


Image 11: The map, showing groundwater withdrawals as a percentage of groundwater recharge, is based on state-level estimates of annual withdrawals and recharge reported by India's Ministry of Water Resources.

Credit: NASA

Source- https://www.indiawaterportal.org/articles/images-and-facts-ground-water-situation-india

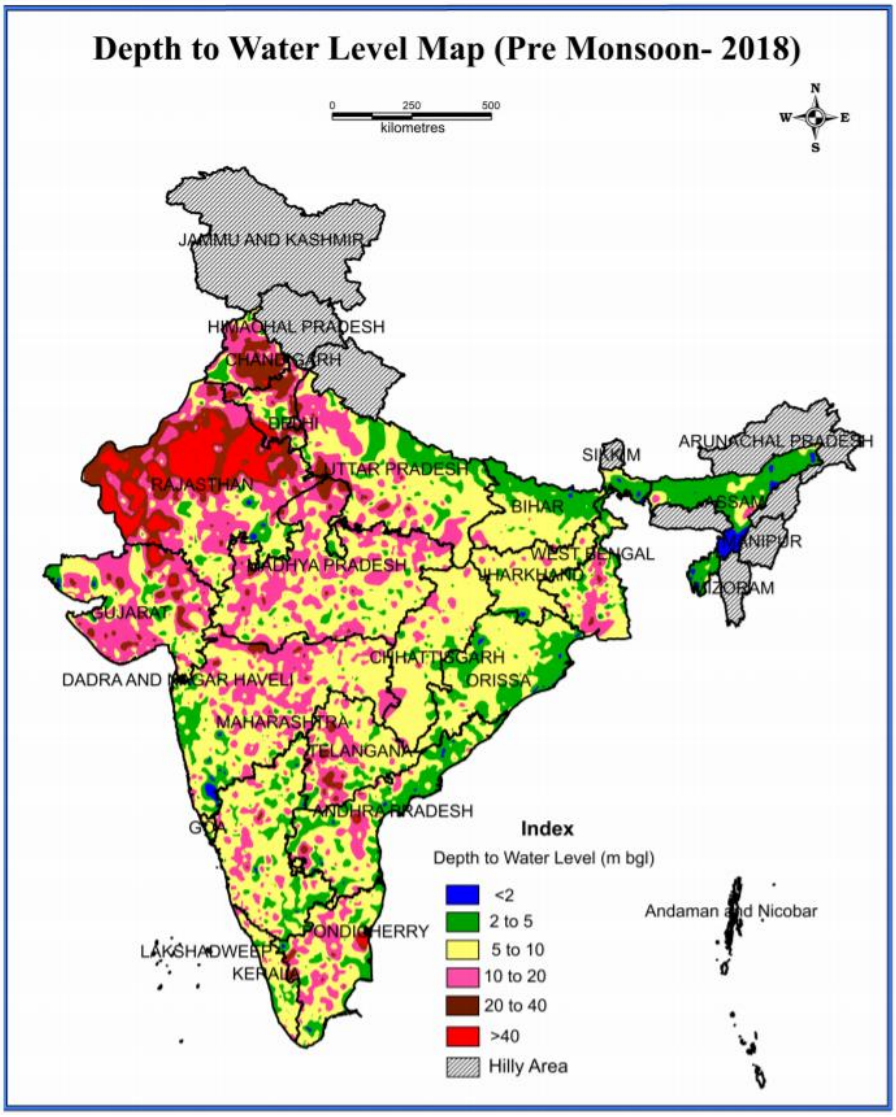


Image 12: Depth of Water Level

Source- http://cgwb.gov.in/Ground-Water/AllIndiaGWReportMay2018.pdf

Emerging Water Problems

1. The per capita availability of water is dwindling day-by-day due to increase in population.
2. The available water resources are also getting polluted with industrial, agricultural and domestic effluents, and this, in turn, is further limiting the availability of usable water resources.
3. Deterioration of Water Quality - Water quality refers to purity of water, or water without unwanted foreign substances. Water gets polluted by foreign matters, such as micro-organisms, chemicals, industrial and other wastes. Such matters deteriorate the quality of water and render it unfit for human use. When toxic substances enter lakes, streams, rivers, ocean and other water bodies, they get dissolved or lie suspended in water. This results in pollution of water, whereby quality of water deteriorates affecting aquatic systems.

Sometimes, these pollutants also seep down and pollute groundwater. The Ganga and the Yamuna are the two highly polluted rivers in the country.

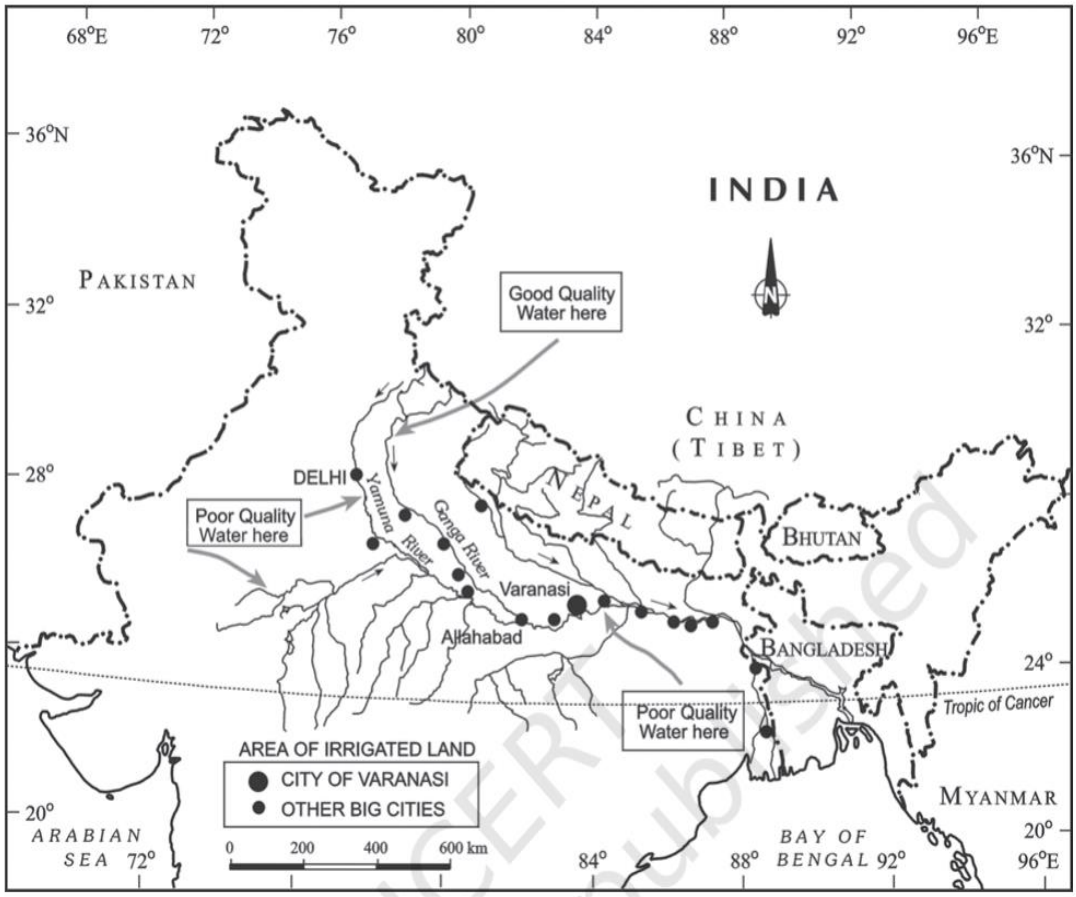


Image 13: The Ganga and its Tributaries and Towns Located on them

Source- NCERT

Although irrigation will continue to be the major consumer of water in coming times, its share in the total water use may reduce while the share of water use for domestic, industrial and energy purposes will rise due to urbanisation and industrialisation.

The requirement of water for other uses such as navigation, ecological and recreation, although not so significant in terms of consumptive use, will continue to be important and will have specific quantity and for temporal needs.

Therefore, long term perspective planning for sustainable development of water resources in a holistic and integrated manner, with emphasis on more efficient use is necessary to achieve the goal of economic prosperity.

Causes of Water crisis in India

1. The increasing population is a reason for insufficient water per head. While it has been estimated that the amount of usable water should be between 700-1200 billion cubic meters, India has only 1000 cubic meters of water per head.

2. Water in most rivers is polluted marking it unfit for drinking or any other use. The poor quality rises from insufficient and delayed investment in urban water-treatment facilities. Industrial effluent rules are not implemented due to inadequate technical and human resource availability with the state pollution control boards.
3. Excess extraction by farmers has led to the dwindling groundwater supplies it is because access to ground water is free and anyone has a right to pump water from their own land.
4. Poor monsoon due to climate change has further aggravated the groundwater situation since the latter heavily depends on rains. Poor rainfall compels the farmers to dig further down for groundwater to irrigate the field. This results in pushing the tables deeper down.
5. Unrestrained urbanization has contributed in a big way and despite India being one of the richest nations in water supply, the government and citizens have exploited the water reserves.
6. Quality of groundwater is another issue especially where it is used for human consumption. A number of factors contaminate the groundwater like sewage, run off from landfills, use of pesticides and fertilizers etc.
7. Depleting groundwater has posed such a threat that cities are now compelled to look for alternate supplies either because of polluted groundwater or that it will cease to exist very soon.

Every organism has a right to live in a pollution free environment. Water pollution can contaminate the freshwater and leaving us with none for the future generations. Water pollution also causes health issues. It has negative effects on agriculture and the environment. It is our main duty to protect the water and prevent them from getting polluted. We the people must take initiative steps in protecting the environment along with the government. The Acts which are already prevailing must be in a fully effective manner to protect our environment which will make things easier.

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