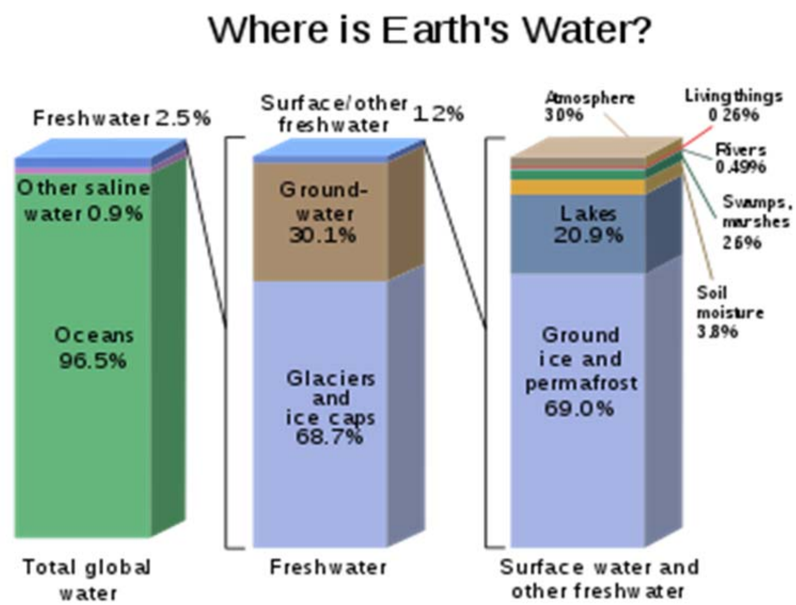
Chapter **2**

Water Resources of India

Water resources are sources of water that are potentially useful. Uses of water include agricultural, industrial, household, recreational and environmental activities. The majority of human uses require fresh water. 97 per cent of the water on the Earth is salt water and only three percent is fresh water; slightly over two thirds of this is frozen in glaciers and polar ice caps. The remaining unfrozen freshwater is found mainly as groundwater, with only a small fraction present above ground or in the air.



Fresh water is a renewable resource, yet the world's supply of groundwater is steadily decreasing, with depletion occurring most prominently in Asia, South America and North America, although it is still unclear how much natural renewal balances this usage, and whether ecosystems are threatened.[3] The framework for allocating water resources to water users (where such a framework exists) is known as water rights.

A graphical distribution of the locations of water on Earth. Only 3% of the Earth's water is fresh water. Most of it is in icecaps and glaciers (69%) and groundwater (30%), while all lakes, rivers and swamps combined only account for a small fraction (0.3%) of the Earth's total freshwater reserves.

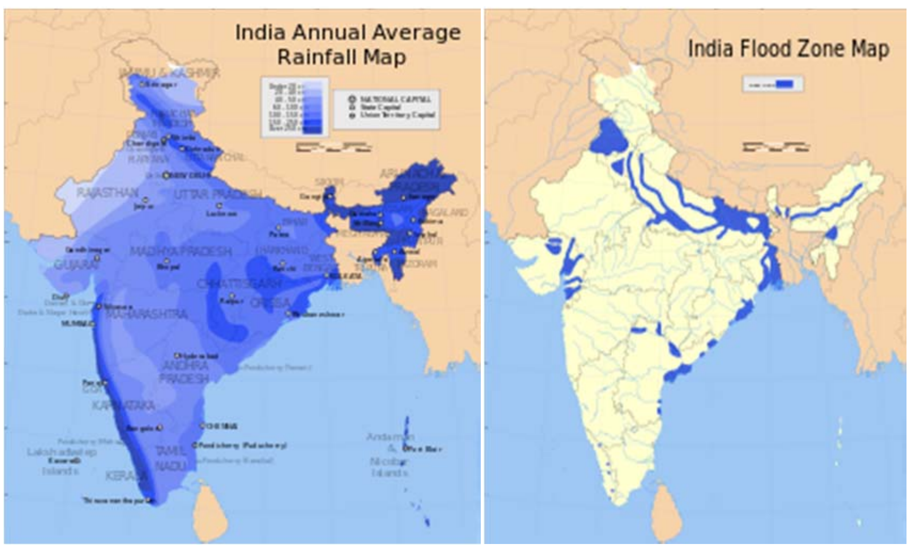
India experiences an average precipitation of 1,170 millimetres (46 in) per year, or about 4,000 cubic kilometres (960 cu mi) of rains annually or about 1,720 cubic metres (61,000 cu ft) of fresh water *per person* every year. Some 80 percent of its area experiences rains of 750 millimetres (30 in) or more a year. However, this rain is not uniform in time or geography. Most of the rains occur during its monsoon seasons (June to September), with the north east and north receiving far more rains than India's west and south.

Other than rains, the melting of snow over the Himalayas after winter season feeds the northern rivers to varying degrees. The southern rivers however experience more flow variability over the year. For the Himalayan basin, this leads to flooding in some months and water scarcity in others. Despite extensive river system, safe clean drinking water as well as irrigation water supplies for sustainable agriculture are in shortage across India, in part because it has, as yet, harnessed a small fraction of its available and recoverable surface water resource. India harnessed 761 cubic kilometres (183 cu mi) (20 percent) of its water resources in 2010, part of which came from unsustainable use of groundwater.[2] Of the water it withdrew from its rivers and groundwater wells, India dedicated about 688 cubic kilometres (165 cu mi) to irrigation, 56 cubic kilometres (13 cu mi) to municipal and drinking water applications and 17 cubic kilometres (4.1 cu mi) to industry.[1]

Vast area of India is under tropical climate which is conducive throughout the year for agriculture due to favourable warm and sunny conditions provided perennial water supply is available to cater to the high rate of evapotranspiration from the cultivated land. Though the overall water resources are adequate to meet all the requirements of the country, the water supply gaps due to temporal and spatial distribution of water resources are to be bridged by interlinking the rivers.

The total water resources going waste to the sea are nearly 1200 billion cubic meters after sparing moderate environmental / salt export water requirements of all rivers. Food security in India is possible by achieving water security first which in turn is possible with energy security to supply the electricity for the required water pumping as part of its rivers interlinking.

a) Annual average rainfall in India. b) Map showing rivers and flood prone areas in India



Drought, floods and shortage of drinking water[

Instead of opting for centralised mega water transfer projects which would take long time to give results, it would be cheaper alternative to deploy extensively shade nets over the cultivated lands for using the locally available water sources efficiently to crops throughout the year. Plants need less than 2% of total water for metabolism requirements and rest 98% is for cooling purpose through transpiration. Shade nets or poly tunnels installed over the agriculture lands suitable for all weather conditions would reduce the potential evaporation drastically by reflecting the excessive and harmful sun light without falling on the cropped area.

The precipitation pattern in India varies dramatically across distance and over calendar months. Much of the precipitation in India, about 85%, is received during summer months through monsoons in the Himalayan catchments of the Ganges-Brahmaputra-Meghna basin. The north eastern region of the country receives heavy precipitation, in comparison with the north western, western and southern parts.

The uncertainty in onset of annual monsoon, sometimes marked by prolonged dry spells and fluctuations in seasonal and annual rainfall is a serious problem for the country. Large area of the country is not put to use for agriculture due to local water scarcity or poor water quality. The nation sees cycles of drought years and flood years, with large parts of west and south experiencing more deficits and large variations, resulting in immense hardship particularly the poorest farmers and rural populations. Dependence on erratic rains and lack of irrigation water supply regionally leads to crop failures and farmer suicides. Despite abundant rains during July–September, some regions in other seasons see shortages of drinking water. Some years, the problem temporarily becomes too much rainfall, and weeks of havoc from floods.

Surface water and groundwater storages

India currently stores only 6% of its annual rainfall or 253 billion cubic metres (8.9×10^{12} cu ft), while developed nations strategically store 25 % of the annual rainfall in arid river basins. India also relies excessively on groundwater resources, which accounts for over 50 per cent of irrigated area with 20 million tube wells installed.

India has built nearly 5,000 major or medium dams, barrages, etc. to store the river waters and enhance ground water recharging.The important dams (59 nos) have an aggregate gross storage capacity of 170 billion cubic metres (6.0×10^{12} cu ft). About 15 percent of India's food is being produced using rapidly depleting / mining groundwater resources. The end of the era of massive expansion in groundwater use is going to demand greater reliance on surface water supply systems.

Water supply and sanitation

Water supply and sanitation in India continue to be inadequate, despite long-standing efforts by the various levels of government and communities at improving coverage. The level of investment in water and sanitation, albeit low by international standards, has increased during the 2000s. Access has also increased significantly. For example, in 1980 rural sanitation coverage was estimated at 1% and reached 21% in 2008. Also, the share of Indians with access to improved sources of water has increased significantly from 72% in 1990 to 88% in 2008. At the same time, local government institutions in charge of operating and maintaining the infrastructure are seen as weak and lack the financial resources to carry out their functions. In addition, no major city in India is known to have a continuous water supply and an estimated 72% of Indians still lack access to improved sanitation facilities.

In spite of adequate average rainfall in India, there is large area under the less water conditions/drought prone. There are lot of places, where the quality of groundwater is not good. Another issue lies in interstate distribution of rivers. Water supply of the 90% of India's territory is served by inter-state rivers. It has created growing number of conflicts across the states and to the whole country on water sharing issues.

A number of innovative approaches to improve water supply and sanitation have been tested in India, in particular in the early 2000s. These include demand-driven approaches in rural water supply since 1999, community-led total sanitation, a public-private partnerships to improve the continuity of urban water supply in Karnataka, and the use of micro-credit to women in order to improve access to water.

Water Resources of India

Water resources of India Although India occupies only 3.29 million km2 geographical areas, which forms 2.4% of the world's land area, it supports over 15% of the world's population. The Water Resource of India: From Distribution to Management 847 population of India as on 1 March 2001 stood at 1,027,015,247 persons. Thus, India supports about 1/6th of world population, 1/50th of world's land and 1/25th of world's water resources. India also has a livestock population of 500 million, which is about 20% of the world's total livestock population. More than half of these are cattle, forming the backbone of Indian agriculture. The total utilizable water resources of the country are assessed as 1086 km3. A brief description of surface and groundwater water resources of India is given below. Surface water resources: In the past, several organizations and individuals have estimated water availability for the nation. Recently, the National Commission for Integrated Water Resources Development estimated the basin-wise average annual flow in Indian River systems as 1953 km3. Utilizable water resource is the quantum of withdrawable water from its place of natural occurrence. Within the limitations of physiographic conditions and socio-political environment, legal and constitutional constraints and the technology of development available at present, utilizable quantity of water from the surface flow has been assessed by various authorities differently. The utilizable annual surface water of the country is 690 km3. There is considerable scope for increasing the utilization of water in the Ganga–Brahmaputra basins by construction of storages at suitable locations in neighbouring countries. Groundwater resources: The annual potential natural groundwater recharge from rainfall in India is about 342.43 km3, which is 8.56% of total annual rainfall of the country. The annual potential groundwater recharge augmentation from canal irrigation system is about 89.46 km3. Thus, total replenishable groundwater resource of the country is assessed as 431.89%. After allotting 15% of this quantity for drinking, and 6 km3 for industrial purposes, the remaining can be utilized for irrigation purposes. Thus, the available groundwater resource for irrigation is 361 km3, of which utilizable quantity (90%) is 325 km3. As per the estimates by the Central

Groundwater Board (CGWB) of total replenishable groundwater resource, provision for domestic, industrial and irrigation uses and utilizable groundwater resources for future use. The basin wise per capita water availability varies between 13,393 m3 per annum for the Brahmaputra–Barak basin to about 300 m3 per annum for the Sabarmati basin.

Water pollution

Out of India's 3,119 towns and cities, just 209 have partial treatment facilities, and only 8 have full wastewater treatment facilities (WHO 1992). 114 cities dump untreated sewage and partially cremated bodies directly into the Ganges River.[27] Downstream, the untreated water is used for drinking, bathing, and washing. This situation is typical of many rivers in India and river Ganga is less polluted comparatively.[28]

Open defecation is widespread even in urban areas of India

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Water requirements of India

Traditionally, India has been an agriculture-based economy. Hence, development of irrigation to increase agricultural production for making the country self-sustained and for poverty alleviation has been of crucial importance for the planners. Accordingly, the irrigation sector was assigned a very high priority in the 5-year plans. Giant schemes like the Bhakra Nangal, Hirakud, Damodar Valley, Nagarjunasagar, Rajasthan Canal project, etc. were taken up to increase irrigation potential and maximize agricultural production. Long-term planning has to account for the growth of population. According to National Water Policy1, the production of food grains has increased from around 50 million tonnes in the fifties to about 203 million tonnes in the year 1999–2000. A number of individuals and agencies have estimated the likely 848 Sneh Gangwar population of India by the year 2025 and 2050. According to the estimates adopted by NCIWRD, by the year 2025, the population is expected to be 1333 million in highgrowth scenario and 1286 million in low growth scenario. For the year 2050, high rate of population growth is likely to result in about 1581 million people while the low growth projections place the number at nearly 1346 million. Keeping in view the level of consumption, losses in storage and transport, seed requirement, and buffer stock, the projected food-grain and feed demand for 2025 would be 320 million tonnes (highdemand scenario) and 308 million tonnes (low-demand scenario). The requirement of food grains for the year 2050 would be 494 million tonnes (high-demand scenario) and 420 million tonnes (low demand scenario). The availability of water in India shows wide spatial and temporal variations. Also, there are very large inter annual variations. Hence, the general situation of availability of per capita availability is much more alarming than what is depicted by the average figures Estimates of India's water budget, i.e., annual flow of water available for human use after allowing for evapo-transpiration and minimum required ecological flow, vary considerably. The water budget derived from MoWR estimates, utilizable water of 1,123 billion cubic metres (BCM) against current water use of 634 BCM suggesting more than adequate availability at the aggregate level given current requirements. This is based on the Central Water Commission's estimates of India's water resource potential as 1,869 BCM. The standing sub-committee of MoWR estimates total water demand rising to 1,093 BCM in 2025, thus reaffirming a comfortable scenario. More recent calculations based on higher estimates of the amount of water lost to the atmosphere by evapo-transpiration are much less comforting. Narasimhan (2008) has recalculated India's water budget, using an evapo-transpiration rate of 65 per cent, which compares with worldwide figures ranging from 60 per cent to 90 per cent instead of the 40 per cent rate assumed in official estimates. After allowing the same 48.8 per cent for ecological flows, his estimate of water utilizable for human use comes to only 654 BCM, which is very close to the current actual water use estimate of 634 BCM. In addition to the fact that aggregate estimates suffer from data infirmities and arbitrary assumptions and are still being debated and contested, it is also important to emphasize that in a country of such immense physiographic, hydro geological, and demographic diversity, and also vastly different levels of economic development (hence water use), water balances for the country as a whole are of limited value since they hide the existence of areas of acute water shortages and also problems of quality. What is required is a much more disaggregated picture, accurately reflecting the challenge faced by each region. The exact level at which regions need to be defined would depend on the purposes of the exercise, as also the unifying features of the region, such as basin and aquifer boundaries. Water Resource of India: From Distribution to Management 849 4. Water resources management in India In view of the existing status of water resources and increasing demands of water for meeting the requirements of the rapidly growing population of the country as well as the problems that are likely to arise in future, a holistic, well planned long-term strategy is needed for sustainable water resources management in India. The water resources management practices may be based on increasing the water supply and managing the water demand under the stressed water availability conditions. Data monitoring, processing, storage, retrieval and dissemination constitute the very important aspects of the water resources management. These data may be utilized not only for management but also for the planning and design of the water resources structures. In addition to these, now days decision support systems are being developed for providing the necessary inputs to the decision makers for water resources management. Also, knowledge sharing, people's participation, mass communication and capacity building are essential for effective water resources management.

Water conservation implies improving the availability of water through augmentation by means of storage of water in surface reservoirs, tanks, soil and groundwater zone. It emphasizes the need to modify the space and time availability of water to meet the demands. This concept also highlights the need for judicious use of water. There is a great potential for better conservation and management of water resources in its various uses. On the demand side, a variety of economic, administrative and community-based measures can help conserve water. Rainwater harvesting is the process to capture and store rainfall for its efficient utilization and conservation to control its runoff, evaporation and seepage another way through which we can improve freshwater availability is by recycle and reuse of water. It is said that in the city of Frankfurt, Germany, every drop of water is recycled eight times. Use of water of lesser quality, such as reclaimed wastewater, for cooling and fire fighting is an attractive option for large and complex industries to reduce their water costs, increase production and decrease the consumption of energy. This conserves better quality waters for potable uses. Currently, recycling of water is not practised on a large scale in India and there is considerable scope and incentive to use this alternative. Another strategy, which needs consideration, is changes in water pricing structures.

What is water privatization? Water privatization involves transferring of water control and/or water management services to private companies. The water management service may include collection, purification, distribution of water, and waste water treatment in a community. Traditionally this service has been provided by the local governmental infrastructure such as the municipality or local city council. The pro privatization lobby including water corporations, world bank and IMF has aggressively campaigned for water privatization on the grounds that, while water subsidies promote wasteful practices, commoditisation of water should allow market forces (supply and demand) to set the water tariff, which in turn will reduce water consumption and promote water conservation. Furthermore, it is argued that opening this sector to private providers, will bring in badly needed capital for upgrading and development of infrastructure There are several models of water privatization that are currently in trend in different parts of the world.9 Depending on the degree of privatization, these models can be broadly categorized into: Service Contracts – In this model, public authority retains overall responsibility for the operation and maintenance of the system, and contracts out specific components. Service contracts last 1-3 years and include services such as meter reading, billing and maintenance. While public ownership is maintained and community accountability structures remain in place, the transparency of operation can be limited. Contracts are often not openly negotiated and regulation and oversight is usually lacking. (Design), Build, Operate, Own and Transfer or (D) BOOT – This model of privatization is usually used for system infrastructure development e.g. water treatment plants that require significant finance. The private operator is required to finance, construct, operate and maintain the facility for a specific period of time (usually more than 20 years). At the end of 4 the term, the infrastructure may be turned over to the municipality or the contract is renewed. This model is more prevalent in developing countries. Examples of (D) BOOT include Tiruppur Project in TN India and Cochabamba experience in Bolivia. Divestiture – In this model, the government or public authority awards full ownership and responsibility of the water system including the water source to a private operator under a regulatory regime. This is also done in the form of 10-20 year renewable contracts on the entire system. The government moves operation to private hands thus improving efficiency. Competition is limited through the process of bids on the divestiture. The private sector firm is then expected to takes the risks and recoup investment/profits. This model cedes tremendous power over an essential resource to corporations. Examples of divestiture include the Rasmada scheme, under which a 22-year lease over a stretch of the Shivnath River in Chattisgarh was accorded to Radius Water, Inc. Water privatization has been recommended by the Indian government’s national water policy10 to address the issue of water scarcity. In its article 13 titled, “Private sector participation” the policy says that “private sector participation should be encouraged in planning, development and management of water resources projects for diverse uses, wherever feasible”. This has placed water privatization at the forefront of developmental policies implemented by several state governments.11 while the policy is silent on the kinds of privatization models that will be adopted, as can be seen from the case studies below, most of the privatization that has been done in India follows the (D) BOOT model. The national water policy also encourages interlinking of rivers to improve water availability in water scarce areas. 12 The proposed river linking scheme has at its heart of funding, water privatization, which will further isolate the water source and responsible water management from local communities. Many state governments, neighbouring nations sharing river waters with India and experts have questioned the merits of such a scheme on numerous grounds including lack of feasibility and impact studies on this project, ecological disasters from river diversion schemes around the world, as well as adverse environmental impact due to submergence, soil salinity and water logging.