

Water Crisis in India: A Long Term Solution

Shardendu Kumar Jha

Department of Chemistry, K.S.R. College Sarairanjan, Samastipur
e-mail-jhask61@gmail.com

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Abstract : India, accounting for around 17% of the world population has been endowed with just four per cent of the world's fresh water resources, which clearly highlights the need for its judicious use. Following the Falkenmark Index, more than half of the twenty river basins have water scarcity conditions with availability of less than 1000 cbm per capita per annum. According to a report of the Union Water Resources Ministry, total water demand in the country is estimated to increase by 34 per cent by 2025 and over 78 per cent by 2050, indicating a major gap of around 30 per cent with respect to the replenishment rate capacity signalling a serious water crisis in the nation.

(Keywords : Desalination, Semi-permeable membrane, MED, MSF, RO, CAB, CPA, TFC)

Introduction

Water is an essential ingredient for

evolution and sustenance of life. Availability of abundant water makes earth a unique planet. Three-fourth surface of the earth is covered with water.

Further, availability of water on earth has a unique characteristic. The total volume of water available on earth is estimated as 1450 million cubic kilometre, which remains unchanged and does not deplete in its virtual consumption. The mass of water remains unchanged moving in nature in a huge water-cycle. The quantity of water on the earth remains the same as was available millions of years ago. However, very small portion of soft water on the earth is available in rivers, lakes and ponds or as underground water at lower depths wherefrom its harnessing is viable. Estimated availability of water on the earth from various sources has been estimated as follows.

Water Resources on the Earth

Sources	Quantity of available water (in lakh cubic kilometer)	Percentage
Seas and oceans	13,700	93.93
Ground water	600	4.12
Polar icecaps	240	1.65
Lakes	2.3	0.016
Soil moisture	0.83	0.005
Atmospheric vapour	0.14	0.001
Rivers	0.012	0.0001
	Total = 14,500	

Ironically, in this abundance of water on the earth, 94% of water is available in seas and oceans, which is highly saline (average salt content of 35,000 mg/litre) and as such not suitable for normal use of man. Saline water is not suitable either for drinking purpose or for irrigation and has only limited use in industries. Soft water with dissolved salts within acceptable limits is only of normal use. A major portion of usable soft water on the earth is locked in huge icecaps of north and south poles. Only a small portion of soft water is available in rivers, lakes and ponds or as underground water at lower depths wherefrom its commercial harnessing is not viable. While population has explored the amount of fresh water on the planet has stayed constant. Water use has grown more than twice the rate of population increase in the last century. Today nearly 700 million people worldwide suffer from water scarcity. And that number is

expected to grow to 1.8 billion in just 10 years. With rising world population and commensurate increase in requirement of soft water for drinking and sanitary needs, irrigation and industries, the existing source of fresh water have been rendered grossly inadequate to cater to various competing demands. In view the heavy stress on fresh water supply, adding saline sea water with necessary treatment for resource augmentation is becoming inevitable².

Water resources in India

Main sources of fresh water in India, as elsewhere, are rains and snowfall. In comparison of the average annual rainfall of 1110 mm of the world, the average annual rainfall in India³ is 1160 mm. available water resources of India from various sources are indicated in the following table

Total Water Resources of India

Sources	Quantity of water (in cubic kilometer)	Percentage
Rains and snowfall	4,000	100
Rainfall during monsoon	3,000	75
Underground seepage and atmospheric evaporation	2,130	53.3
Average annual flow through rivers	1,870	46.7
Estimated Useful resources of water		
Rivers and lakes	690	17.3
underground water	430	10.4

It can be observed that on an average 4000 cubic kilometre water is received annually in the country from rains and snowfall in the Himalayan region. It is estimated that attar seepage through the soil and atmospheric evaporation the average annual flow through the rivers is 1870 cubic kilometres. But out of total flow in the rivers,

nearly 500 cubic kilometres of water flows through the narrow and inaccessible hilly regions of the north-East where demand of water is rather low. Keeping these aspects in consideration, around 690 cubic kilometres water is annually available for use. Around 430 cubic kilometres water is annually available⁴ in the country from

underground sources.

The above rainfall data⁵ are based for the country as a whole and represent annual average. Computation of availability of water for a specific region or for a particular season of the year would be misleading. In fact, there are wide regional and seasonal variations in rainfall rates in the country. In comparison with the eastern region of the country, western part of the country receives quite low rainfall. Whereas the average annual rainfall in western Rajasthan is merely 100 millimetres, it is 25,000 millimetres in Assam and world's highest rainfall rate of more than 11,000 millimetres is in Cherapunji area of Meghalaya State. Likewise, while windward side of the Western Ghats receives above 6000 millimetres annual rainfall, area around 80 km east, the leeward side of the Western Ghats flows down the steep slope of the hills to the Arabian Sea and its harnessing for useful application is practically not possible. Over and above the regional variations in the rainfall, there is wide imbalance in seasonal pattern of rainfall as well. Around 75% of the total annual rainfall is received during the four months of the monsoon from June to September⁶

. As a result of such wide variations in regional and seasonal rainfalls, while some parts of the country face deluge, a large area suffers from acute shortage of even drinking water.

On account of such skewed distribution of regional and seasonal rainfall, availability of water in various regions is not uniform. While two-thirds of total water of the country is available in the region North of the Tropic of Cancer, half of cultivable land and major industries are located in south of the Tropic of Cancer. Even in North of the Tropic of Cancer, there is vast imbalance in the availability of water in the rivers on North of the River Ganges from those in south. Northern rivers are mostly perennial as they receive water from the glaciers

of the

Himalayas round the year, over and above the water from usual rainfall. But rivers on the southern side are rain-fed only. As a result, these rivers either get dry or have insignificant flow during the summer. Furthermore, harnessing coastal rivers and small rivulets of the Deccan Plateau for round the year use is not economically viable. Rational water resource development employing appropriate technology to ensure adequate water supply to all users throughout the year is mandatory for meeting basic water needs of the populace⁷.

In view of the above considerations, water reservoirs need to be constructed on rivers, especially on non-perennial rivers, for storage of excess water available during rainy season. By storing excess water of the rainy season that otherwise causes floods and ultimately flows into the sea to be rendered un-utilisable, water scarcity during dry months can be mitigated. Post-independence, the water storage capacity of the country has been increasing continually by constructing dams and barrages. At the time of independence, the available water storage capacity was merely 18 cubic kilometres, which has been raised to more than 250 cubic kilometre in 2016. But much has to be done to utilize the full potential of various rivers river valleys of the country. While the flow of water through of the rivers of America is comparable to that of the rivers of India, the total water storage capacity created in America⁸ is 450 cubic kilometres.

Utilization of water in India
Foremost utilization of water is for drinking purpose. In addition, water is essentially used for the following activities.

- a) Sanitation,
- b) Irrigation
- c) Electricity generation,
- d) Industries,
- e) Fishery,
- f) Transportation through waterways and
- g) Water sports.

Whereas water is not consumed in its usage in fisher, waterway transportation and water sports, water gets consumed in the process of drinking and sanitation, irrigation, generation of electricity and industries. In this backdrop some statutory restrictions on indiscriminate use of limited water resource are inevitable. For equitable distribution of water to various competitive uses, Government of India has prioritised⁹ allocation of water in the following order.

- i. Drinking and sanitation,
- ii. Irrigation,
- iii. Electricity generation and
- iv. Industries

Any civilized society will provide highest priority to supply clean and healthy drinking water to its people. Irrigation gets next priority after drinking water, although irrigation consumes much more water than what is required and water use is the most inefficient in irrigation. There has been no improvement in the irrigation practice in the country from ancient times.

Yet irrigation has to be served for the obvious reason that India still remains an agrarian country and the country has to feed its huge population. Further, agriculture also makes a considerable contribution to the GDP of the country.

In the list of priority for water allocation, electricity generation finds the next slot after irrigation, which also stands to sound logic. Electrical power is essentially required for all economic activities and for improving the quality of life of the people.

Ipso facto, industry gets the last priority in allocation of water resources by the government. Yet intense industrialisation of the country is inevitable for economic development¹⁰.

Augmentation of Water Resources

Water shortage is an all-pervading issue

worldwide. While population is exploded, the amount of freshwater on the planet has stayed constant. Water use has grown more than twice the rate of population increase in the last century. According to the UN, 1.2 billion people (almost one-fifth of the world's population) live in areas where water is scarce and another 500 million people are nearing this situation¹¹.

With exponential rise in the requirement of soft water for drinking and sanitary needs, irrigation and industries, the existing sources of freshwater has been rendered grossly inadequate to cater to various competing demands. In view of the heavy stress on fresh water supply, adding brackish and saline sea water with desalination for resource augmentation is becoming inevitable. Desalinated water can be produced by either using brackish water (water with salt content of less than 10,000 mg/L) or seawater, which salinity in range of 30,000 to 44,000 mg/L. while desalination of brackish water offers opportunities to produce lower cost water, it's unlikely to be a main source of alternative water supply in the future.

The total volume of brackish water worldwide is limited (less than 1% of the world's water) and in most arid regions of the world. It is almost fully utilised. Desalination of saline and brackish water promises harnessing of practically inexhaustible source of sea water available on the earth.

Following are the basic processes technically available for desalination of water to render it suitable for normal use of man.

- 1) Thermal desalination-based technology of Multi-Effect Distillation (MED) and Multi-Stage Flash Distillation (MSF).

Thermal-based desalination follows natural process for fresh water generation by evaporation and condensation. Saline water passes through several chambers where pressure and temperature are lowered down progressively in successive chambers. In each chamber certain

amount of water evaporates while dissolved salts are left in the remaining water. The water from the last chamber is disposed of into the sea as brine. The water vapour from each chamber is collected and condensed as desalinated water.

MED process¹² for desalination of water has been in use since the middle of the 19th century.

In this process, sea water is heated in various stages by steam and a portion of sea water is evaporated to vapour at each stage which, in turn, is converted to distilled water by cooling with incoming sea water. In this process of desalination of water, the ratio of obtainable pure water and consumption of steam is maximum. Power consumption per cubic meter of product water is Multi-Effect Distillation (MED) plant for desalination of water ranges from 6.5 to 11 kWh. MSF¹³ mostly is use presently, is improved technique of Multi-Effect Distillation (MED). Although MSF distillation process is simple and reliable, consumption of energy in desalination of water by this process is quite high and as such, product water is expensive.

Power consumption per cubic meter of product in Multi-Stage Flash Distillation (MSFD) plant ranges from 13.5 to 25.5 kWh for desalination of water.

MSF process of water desalination is normally used in conjunction with thermal power plant where energy from low pressure steam is available for heating sea water. Such desalination plant has multi-stage construction. A heat exchanger and a condensate collector are installed at each stage of the plant. Sea water is pumped through a bank of pipes called heater. Low pressure steam is condensed over the pipe to heat sea water.

If the pressure over the surface of water is reduced, boiling point of water is reduced and when pressure over surface of water is equal to

the vapour pressure of water corresponding to its temperature, water starts boiling.

Sea water heated in brine heater is sent to the first stage of the plant where inside pressure is reduced and maintained at vapour pressure corresponding to the temperature of sea water at that stage. As a result, a part of sea water is evaporated in a flash. Water thus evaporated in flash is extracted and is condensed in brine heater to obtain pure water. On account of extraction of latent heat of evaporation, the temperature of remaining water is reduced and its salinity gets increased as the portion of water evaporated wherefrom is pure water leaving its mineral contents behind.

Balance sea water is passed through various stages of the plant in succession. Pressure at each stage is maintained equal to the vapour pressure of water corresponding to the sea water temperature at that stage. On account of continually reducing pressure at water surface at each stage, sea water gets progressively evaporated and extracted. Water vapour collected is sent to brine heater for heating feed sea water and gets condensed to pure water. Thus, by reducing pressure at sea water surface at successive stages, a part of sea water can be evaporated and condensed later too pure without supplying energy from external sources.

Commercial Multi-Stage Flash (MSF) distillation plants may have 4 to 40 stages with 4,000 to 30,000 cubic meters per day desalination capacity. Sea water temperature after brine heater is normally maintained in between 90 to 120°C. Although MSF plants are plants are capable of operation up to 120°C but corrosion and scale deposition cause problem at temperature operation of the plant. Protection against corrosion may be provided by using titanium tubes.

Around 15% of the total flow of saline water can be purified by MSF process. Unlike

reverse osmosis process of desalination, pre-treatment of sea water is not necessary in desalination of water by MSF process. Around 14% of the total flow of saline water can be purified by MSF distillation process.

2) Pressure desalination by Reverse Osmosis (RO) process based on membrane technology. Saline water under pressure is passed through semipermeable membranes, which allow only water to pass and prevent passage of salts. Membrane technology was introduced in water treatment field in 1960s with development of high capacity synthetic membrane. Following successful desalination of water using membranes in 1970s, membrane technology emerged as viable alternative to desalination of saline and brackish water by thermal desalination technology.

Reverse Osmosis Plant

Osmosis is a natural process¹⁴. If a semipermeable membrane separates two solutions of a substance having different concentration, there is tendency for solvent of the solution with less concentration to pass into the solution with higher concentration. While solvent can pass through the semipermeable membrane, the solute cannot. The minimum pressure required to be exerted on a solution to prevent the passage of pure water into the solution from the other side of the semipermeable membrane is called the osmotic pressure. The osmotic pressure of a solution depends on the nature of the salt dissolved in the solution as well as on the concentration of the solution. The osmotic pressure of a salt solution with per gram per litre concentration is normally 0.7 bar. Thus osmotic pressure of brackish water with 1,500 mg/L dissolved salt would be around 1 bar and saline sea water with 35,000 mg/L dissolved salt would be around 25 bar.

On the contrary, forcing solvent water of a solution of higher concentration to flow through a semi-permeable membrane into a solution of

lower concentration by exerting pressure more than the osmotic pressure is called reverse osmosis. Reverse osmosis process finds an important application in recovery of pure water from saline and brackish water or from industrial waste water. By exerting high pressure on saline and brackish water on one side of the semi-permeable membrane, pure water or water with low salt content is obtained from the low pressure side of the membrane. The salinity of left-over water on high pressure side gets increased and it is called brine or reject.

The difference between the external pressure exerted on saline water and osmotic pressure of water is the driving force of reverse osmosis process. For desalination of brackish water by reverse osmosis process, external pressure of 20 to 30 bar is required and the external pressure necessary for reverse osmosis desalination of saline sea water is 50 to 70 bar. The pressure loss in passage of feed water through the membrane assembly is not significant.

Around half of the energy required for desalination of water remains available in the outlet brine. By operating pumps with the residual pressure available in the outlet brine, energy available in the reject can be recovered. Most of reverse osmosis water desalination plants being operated on commercial scale are installed with energy recovery devices based on Pelton or Francis turbines.

Semi-permeable Membrane

Membranes of microfiltration, ultra-filtration and Nanofiltration are of synthetic organic polymers. For reverse osmosis the following membranes are in use:

- a) Cellulose Acetate Blend (CAB),
- b) Composite Polyamide (CPA) and
- c) Thin Film Composite (TFC).

Each membrane material has certain advantages

as well as some limitations. Membrane material is selected based on its characteristics and application requirements.

Fouling of Membrane

Fouling is a common problem of membranes. Fouling may occur at membrane surface or its pores. Fouling of membrane directly affect production from desalination plant and the working life of the membrane. The following are the factors causing fouling membrane:

- Biofouling,
 - Scale deposit
 - Colloidal particulates
 - Compaction of membrane on account of high pressure of feed water
- Energy consumption is an important aspect of brackish and saline water treatment by reverse osmosis desalination process¹⁵. Installation of a water desalination plant would be commercially viable if the energy consumption in treatment process is low. In this context, reverse osmosis process has distinct advantage over MED and MSF processes of desalination. Over and above, electrical energy required in pumping of water, heat energy is required in MED and MSF processes for evaporation of water.

Salinity of feed water has significant role in consumption of energy. More is the salinity of feed water; more would be the energy of consumption in treatment. The effect of high salinity has more effect on energy consumption in desalination of water by reverse osmosis process compared to that in MED and MSF processes. Osmotic pressure of water is directly proportional to the salinity of water. Higher salinity means higher osmotic pressure and as such higher pressure of feed water is needed in the membrane train¹⁶.

With development of efficient energy recovery devices, specific energy consumption in reverse osmosis desalination plant is presently 3 to 5.5 kWhm³ of pure water production.

Further, continual development in membrane technology leading to reduction in prices has rendered desalination of saline and brackish water by reverse osmosis process common in use. According to the International Desalination Association (IDA), out of total water desalination plants in the world in the year 2011, 60% plants were based on reverse osmosis process.

As availability of fresh water from conventional sources dries up and demand for water mounts for drinking and sanitary needs.

Irrigation and industries, recovery of usable water from saline sea water and brackish ground water will become increasingly inevitable for arid regions of the world. In India as well, the future of meeting the relentlessly increasing demand of water lies in recovery of pure water from desalination of immensely available saline sea water and brackish ground water¹⁷. Desalination entails large investment cost, high energy consumption and has to some extent, negative impact on the improvement and on aquatic lives of oceans. But rapid improvement is taking place in desalination technology.

Major breakthrough in membrane technology, thanks to other Nano engineering approach and development of energy recovery equipment in early nineties, resulted in significant growth in installation of RO plants. In addition, combination of sensor driven optimization and automation as well as new types of membranes including two-dimensional single atom-thin graphene being developed would lead to desalination plants of much smaller size using much less energy. In theory, an essentially two-dimensional graphene membrane provides the least possible resistance¹⁸.

Further, small, mobile desalination could be employed for irrigation use far away from the ocean where demand of water is great and rising. Desalination plants operate in more than 120 countries of the world, including Saudi

Arabia, Oman, UAE, Spain, Cyprus, Portugal, Greece, Italy, India, China, Japan and Australia.

Worldwide Seawater Desalination Capacities (in %)

Middle East	53.3
North America	17.0
Europe	10.1
Asia	10.6
Africa	6.2
Central America	1.8
South America	0.6
Australia	0.4

The Largest Desalination Plants in the World

Among around 20,000 desalination plants installed in the world¹⁹, the following are the largest ones:

- i. Ras al-Khair, Saudi Arabia: 1,036,000 m³/day It is hybrid plant that uses both thermal MSF and RO technologies. It is located at 75 km north-west of Jubail and serving Riyadh. It also has a power generation capacity of 2400 MW.
- ii. Taweelah, UAE: 909,200 m³/day
- iii. Shuaiba-3, Saudi Arabia: 880,000 m³/day
It is located 90 km south of Jeddah
- iv. Sorek, Israel: 624,000 m³/day
It is located 15 km south of Tel Aviv and developed by IDE Technologies. It is based on RO technology
- v. Rabigh-3 IWP, Saudi Arabia: 600,000 m³/day
- vi. Fujairah-2 UAE: 591,000 m³/day

It is a hybrid plant comprising a 450,000 m³/day thermal plant, 136,500 m³/day RO plant and 2,000 MW power plants.

According to IDA, 18,426 desalination plants were in operation in the world in 2015 producing 86.8 million cubic metres per day pure water.

Water Management in Arid Zones of Middle East

The Middle East is one of the driest regions on the earth. Average rainfall in the Middle East ranges between 20-40 cm per year against a global average of 72 cm. The region faces droughts quite frequently. Further, rapidly growing population aggravates problem of water scarcity. Saudi Arabia, the largest country of

Middle East does not have any lakes or rivers. Saudi Arabia is also the world's largest consumer of water next to the U.S. and Canada with consumption of 250 litres per capita per day. In absence of natural sources of soft water, Kingdom of Saudi Arabia (KSA) has become the largest producer of desalinated water in the world to meet its huge demand of water and has some of the largest water desalination installations²⁰.

Desalination plants using all three processes of desalination; MSF, MED and RO technologies are installed in the Middle East. While RO plants account for more than 55% installations, MSF based plants 25% and balance MED plants. Thermal technologies are mainly used by oil rich countries neighbouring the Persian Gulf where energy prices are low. These countries include Saudi Arabia, Kuwait, UAE, Qatar, Oman and Bahrain with a total installed²¹ capacity of around 26 million m³/day by 2008.

Saudi Arabia where more than 70% of water needs are satisfied by desalination is the largest producer of desalinated water in the world. It produces about one-fifth of the world productions. The volume of water supplied by the country's 27 desalination plants at 17 locations was 3.3 million m³/day. 12 plants use MSF and 7 plants use MED. Both MSF and MED plants are integrated with power plants using steam from the power plants as a source of energy. 8 plants are single-purpose plants that

use RO technology and draw power from the grid. The MED plants are much smaller.

Use of fossils-based fuels for power generation consumes produces harmful carbon emissions, which contribute to environmental pollution. The government is also promoting the adoption of new technologies like solar and nuclear operate desalination plants.

Israel Water System

Faced with limited rainfall and a harsh climate, Israel has increasingly relied on seawater since it built its first desalination plant in Eilat in the 1960s. Presently about 60% of Israel's domestic water demand is met through desalination-the process by which salt and other impurities are removed from seawater to produce potable water²².

Fortunately, desalination along with drip irrigation, water recycling and sustainable water conservation policies has increased Israel's water supply and amazingly transformed its water shortage into a water surplus. In fact, Israel is the only country where the desert is shrinking thanks to the abundance of water for agriculture²³.

Indian Perspective

As per the international norms, if per-capita water availability is less than 1700 m³/year, the country is categorised as water stressed and if it is less than 1000 cubic meters per capita per year, the country is classified as water scarce. With rising population in India per capita progressively reducing water availability is indicated as follows:

Year 1951:- 5,200 m³
 Year 1991:- 2,309 m³
 Year 2001:- 1,902 m³
 Year 2010:- 1,588 m³

It can be observed that India has fallen under water-stressed region. Further, percapita water availability in India is projected to further

reduce to 1401 and 1191 cubic meters by the years 2025 and 2050 respectively.

The World Bank estimates that 21% of infectious diseases in India are related to unsafe water. In India, diarrhea alone causes 1,600 deaths daily²⁴.

Available water sources of natural water are not adequate to provide a sustainable water supply. Adequate and reliable availability of usable water for all sectors of water use, irrespective of differing priorities attached to them, is essential for all round development of economy and for improvement in quality of life of the people. In this backdrop, augmentation of the existing limited resources of fresh water in the country is sine qua non and a challenge of the policy makers of the country.

The following measures for augmentation of water resources need be seriously planned and implemented²⁵ with due priority.

- Construction of dams and barrages on the rivers for storage of excess rainwater.
- Inter-basin transfer of water from areas of excess rainfall to water-scarce regions.
- Interlinking of rivers.
- Recharge of ground water by rainwater harvesting.
- Desalination of saline and brackish water for normal use.

Measures for augmenting availability of usable water outlined above, other than desalination of seawater, relate to efficient management of available source of fresh water without adding any new resource. While reusing, recycling and reclaiming of water will improve use of water but one cannot recycle something that one does not have. In India, the future of meeting the relentlessly increasing demand of water lies in recovery of pure water from desalination of immediately available saline sea

water and brackish groundwater. Seawater has great potential to improve a sustainable and drought-proof water supply in peninsular India and islands²⁶.

The total coastline of India measures about 7,517 km, which distributed among nine coastal states and four Union Territories. The nine coastal states are Gujrat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal. The four Union Territories lying on the coastline are Daman and Diu, Puducherry, Lakshadweep Islands and Andaman and Nicobar Islands. Out of four Union Territories, two are located in mainland India while two are Islands; Gujrat has the longest coastline 16,000 km.

The traditional criticism of RO technology is that it costs too much. The process uses a great deal of energy to force salt water against polymer membranes that have pores small enough to let fresh water through while holding salt ions back. In addition, concentrated desalination reject dumped into the ocean harmful to marine life and environments. Israel has proven itself as a world leader in desalination after decades of research and installation of a large number of desalination plants in various parts of the world. Internationally reputed desalination company, Israel Desalination Enterprises (IDE) technologies have built three desalination plants in Sorek, Ashkelon and Hydera in Israel. In addition, the company's 400 plants in 40 countries built over four decades provide 3 million cubic meters of potable water around the world daily. IDE has built India's largest desalination in Gujrat in 1998, which supplies water to India's largest oil refinery. The plant has proven so successful that IDE carried out expansion works, a project that was shortlisted²⁷ for the "Industrial Desalination Plant" of the year by Global water Awards 2017.

IDE has taken many steps to reduce the cost and provide environmental protection

consideration of its plants. The company reduces energy consumption through energy recovery equipment and by keeping reverse osmosis membranes clean, so that less pressure is needed to push water through the membranes. IDE is also the only desalination company that offers chemical-free desalination, which means there is minimal impact on the environment.

Conclusions:

As has been discussed in the section on water resources in India, the water resources in the country are under stress. Although India has 4% of the total water resource in the world, but it is much less than proportionate when we take into account that India has 17% of the world population. The demand-supply gap for the country as a whole has been estimated to be imbalanced in the near future; however many regions are already suffering from conditions of water scarcity and drought. This situation which impacts both rural and urban areas is further compounded by climate change which not only would lead to erratic rainfalls and shrinking glaciers but also would make the extreme weather events like floods and cyclones much more common. It would put to risk the living standards of 60 million Indians, as has been highlighted by a 2018 World Bank report on South Asian Hotspots. It is thus important to have adequate mechanism and policy framework considering that the supply of water is constant and in fact depleting over time as against rapid increase in demand. The country is already in deep water crisis and it is expected to worsen in near future if radical corrective measures are not taken now. In last few decades, various experts, institutions and policy documents in India have reiterated the need of adopting integrated and sustainable water policies. Some of these policy solutions, both the demand side and the supply side, are highlighted in this paper. However, due to various hindrances these progressive ideas remain unimplemented. The political economy of water in India and the challenges arising from it remain the largest hindrance to treading the path

of solving the water governance and management issues to ensure a sustainable supply. Its impact is seen on the data collection and sharing also that occurs due to lack of institutional coordination. It is also due to the political economic reasons that the already existing bureaucratic and institutional framework offers friction to involvement of professionals from diverse backgrounds and stakeholder participation, which keeps the policies devoid of a holistic and inter-disciplinary perspective on water related issues. Further, the conflicting interests of different sections and their vested interests, deters any reforms in the pattern of control over water resources and this exists not only in the higher echelons but also in the public and communities. Finally, it has been

pointed out that how the myopic outlook of economic development blocks all the wisdom on sustainable use of water and threatens the survival of our water bodies, such as rivers, and lakes, thus directly and adversely influencing the demand- supply gap in water access.

Therefore besides addressing the issue of physical scarcity of water, at the same time it is needed to also consider the socio-economic scarcity, which means that the access to water is not threatened by its physical availability but due to lack of investment and political will in harvesting and storing the water and in efficiently and equitably managing its distribution and usage.

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