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GLOBAL WATER SCARCITY DUE TO CLIMATE CHANGE AND ITS CONSERVATION STRATEGIES WITH SPECIAL REFERENCE TO INDIA : A REVIEW

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ABSTRACT

The strategic importance of fresh water for global water and food security will probably intensify under climate change which worsen the situation as it leads to increased frequency and intensity of climatic extremes such as flood, drought, cyclone, heat/ cold waves, alteration in water cycle, water resources depletion, increased variability of precipitation, salt water intrusion in aquifers, increasing irrigation demand, decreasing soil moisture and rapid evaporation of surface water and many more. This review provides an insight about climate change and its impact on quantity and quality of water, water scarcity on a global scale with emphasis on Indian water resources, its availability and conservation strategies to mitigate water scarcity. Global warming resulting in climate change is expected to account for about 20% of the global increase in water scarcity. Global water consumption has increased six fold in last century and in coming decades is expected to grow rapidly. By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world's population could be living under water stressed conditions. African continent is the worst affected by the scarcity of water. The gross per capita water availability in India will decline from about 1820 m^3 per year in 2001 to as low as about 1140 m^3 per year in 2050. It is estimated that the country would need 1180 billion cubic meters (BCM) of water annually by 2050. So, there is an urgent need of sustainable utilization of water resources, formulation of climate adaption strategies, making the people and government aware about shrinking water resources as well as taking urgent action for conservation and harvesting of water at local, national and global scale.
***Keywords*:** Water Scarcity, Climate change, Inter governmental Panel on Climate Change (IPCC), depletion, conservation.

Introduction

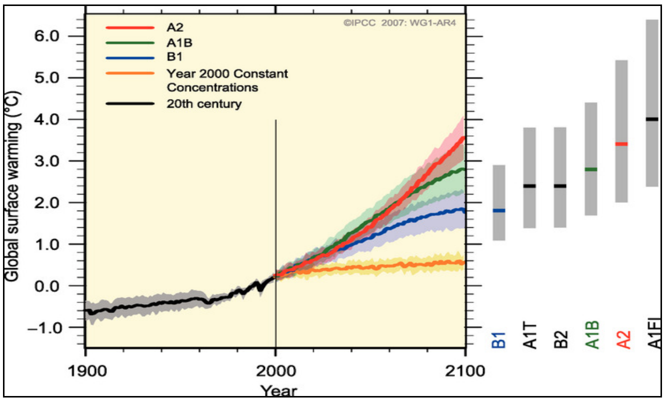
According to the World Economic Forum's Global Risks Report 2016, water crisis is one of the biggest challenges all over the globe. About 4 billion people, two-thirds of the global population are facing the problem of water scarcity. Nearly half of the people suffering from scarcity of water live in India and China whereas Sub-Saharan Africa is the worst affected area.

The water-stressed basins (per capita water availability below 1,000 m^3 per year) are located in Northern Africa, The Mediterranean Region, The Middle East, The Near East, Southern Asia, Northern China, Australia, The USA, Mexico, North-Eastern Brazil and the West Coast of South America (Grafton and Hussy, 2011). The estimates for the population living in such water-stressed basins range between 1.4 billion and 2.1 billion (Vörösmarty *et al*., 2000; Alcamo *et al*., 2003; Arnell, 2004). According to the study the Global estimates of the number of people living in areas with high water stress differ significantly (Panwar and Chakrapani, 2013; Rodell *et al*., 2009; Shah, 2009; Kundzewich, 2007). By 2030, India's water demand will exceed supply of water by a factor of two by 2030, with severe water scarcity on the horizon for hundreds of millions. This may lead to reduction in approx. 6% loss in the country's GDP (Ranaand Guleria, 2018).

Climate change is predictable to raise the number of water-stressed areas and worsen scarcities in already water-shortage areas (United Nations, 2020).There is a clear correlation between access to safe water and GDP per capita. Scientists have studied the climate change, water scarcity and its impact on global population (Khan, 2014; Mehta, 2012; Jain, 2011; Johan, 2009; Mall, 2006; Kumar, 2005). However, some scientists have estimated that by 2025 more than half of the world population will be facing water-based vulnerability. Approximately 70% of the fresh water used by humans goes to agriculture. Climate change affects not only water resources but also reduces the crop yield as a result the demand for irrigation water increases. About 3.2 billion people residing in cultivated or agriculture regions facing high to very high water shortage, about one sixth of the global population or 1.2 billion people- reside in harshly water stressed agricultural zones (FAO, 2020). As the surface water resources are shrinking the dependency on aquifers increases thereby reducing the ground water level.

Climate Change Scenario: Global warming is expected to account for about 20 percent of the global increase in water scarcity this century. Global water consumption increased six fold in the last century - more than twice the rate of population growth and will continue growing rapidly in coming decades. The global mean surface temperature (GMST) of 2016-2020 was the warmest compare to any equivalent period on record which is presently 1.1 °C (±0.1°C) over the pre-industrial (1850-1900) times and 0.24 °C (±0.10°C) warmer compare to the GMST for 2011-2015 (WMO 2020). Projected human induced global warming matches the degree of experienced (observed) warming to within ±20% and it is presently rising at 0.2°C (probable between 0.1°C and 0.3°C) per decade as result of previous and current emission (IPCC SR15 2018).

Multi-Model Averages and Assessed Ranges for Surface Warming



(Source: IPCC)

Fig 1. : Global surface temperature under different emission scenario. The best estimate for the low scenario (B1) is 1.8°C (likely range is 1.1°C to 2.9°C), and the best estimate for the high scenario (A1FI) is 4.0°C (likely range is 2.4°C to 6.4°C).

The potential consequences of elevated greenhouse gases concentration in the atmosphere are as follows:

a) Higher mean temperatures which may affect minimum winter temperature, summer average temperature, summer average rainfall and intensities during the growing season.

b) Changes in the spatial and temporal distribution of rainfall.

c) An increased risk of both heavy rainfall events and droughts.

d) The water holding capacity of atmosphere increases exponentially with its temperature. So, the evaporation and transpiration rate increases. Cloudiness, humidity and windiness are also linked with the changes in temperature.

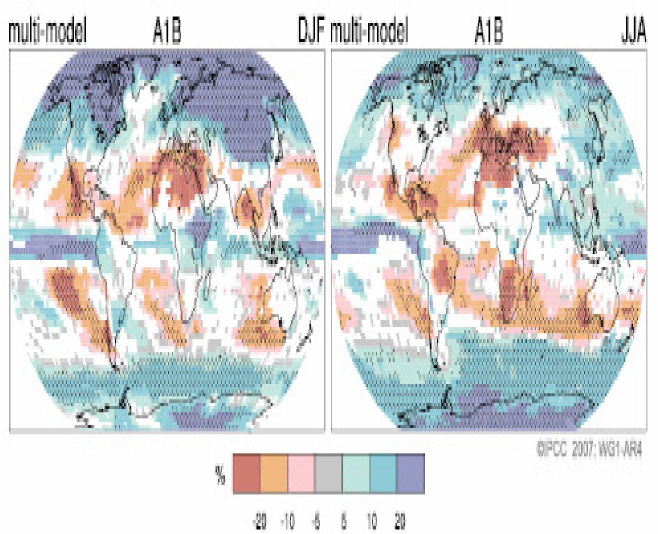
e) Climate change alters the proportion of liquid fresh water and its location all over the globe. When this becomes chronic through regular droughts and flooding, the quality of life in those regions is seriously affected.

If measures are not taken to mitigate climate change, a study by the UK Meteorological Office predicts that severe droughts now occurring once every 50 years could occur every other year by 2100.

Evidences of changes in hydrological cycle

The changes in hydrological systems (precipitation pattern, temperature patterns, ocean currents etc.)may result in increased/decreased frequency and intensity of precipitation pattern as well as climatic extremes such as drought, flood, storm, across the globe.

Projected Patterns of Precipitation Changes



(Source: IPCC)

Fig. 2 : Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change.

- Increased nighttime temperature due to global warming– Since 1950 the daily minimum temperatures have increased at twice the rate of daytime temperature resulting in increased cloudiness and humidity and increased evaporative cooling during the daytime.
- Mean atmospheric water–vapour concentration has increased- To maintain the water balance, evaporation from oceans must be balanced by precipitation into the oceans plus runoff from the continents. The radiosonde and satellite data suggest that the mean atmospheric water-vapour concentration has increased enabling storms to generate more precipitation.
- The precipitation amount has increased in the middle and high latitudes. In the United States the average annual rainfall has increased by 10% during twentieth century. In northern Hemisphere tropics, especially in Africa, a significant decrease in rainfall has occurred since 1950.In tropical Pacific, the sea surface temperature, evaporation rate and rainfall amounts have increased.
- Increased intensity of weather extremes-The increased intensity of storms associated with atmosphere fronts has been observed in the Northern Hemisphere.
- Increase in mean monthly average temperature above normal resulted in increased rainfall in Australia and United States.

Water scarcity: Hydrologists typically assess scarcity by looking at the population-water equation. An area is experiencing water stress when annual water supplies drop below 1,700 m^3 per person (Gulati and Banerjee, 2016).

When annual water supplies drop below 1,000 m^3 per person, the population faces water scarcity, and below 500 cubic meters "absolute scarcity". By 2025India and China will continue to be the largest countries facing water stress.

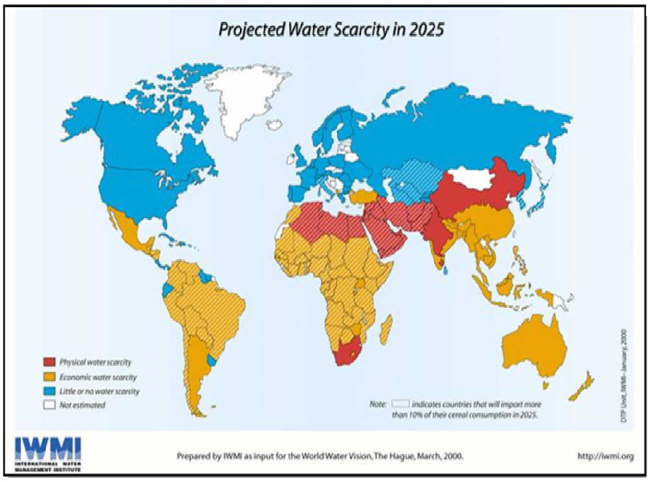


Fig. 4 : Projected Global Water Scarcities by 2025

Climate change Impact on Water resources (Surface & Ground)-

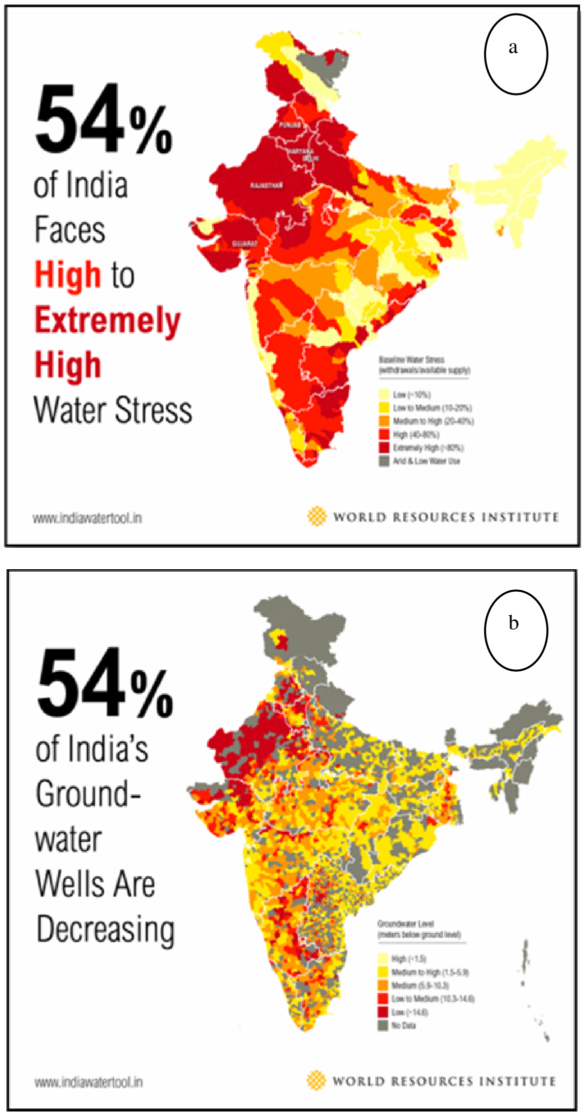
India's water scarcity- India has 18% of the World's population and only 4% of the water resources of the World. India is placed at 120th position amongst 122 countries in the water quality index because 70% of water in India is contaminated (Ranaand Guleria, 2018). In India more than 600 million people are facing acute water shortages in India and about 3/4th of the households in India do not have drinking water at their premise. Irrigation sector is the prime sector utilizing about 78% of water use in the country (Gulatiand Banerjee, 2016).

According to the Ministry of Water Resource, the annual per capita availability of water in India decreased from 6,042 cubic meter in the year 1947 to 1,545 cubic meter in 2011 and is likely to reduce to 1,340 cubic meter by 2025 and to 1,140 cubic meter by 2050 respectively. In the recent past, many cities faced imminent threat of water scarcity which includes cities like Delhi, Bengaluru, Hyderabad, Shimlaetc. Latur District of Marathwara region in Maharastra witnessed severe water crisis because of drought and has taken the lives of many farmers (Rana and Guleria, 2018).

From a climate change point of view, India's groundwater hotspots are western and peninsular India. The rise of mean annual temperature in the Ganga basin is expected to rise between 1 to 4.8°C during the period from 2000 to 2050 (Eddy *et al.*, 2011). For groundwater, the immediate concern from on-site sanitation systems is a risk of direct migration of pathogenic bacteria and viruses to underlying aquifers and neighboring groundwater sources.

It will affect groundwater criticality thereby increasing the pumping cost and carbon emission (Green, 2011). According to an estimate groundwater pumping with electricity and diesel accounts for an estimated 16–25 million mt of carbon emissions, 4–6% of India's total. Agriculture is likely to be most vulnerable sector due to climate change and irregular weather phenomenon (Ahsan *et al.*, 2020; Markou *et al.*, 2020).

With 54 percent of India's total area facing high to extremely high stress (WRI, 2014). The extremely high stress area blanketing Northwest India. The region is India's breadbasketi.e Punjab and Haryana alone produce 50 percent of the national government's rice supply and 85 percent of its wheat stocks. Both crops are highly water intensive. Red and dark-red areas are highly or extremely highly stressed, meaning that more than 40 percent of the annually available surface water is used every year (Fig. 4). A report by the Central Ground Water Board showed that 1499 out of 6881 assessed units in 2017 came under 'over-exploited' and 'critical' categories. Almost 22% of the ground water (assessed units) in the country has either dried up or is in the 'critical' and 'over-exploited' categories.



(Source: World Resources Institute)

Fig. 4: Map of India showing the water stress region (a)and decreasing ground water level (b)

Groundwater levels are also declining at a rapid rate across India because of higher dependency on it. Of the 4,000 wells captured in the IWT 2.0 showing statistically significant trends, 54 percent dropped over the past seven years, with 16 percent declining by more than 1 meter (3.2 feet) per year. Northwestern India again stands out as highly vulnerable. Of the 550 wells studied in the region, 58 percent have declining groundwater levels. National supply predicted to fall 50 percent below demand by 2030. Tamil Nadu (541) have the highest number of water stressed blocks followed by Rajasthan (218) and Uttar Pradesh (139). The annual extraction of water in these states exceeds the rate of annual replenishment. Chennai is the first Indian state which ran completely of ground water in the year 2019.

Reasons for water scarcity in India

- Rising demand of water due increasing population, industrialization, urbanization, increased agricultural activities.
- Lack of efficient water management and distribution of water between urban consumers, the agriculture sector and industry
- Inefficient use of water for agriculture and growing water intensive crops like paddy in areas with water scarcity.
- Release of chemicals and effluents into rivers, streams and ponds
- Sewage and wastewater drainage into water bodies.
- Reduction in traditional water recharging areas. Most of the rainwater that we receive runs as surface waste and discharges into rivers and oceans.
- Traditional rainwater harvesting techniques like construction of Johads, Khadinsetc are no longer prevalent due to presence of dams etc.
- Lack of on-time de-silting operations in large water bodies that can enhance water storage capacity during monsoon.
- Over extraction of easily available surface and ground water resources. Indiscriminate usage of ground water by digging borewells and using electricity to pump out groundwater is severely depleting the water resource. India earlier had borewells running into thousands which has now increased to approximately 20 million
- Changing climate is one of the prime factors responsible for water scarcity.

Climate change impact on water resources and food security- The changes in precipitation will have a negative impact on agricultural production. In India, winter precipitation is projected to decline in the future, and hence will result in increasing the demand of water for irrigating rabi crops. Kharif crop production will also have to cope with heavy floods and droughts. Increased temperature will favour the growth of weeds and their shifting to the higher latitudes. As a result, environmental stress on crops may increase, which may become more vulnerable to insects, pathogens and weeds. The effect of weed growth on yield suggests losses in the range 28–74% in rice and 15–80% in wheat and these drawbacks shall have an adverse impact on the nation's economic growth and GDP. Agriculture sector consumes nearly 89% of the available water resources in India. Variation in temperature and rainfall pattern will deplete soil moisture which can reduce the agricultural yield. As a consequence of this there will be more demand for irrigation water. The effect of this depletion will be felt directly in the rain-fed agriculture and indirectly in surface and groundwater fed areas (Zhuo *et al.*, 2017). It is estimated that crop production loss in India by 2100 AD could be 10-40% despite the beneficial effects of higher CO_2 on crop growth. The worldwide yield of wheat, rice maize and soyabean would likely to decrease approximately by 6%, 3.2%, 7.4% and 3.1% with rise in each degree Celsius in global mean temperature (Zhao *et al.*, 2017). Farmers should be helped to create and use water efficient technology such as sprinkle and drip irrigation.

Conservation strategies of India:- Indian legal system provides man laws for addressing the problem of water pollution thus promotes its conservation. These include Water (Prevention & Control of Pollution) Act, 1974, Environment (Protection) Act, 1986, Public Interest litigation under article 32 & 226 of the Indian Constitution. Globally many organization, institution and companies are working towards water conservation. UN initiatives are helping to raise the issue. World Water Day 2007 was dedicated to the theme "Coping with water scarcity". It highlighted the increasing significance of water scarcity worldwide. The theme of the 2013 World Day to Combat Desertification is drought and water scarcity. Importance of drinking water has been emphasized by declaring date as International drinking water supply and sanitation decade. Indian government has also taken many initiatives for water conservation and prevention of water scarcity such as establishment of National Water Development Agency (1982), "Water Conservation Year"- 2013, Integrated Watershed Management Programme (IWMP), National Water Mission etc. Composite Water Management Index has been launched by NITI Aayog as a useful tool to assess and improve the performance in efficient management of water resources (Rana and Guleria, 2018).

India needs to works in the following steps for water conservation

- **Water Banking and Drought Mitigation:** The concept of water banking depends on water availability and its usage. Water bank can be developed by construction of ground water storage (artificial recharge) or by water transfer (waste water recycling, interlinking of pond and rivers) which will reduce the physical, agricultural and economic impact of water scarcity and drought. Water banks will allow the traditional agricultural usage of water and also provide drought protection and helps in conservation of water.
- **Water credit**: Environmentalist proposes making water tradable commodity by introducing 'water credits' on the lines of 'carbon credits': Industries, institution and individuals should implement water credit system. This would help in maximum utilization of every available drop of water. The concept of water credit should be implemented globally.
- **Misuse of Water Act**: Strict implementation of existing water act and formulation of act for misuse of water will help to protect our water bodies.
- **Water management strategies:** Efficient water management strategies and techniques (Reduce, Reuse and Recycle) and Modified Recycling Distillation Technique (Sharma, 2004) that saves gallons of water in laboratories is an excellent example of reusing water.
- **Effective rain water harvesting –** It will not only help in recharging ground water aquifers but will also reduce the surface runoff during rainy season.
- **Promoting afforestation**: Trees helps in catching the rain, recharges ground water level, prevent erosion and surface runoff. They are the sinks for CO_2 on the Earth,

and afforestation is the best way to minimize the effect of climate change.

- **Promoting adaptive sustainable agriculture:** Agriculture sector is the major consumer of earth's fresh water resources so sustainable agricultural system should be implemented. It includes effective crop weather advisories; nature-friendly agricultural practices; indigenous and improved cultivars; improved soil health, biodiversity conservation. Farmers should be trained and encouraged to switch to sprinklers, drip irrigation and other water efficient technologies.
- **Promoting Ground water recharge**: The country would not be able to meet its future demand unless it recharges its aquifers adequately and uses water more efficiently and judiciously. Rainwater harvesting should be given emphasis. Building check dams on riverbeds will improve groundwater levels.
- **By creating public awareness:** Awareness in people regarding water conservation & management will help in efficient utilization of water as well its conservation. Communities must be incentivised to adopt water budgeting, water use efficiency etc.

Conclusion

More than 600 million people face high to extreme water stress in India. The problem of water scarcity is likely to worsen in the coming decades. To overcome the problem of water scarcity, efficient water management strategies and techniques (Reduce, Reuse and Recycle) should be implemented at each and every level of water use. Still, we need to do more towards sustained utilization of water, protection and conservation of water resources, rain water harvesting, development of surface and ground resources, establishment of water bank etc. People should become climate resilient, that means to become able to cope with and adapt to climate-induced shocks such as unseasonal and intense rainfall, poor rains and long dry spells, storms, rising temperatures etc. reduce losses, maintain productivity and capitalize on opportunities that climate change offered.

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