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WORLDWIDE WATER SCARCITY OWING TO CLIMATE CHANGE AND ITS PRESERVATION TECHNIQUES WITH PARTICULAR FOCUS ON INDIA

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ABSTRACT

Many major cities in India are now experiencing severe water shortage, impacting millions of people. The data indicates that only a small number of Indian cities have effective water management systems in place despite the increasing population of the nation. The research papers address the imminent water issue in India. India's reduced monsoon rainfall is attributed to climate change, fast and unplanned urbanization, uncontrolled development, and lack of effective water management planning. Both towns had severe water shortages in recent years, particularly impacting vulnerable communities. The case studies analyse the systemic risk and main factors leading to the water crisis in two cities, along with its social, physical, and economic consequences. The studies also provide solutions to address the problem. The research indicates that failed agriculture, political tensions in urban and rural regions, economic issues from company closures, and a rising number of farmer suicides have led to a significant influence on socio-economic, environmental, and political systems. The case study proposes preventive, mitigative, and preparatory actions for proactive urban management. The research study examines actions performed at a local level to mitigate water crises and the main problems encountered in risk management. The research study emphasizes the importance of taking proactive measures for long-term sustainability and resilience-building. It also advocates for promoting social behaviour change communication campaigns and capacity-building programs among stakeholders and citizens to effectively manage risks.

Keywords: - Water Scarcity, Systematic Risk, Management, Preservation.

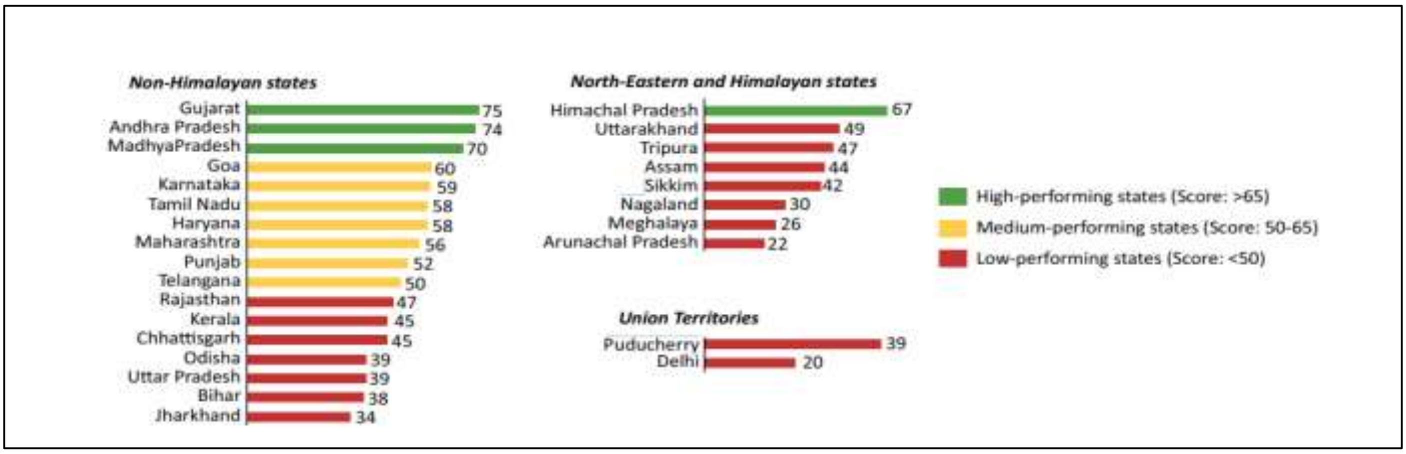
INTRODUCTION

Earth is the only known planet in the solar system with water and life. Although 70% of the Earth's surface is covered by water, just 1% is readily accessible. Water is crucial for all living forms for home and agricultural purposes. Water is used for power generation and in industrial processes. As reports of water scarcity and droughts in many regions continue to rise, the need of conserving water and improving its use efficiency has become crucial. Worldwide, the task of supplying clean drinking water is more difficult due to the rise of the population.

Water is essential for the survival of plants, animals, humans, and all living entities. Water is essential for food security, cattle farming, industrial production, and the preservation of biodiversity and the environment. Freshwater is the only supply accessible for activities like drinking, industrial use, agriculture, and other functions. India is not water-poor, but due to increasing human population, chronic negligence, and over-exploitation, water is becoming limited. India is particularly susceptible because to the increasing demand and undisciplined lifestyle, which is a global problem. Stakeholders need to promptly address the need for sustainable use of existing water resources to enhance the quality of life. By 2025, a third of the developing world's population will experience acute water scarcity (Seckler et al. 1998). In several water-scarce areas, significant volumes of water flow into the sea each year. Often, floodwater is not adequately used, and floods may cause significant damage. Over two billion people globally reside in areas experiencing water shortage, with India suffering a severe problem in this regard. Millions of Indians today do not have access to potable water, and the situation is deteriorating. India's water consumption is increasing rapidly. India has the world's second-largest population, projected to surpass China's by 2050, reaching 1.6 billion, leading to heightened pressure on water supplies due to population growth. The delicate equilibrium between water demand and water availability has become critical in numerous countries worldwide. The escalating demand for water across all sectors of production poses a significant challenge for the future. Therefore, adopting a sustainable approach to water resource management in every sector is imperative. This article aims to evaluate the reasons of water shortage and its impact on global civilization, as well as explore potential solutions to address this issue.

INDIA'S PERFORMANCE IN WATER RESOURCE MANAGEMENT

Figure 1: - State-level performance on water resource management



***Sources: -** CWMI Report, Aug 2019*

In August 2021, Dr. Rajiv Kumar, Vice Chairman of the National Institution for Transforming India (NITI) Aayog, said India had 1999 billion cubic metres of yearly accessible water after evapotranspiration and 1122 billion cubic metres of utilisable water potential. India consumes 251 billion cubic metres of groundwater annually, over a quarter of the world's total. Groundwater is essential for approximately 60% of irrigated agriculture, 85% of drinking water, and rising industrial and urban demand. By 2050, per capita water availability is anticipated to drop to 1250 cubic metres from 1400 cubic metres in 2025. In June 2018, NITI Aayog produced the "Composite Water Management Index (CWMI)," which declared India's worst water crisis. According to the research, 600 million people faced severe to acute water shortage, and 200,000 died yearly from lack of clean water. The assessment placed India 120th out of 122 countries in water quality, with 70% of its water contaminated. By 2030, water demand is anticipated to surpass availability by two times, causing shortages for hundreds of millions of people and a possible GDP drop. The CWMI encouraged state cooperation and competition. This was the first attempt to provide complete data for water management and consumption across the water cycle in India. The Ministry of Jal Shakti, Ministry of Rural Development, and all States/UTs collaborated on the water data collection initiative. The research was known for advising states on their strengths and weaknesses and how to secure their water future. CWMI 2.0, announced in August 2019, compared states for 2017–18 to 2016–17. Gujarat led in 2017-18, followed by Andhra Pradesh, Madhya Pradesh, Goa, Karnataka, and Tamil Nadu. Himachal Pradesh led North Eastern and Himalayan States. The initial UT data showed Puducherry as the top performance. Haryana led general states and Uttarakhand led North Eastern and Himalayan states in incremental index increase from 2016 to 2017. In the previous three years, 80% of states examined on the Index have improved their water management scores by +5.2 points. Unfortunately, 16 of the 27 states have Index scores below 50 (out of 100), putting them in the low-performing category. These states account for 48% of India's population, 40% of agricultural production, and 35% of economic output. Over 25% of India's population lives in Uttar Pradesh, Rajasthan, Kerala, and Delhi, four of India's top 10 economic contributors. They scored 20–47 on the CWMI. Major agricultural producers are struggling to manage water resources, threatening food security. This is worrisome since over half of the Index scores depend on agricultural water management. Water governance and data management are improving across states, laying the groundwork for long-term success.

CAUSES OF WATER RELATED PROBLEMS

In order to achieve socio-economic progress and prosperity, it is crucial to have an adequate supply of high-quality water to fulfil the needs of agriculture, industry, households, etc. Insufficient preparation, lack of knowledge, and failure to take necessary steps have led to a challenging scenario. Therefore, a concerning situation of water shortage and environmental deterioration is slowly developing in India. Intense competition for water across several industries is depleting raw water supplies. Surface and groundwater contamination is significantly diminishing their quality. The primary reasons for the water problem in India are the unequal distribution of water resources, resulting in frequent floods and droughts. Excessive contamination of freshwater resources mostly caused by agricultural, industrial, and municipal activities. The municipal water supply is very inconsistent and of low quality. Laws granting unrestricted ownership of groundwater to landowners, along with unregulated usage of bore-wells, have led to excessive extraction of groundwater, surpassing the rate of recharging. Lack of focus on water conservation, efficient water use, water re-use, groundwater recharge, and ecosystem sustainability. Low water pricing that do not deter wasteful use.

SUSTAINABLE WATER MANAGEMENT IN INDIA

This section addresses the primary water-related issues and outlines a plan for sustainable water management.

Dealing with Variabilities

Water availability in India varies greatly in terms of both location and time. Per-capita water availability ranges from 13,393 m3/year in the Brahmaputra-Barak basin to around 300 m3/year in the Sabarmati basin. Figure 3 shows the amount of water available per person in distinct river basins, emphasising significant differences. According to international standards, a country is considered water stressed if water availability exceeds 1,700 m3 per capita/year, and defined as water scarcity if it exceeds 1,000 m3 per capita/year. India is not classified as water-stressed, however the actual per capita water availability situation is more severe than indicated by the average statistics. Illustrates that several basins are now under water stress, and more will face this issue in the future. Previous discussions have addressed the variability of precipitation in terms of both space and time. Out of 8760 hours in a year, the majority of precipitation occurs in around 100 hours. High levels of precipitation and streamflows need the regulation of river flows via the use of surface or sub-surface storages. Uneven water resources distributions lead to seasonal abundance and destructive floods in some locations, while extensive areas in other regions are consistently afflicted by drought. The following two issues will be addressed next.

- ***Floods***

India often experiences floods of varying magnitudes, making them the most common natural disasters in the country. Approximately 80-90% of the yearly rainfall occurs during the four months of monsoon, leading to the occurrence of floods during this season. The primary reasons for floods in India are insufficient ability of river banks to handle high water levels, erosion and sedimentation of river beds, inadequate natural drainage systems, and cyclones with severe rainfall or cloud bursts.

The Rashtriya Barh Ayog (RBA) calculated that an area of 40 million hectares (mha) is susceptible to flooding (see to Fig. 4). The average yearly flood-affected area is 7.52 million hectares. 32 million hectares may be reasonably protected, with 16.45 million hectares already under protection as of 2004. NCIWRD (1999) reported that, on average, 1,515 human lives and 95,285 livestock were lost annually during the second part of the 20th century. Annually, floods claim the lives of around 1,600 people, inundate 8 million hectares of arable land, and result in substantial economic losses.

There is a common belief that despite significant spending, flood damage is on the rise. The analysis indicates that the extent of the floods has not significantly expanded over time. The population impacted by floods shows significant variations and is growing over time due to population increase. Both crop damage and overall damage do not exhibit a clear trend when adjusted for constant pricing.

The Government of India established the Rashtriya Barh Ayog (RBA), also known as the National Flood Commission, to address the comprehensive flood issues in the nation. The National Commission for Integrated Water Resources Development also examined this issue and provided suggestions in 1999 (NCIWRD 1999). NCIWRD correctly noted that it is impossible to provide total protection against floods. Key suggestions include:

a) Develop a comprehensive flood management master plan for each flood-prone basin;
b) Ensure that flood control schemes align with other water-related plans whenever possible;
c) Include flood control aspects in future multi-purpose projects;
d) Well-designed, constructed, and maintained embankments are effective for flood protection.

Structural and non-structural flood control methods exist. Flood waters are prevented from reaching dangerous regions by structural barriers. The constructions include reservoirs, embankments, flood barriers, detention basins, drainage improvements, and floodwater diversion. Reservoirs steadily discharge floodwater following the flood. Hirakud (Mahanadi), Bhakra (Sutlej), and Ukai (Tapi) reservoirs in India store floodwater. Rivers are limited by embankments.

Floodplains are part of the river, therefore non-structural measures prohibit people from accessing flood waters. Careful flood plain use and temporary relocation when the river requires the area are examples. The methods include flood plain zoning, flood proofing, flood forecasting and warning, disaster planning, and flood insurance. To control floods, one must understand the situation and develop mitigating solutions. The method should involve creating a scientific database, a large R&D capacity, improved human resources, rules for scientific flood plain use, and inundation maps and evacuation plans. In India, cities flood often. Some cities flood even with little rain. Unplanned, poorly designed, and poorly managed drainage cause most urban floods. Poor urban drainage causes sickness and unclean conditions. Creating a master drainage plan for each urban region, revitalising lakes and ponds, and maintaining drainages are the solutions. Mountainous flash floods, occasionally induced by cloud bursts, are fast water flow changes with significant volume and discharge.
Large reservoirs upstream of flood-prone areas may absorb flash flood waves. Glacier lakes may arise when glaciers melt and collect large volumes of water behind ice or debris. The dam bursts, releasing water from the temporary lake. This causes glacial lake outburst floods. This Himalayan phenomenon threatens hydropower plants and communities.

- ***Droughts***

Droughts in India mostly result from: i) delayed or failed monsoons, ii) significant fluctuations in monsoon rainfall, and iii) extended periods without monsoon rains. IMD rules classify a meteorological subdivision as drought-affected if its total seasonal rainfall is below 75% of the usual amount. Extended periods of meteorological drought lead to hydrological drought. If the percent departure is above 50%, drought is regarded as "severe"; if it falls between 25-50%, it is considered "moderate." Drought is a slow-moving catastrophe with ambiguous beginnings and conclusions. Drought impacts gradually mount over an extended period and may persist after significant episodes. Droughts are defined by their intensity, length, frequency, and severity. These traits serve as a foundation for developing management solutions to address droughts. Drought indicators, such as the Palmer Drought Severity Index, are used to characterise drought characteristics and for management purposes. To mitigate the effects of droughts, it is essential to comprehend their features, namely their duration. How intense can it be? What is the frequency of its recurrence? Approximately one-sixth of India's land area, inhabited by 12% of the people, is susceptible to drought, with regions receiving less than 60 cm of rainfall annually being the most vulnerable.

Approximately 40 droughts have occurred in the nation since 1800. The 1987 drought was one of the most severe in recent history, impacting over 50% of the nation. Jain et al. (2007) document the droughts in India during the last 200 years. Drought-prone areas are mostly located in arid, semi-arid, and sub-humid climates (refer to figure 5). Chronic drought has impacted regions limited to West Rajasthan and Kutch in Gujarat. Approximately 57% of Rajasthan and 32% of Gujarat are located in dry zones. Approximately 61% of Maharashtra's land is classified as semi-arid. India has significant economic challenges due to natural disasters. Each state has established a fund named Calamity Relief Fund (CRF) to carry out relief and reconstruction efforts. Drought impacts may be lessened by mitigation and preparation strategies such as forecasting, warnings, drought insurance, and disaster relief programmes. It is essential to include drought preparation in water resources management in regions prone to drought. Drought mitigation strategies may be categorised into three kinds.

- Enhance water-supply capacity during drought and establish additional water sources.
- Water-demand measures: decrease water use under drought conditions.
- Measures to minimise the effect of drought in order to reduce negative consequences.

Irrigation is the most efficient method for mitigating drought and plays a significant role in ensuring stability in agricultural output. The Government of India has taken steps periodically to reduce the negative effects of droughts. Key aspects include watershed improvement, dryland farming, soil moisture conservation, and use of spray and drip irrigation systems. India's government administers the Command Area Development Programme (CADP) to enhance water management capacities. The Drought Prone Areas Programme and the Desert Development Programme were created to address droughts.

Water and Environment Pollution

Water pollution is growing in India. Biological, hazardous organic, and inorganic pollutants damage 70% of surface waterways and much of groundwater. Accessible water is often inappropriate for residential, agricultural, and industrial usage. Untreated sewage, industrial discharges, municipal waste leaching, and agricultural fertilisers and pesticides may pollute water. River pollution has increased due to urbanisation and development. Urbanisation, agricultural and industrial activity, and wastewater management efficiency affect water pollution levels in various locations. Dr. RC Trivedi thinks that 6750 km of river length is highly polluted (BOD > 6 mg/l), 8550 km is moderately polluted (BOD 3-6 mg/l), and 29700 km is typically clean (BOD < 3 mg/l).

Water pollution comes from agriculture, industry, and residences.

Agriculture consumes and pollutes most water in India. Reduce agricultural pollution to improve water quality. Reduce chemical usage to boost yields and switch to organic farming to reduce chemical exposure. As with other inputs, specific amounts of fertiliser are best, and applying too much does not increase crop yield. Setting fertiliser and pesticide pricing and enforcing restrictions helps avoid overuse and misuse.

Industry pollutes water, particularly in cities. Industrial wastewater is expected to reach 17,395 million litres per day. Industrial chemicals cause 40%–45% of pollution. Food industries provide 40% of BOD-based organic pollution, followed by industrial chemicals and pulp and paper. Industries must carefully control waste emissions. Industrial symbiosis uses trash from one product/firm as raw material for another, an enticing option. Additionally, hazardous substances must be reduced or replaced. Dutch pollution taxes have greatly decreased heavy metal deposition in waterways. Mercury thermometers are banned in some countries. Numerous freshwater environments have been eutrophicated by intensive fertiliser use. The WHO categorises some fertiliser and pesticide compounds as hazardous and should be banned from contaminating water sources via runoff and leaching.

Wastewater production comes largely from households. About 38,000 million litres of wastewater are generated everyday. The daily Biochemical Oxygen Demand (BOD) is 7600 tonnes, with 5400 tonnes discharged into aquatic bodies. The nation's Class 1 cities create around 35568 million litres per day (mld) of wastewater, yet only 11554 is treated. Human and animal waste management issues increase waterborne infections. Waterborne infections affect 34 million people, including 1.5 million children who die from diarrhoea. Over 180 million working days are lost to waterborne infections annually. For effective wastewater treatment, strict regulations are needed.

Excessive Groundwater Exploitation

Groundwater has helped Indian agriculture, notably in the past 40 years. Food security has improved with the green revolution. Its exponential exploitation, primarily controlled by private individuals, is a major concern. There were 3.86 million dug-wells and 3000 deep tube-wells in 1950. 2002 saw 19.8 million wells and 50 million hectares of irrigation potential (Chadha, 2006). Groundwater sources are divided into three usage categories. The first category,'safe', has utilisation below 70% of the annual usable capacity. Second,'semi-critical,' includes sites with exploitation levels between 70% and 90%, while third, 'critical,' includes places with exploitation levels over 90%. Overexploitation occurs when groundwater development exceeds 100%. Out of 5723 units examined by CGWB in 2006, 893 were over-exploited, 226 critical, 550 semi-critical, and 4078 safe in 2004. The varieties of groundwater blocks are shown in Figure 6. By 2004, 58% of annual groundwater potential was consumed. Many parts of Punjab, Rajasthan, and Tamil Nadu are gloomy zones. Saltwater has entered aquifers in coastal Tamil Nadu and Gujarat due to water table falls. Heavy groundwater extraction has produced overdraft and a drop in water tables in several basins. Groundwater levels drop, resources deplete, wells dry up, water pumping energy increases, and arsenic pollution occurs. The financial and health burden on farmers is great. To prevent groundwater withdrawals from exceeding recharge rates, use must be managed. Project design should start with integrated and coordinated development of surface and groundwater resources and their joint use. Avoid excessive groundwater extraction, especially in coastal locations, to minimise saltwater intrusion. Government must shift from managing groundwater development to promoting equitable and sustainable development. To raise groundwater, regulate well spacing, drilling, water-intensive crops, and power price. Restrict bore-well drilling in overexploited areas until the water table rises. Implement artificial recharging techniques immediately.

Drinking Water Problems

numerous regions in the nation are experiencing a severe lack of potable water owing to numerous factors. In recent decades, the development of water supply and sanitary infrastructure in Indian cities has not kept up with the increasing population. Therefore, access to running water is limited to a few hours daily. During summers or droughts, access to flowing water may be limited to a few hours per week, with extremely low pressure. In several big cities, the municipal water supply meets just a tiny portion of the total demand. Another issue of worry is the declining quality of drinking water in several regions. The national standard specifies 40 litres per capita per day (lpcd) for rural regions and 150 lpcd for urban areas. Despite adhering to these standards, 233,000 settlements lacked access to safe drinking water as of March 2008. Water supply to some habitations is discontinued due to different causes, causing them to revert to being uncovered habitations. At the start of the 10th plan in April 2002, out of 1,422,664 habitations in the nation, 15,798 habitations lacked coverage by any drinking water projects, and 133,305 habitations were just partly covered. Approximately 1,273,561 habitations, which accounts for 89.5% of the total, were completely covered by drinking water delivery systems throughout the nation. Drinking water delivery projects have reached all habitations partly or totally in just 10 states and Union Territories. In March 2004, there were 75,607 habitations left to be covered, with 5,759 falling into the non-covered category (Planning Commission 2006). Approximately 6% of the total water supply is necessary for drinking and household use. One major problem is delivering high-quality water consistently to metropolitan areas. Reducing demand, gathering rainfall, and recycling water are crucial due to the high expense of delivering water from distant sources. The water distribution network must be regularly maintained and monitored to minimise the amount of "unaccounted for" water, which includes leakages and thefts. Delhi reportedly has a higher water availability per person compared to Paris. Paris people have access to water 24/7, but most Delhi residents only have access for a limited number of hours. Approximately 30% of urban water supply is lost owing to leakages and negligence. Water prices should be determined according to its economic worth, consumers' financial capacity, and to prevent waste. Poor individuals might get a certain amount of water at reduced prices. It is crucial to have water sources located close to homes in rural regions to alleviate the responsibility of water collection often placed on women.

Environment Protection and Restoration

Water pollution control techniques and restoration of natural systems should be essential parts of any development plans. To protect our water and ecosystem, we must implement systematic improvements in our agricultural practices, manufacturing processes, and waste disposal methods (Lazaroff, 2000). To achieve this goal, society and people need to possess a deeper understanding and capability to enact the necessary reforms. An environmental flow (EF) is the controlled water flow within a river, marsh, or coastal zone to sustain ecosystems and their benefits in areas with multiple water users. Environmental flows are essential for maintaining river health, promoting economic growth, and reducing poverty. They guarantee the ongoing accessibility of several advantages that healthy river and groundwater systems provide to civilization. Environmental flows often refer to the necessary flow rates in rivers and estuaries to sustain the ecological balance of the water bodies. Some individuals consider EF to be a waste of water, although this perspective is limited. Assessing EFR for Indian rivers involves devising approaches that include Indian circumstances, particularly the respect and religious values associated with the rivers, at various sites. Establishing a suitable equilibrium between growth and conservation is crucial since healthy ecosystems are essential for the civilization's existence.

Threat to Biodiversity and Wetlands

India is home to around 6.5% of the world's animal species and 12.5% of the world's plant species. Almost 7,000 of these species are native only to the subcontinent. Habitat loss in freshwater and coastal regions has put several indigenous species at risk. Freshwater fish are the most endangered due to their heightened susceptibility to water pollution, river fragmentation, and environmental change. Additional endangered species include of freshwater aquatic creatures such as the Gangetic dolphin, as well as several kinds of aquatic birds, amphibians, reptiles, and insects. Wetlands in India span around 4.1 million hectares of land. Many of these have deteriorated as a result of pollution, urban growth, and conversion pressures. This is endangering both the local wildlife and the livelihood of the humans who rely on the wetland habitat. Coastal regions have been significantly damaged by industrial and household pollution, leading to the deterioration of estuarine and coastal ecosystems.

CONCLUSION

In rural parts of India, about 5% of the total freshwater is allocated for drinking and residential use, 10% for industrial reasons, and 85% for agricultural activities. All water is obtained from precipitation on certain rainy days or snowfall, and it is kept either above or below ground. To attain water security, the only option is to prioritise rainwater gathering, aquifer recharge, enough storage, and effective use. Education and awareness initiatives should be implemented to cultivate a conscious thought-process among all stakeholders, starting with schools and extending to communities. NITI Aayog produced a compendium in October 2021 focusing on the role of communities in water management. The compendium highlights best practices in agriculture, groundwater management, watershed development, water infrastructure, and climate risk and resilience. We should also study successful strategies from other nations, like Israel, which has effectively transformed a water scarcity issue into a beneficial one while receiving just a quarter of the rainfall India gets. Israel has achieved water security and is seeing a rise in its groundwater level as a result of using innovative approaches. If individuals do not save water and safeguard our water supplies, future generations will not exist due to the interconnected impact on power use. Let's commit to sharing the duty of conserving water using easy measures at home or in farming, especially on World Water Day on March 22, before it's too late.

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