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India, Water Scarcity

**India: Reversing The Water Scarcity Crisis**

For many people, especially in well-developed countries such as the United States, water is readily available at their home any time of day, throughout their lives. It requires little to no effort to access clean water, a service that is not considered a privilege, but a right. However, this is not the case for millions of people around the world. Water, let alone clean drinking water, is not easily accessible to them, and often calls for a strenuous journey in harsh weather to the nearest groundwater well. This is true for many Indians, who are facing the effects of major water scarcity in the country. There is not enough drinking water in urban or rural areas, and it's very damaging to the country's agriculture and food security. The problem is continuing to worsen because of changing rain patterns, mismanagement of resources, and a rapidly increasing population. Considering the severity of the issue, certain measures need to be taken by the government and communities to alleviate and eventually solve water scarcity.

India is a vast country with an astounding diversity of religions, languages, and cultures. The multifarious society of the Indian subcontinent is complex in its rich heritage and considered among one of the oldest in the world. With the Himalayas in the north, the Deccan peninsular plateau region in the south, and the fertile Indo-Gangetic Plain between the two, India contains diverse geographical features. India is world's largest democracy and is home to over 1.3 billion people or 18% of world's population (US Census Bureau). India is a parliamentary democratic republic where the President of India is the Head of State and the Prime Minister of India is responsible for running the federal government.

India consists of 1.269 million square miles of land, of which 68.84% is rural and 31.14% is urban (Statista). Nearly two-thirds of India's population lives in rural area and dependent upon agriculture (World Bank Data 2017). The average farm size is 1.15 hectares, a little bit bigger than a rugby field. These farms make up 60.45% of the total land and produce India's main crops, which include rice, wheat, maize, and other grains along with pulses, coffee, and tea (Maps of India). India's main non-farm exports are gems, mineral fuels, vehicles, and pharmaceuticals (World's Top Exports). India's unique geography and geology strongly influences its climate and India stays warm or mildly cold during winter but becomes hot in the summer. Although the Tropic of Cancer passes through the middle of India, scientists consider the whole country tropical. Monsoons are responsible for a large percentage of precipitation and the agriculture remains largely depended on it.

The average Indian family size is five people, although it is not unusual to see extended family living together in the same house. Two-thirds of the population is rural, meaning they live in villages in small houses. Their diet mainly consists of rice paired with lentils, curries, and fermented dairy products. Spices are also used very heavily in traditional Indian food. Families in rural areas normally grow their own food. In urban areas, people usually purchase their meats and vegetables at a market. India ranks second worldwide in farm output. In 2016, agriculture accounted for 23% of GDP but employed 59% of the country's total workforce (Asia Development Bank). This large dependency on agriculture for employment resulting in poor incomes for workers in rural India. India's per capita income in 2017 was $1820 (world bank).

Access to healthcare in India is limited but has improved over the years. Today, the doctor-to-patient ratio stands at 1:1,800, whereas 60 years ago, there was only one doctor for every 6,300 people (Madhav). According to UNICEF, the literacy rate for youth aged 15-24 years old is 86%. Access to other services such as electricity and telephone have also increased, with 84.53% of the population having electricity as of 2016, 68.7% of the population having telephone access in 2012.

India is fast becoming one of the water-scarce countries. There is not enough drinking water in all the major metropolitan cities in India and the groundwater tables have plummeted all over India. In rural areas, people are forced to fetch water from miles away. Although India holds 18% of the world's population, it only has 4% of the world's fresh drinking water. Of that 4%, 80% is used for agriculture (Dhawan). As agriculture is fully dependent upon water, farmers are bearing the brunt of the water scarcity situation. Farmer suicides are a common occurrence all over India and many are unable to pay their debtors if their crops fail. Increasing population, erratic weather pattern, mismanaged water resources, and climate change are depleting water resources and leading to water scarcity. According to the data by the government of India, the average annual per capita water availability fell 15% between 2001-2011. It's predicted to fall another 13% by 2025 and 15% again by 2050, which means that in another 30 years each Indian household will have about 1.1 million liters of water per year, down from 1.8 million liters in 2011 (WRIS, India).

Water scarcity impacts men and women in different ways. Particularly in rural areas, men take care of supplying water for agriculture while Indian women are burdened with the task of getting water for their family, so as to help with household chores and to take care of the children. These tasks, such as cooking and cleaning require clean water, which is not readily available to them. This is a very big and grueling responsibility, as women might need to make up to six trips to a well miles away every day. Women do this by holding buckets or jars full of water on their head. "The pressure, added with the distance to water sources, creates back, feet, and posture problems. The heat increases their exhaustion, and the chore itself takes away much needed time for other duties," according to The Water Project. But not only does this duty have physical consequences for women, but it takes time away from other things that they could be doing for their family, such as getting a job and making an income. If water was readily available in rural areas, women would be able to provide much more for their family-- and contribute positively to the country's economy by getting a job-- and avoid physical injury from this exhausting task. Not only adults are affected by this, children, especially girls, are often times forced to drop out of school so they can help retrieve water. Even if they themselves are not making the trip, they end up staying home from school to tend to the household while the mother gets water.

A major concern for water in India is that the dwindling of replenishable water resources. India produces a lot of grain, which requires a lot of water to sustain. As agriculture is using up so much of the water, the country's overall water availability is depleting. In rural communities, the people often don't have a choice but to drill wells in the ground to access groundwater aquifers. In the condition that these areas are in, it is hard for the water table of that aquifer to be replenished as the demand outstrips supply. The problem with this is that the more groundwater wells are drilled and used up, the more it adds to the overall issue of water scarcity. These wells are extremely mismanaged, but there are steps that can be taken to reverse that.

According to the Government of India's Integrated Hydrological Data Book, "In India, a total surface water storage capacity of 253.4 Billion Cubic Meters (BCM) has so far been created. An additional storage of 51 BCM is under construction. Therefore, expected storage capacity after completion of planned projects would be 304.4 BCM against the total availability of 1869.35 BCM of water in the river

basins of this country." This data reveals that a large majority of the rainwater is not captured and utilized. This water is likely to flow into bodies of water such as the Bay of Bengal or the Indian Ocean, which can trigger floods in coastal areas and potentially cause a lot of damage. If the rainwater could be captured and stored, potentially in existing bodies of water, surface water storage capacity would be increased and water scarcity would be reduced. Reservoirs and artificial ponds should be built, which would be able to hold large amounts of water and recharge the water table. Temporary dams should be built in areas which are in dire need of water, so as to slow down the water flow, retain the water, and recharge the underground water table and supply water for wells. This has already been done in Rajasthan along the Arvari River, which had gone dry because of years of neglect. Check dams were built in the barren Arvari riverbed, recharging the underground water table and eventually recovering the river and bringing it back to life. Another example of a successful effort against water scarcity is Jalanidhi, a rainwater conservation program in the southern state of Kerala. In this program, the Kerala government made all new buildings incorporate a system to capture rainwater from the rooftop into wells. The water in the wells then soaks down through the ground and raises the underground water table. Capturing water and controlling water flow has several benefits: for example, control over flash floods. Flooding is a common problem in certain parts of India, but they can be stopped by holding some of the water. Soil erosion can also be prevented through this process. With monsoon season and uncontrolled water flow, "billions of tons of fertile soils along with precious nutrients are washed out of fertile agricultural lands and forests. Reforestation of degraded forests and development of wastelands through afforestation will help in soil and water conservation" (IDSA, 2010).

Another way to help the water scarcity issue is to link rivers in India. The idea is to connect two rivers: one that has excess water and overflows, and one that needs more water. This would even out the water levels in the rivers and solve flooding at the river with more water and provide water for the other one. This has already been proven to be successful in 2016 when the Godavari and Krishna rivers were linked through Pattiseema, a large pumping project that takes water from the Godavari and transfers it to the Krishna river, benefiting farmers and communities in the Krishna River Delta, where there is usually a shortage of water. The Godavari has a history of having excess water and flash flooding, which was reduced by the Pattiseema project.

The development of agriculture and the crop yield improvements of the 20th century and sustain human civilization. However, the food security achieved over the last few decades around the globe is facing challenges from the ever-increasing population, water scarcity, and extreme weather conditions. For example, when crops suffer under abiotic stress conditions such as drought, salinity, and extreme temperature, loss of over 50% productivity has been estimated (Boyer et al). Given the unpredictable nature of drought and climate change over the years, developing crops that are tolerant to abiotic stresses, especially to drought, is one of the most important approaches to maintain or increase crop production.

However, development of drought-resistant crops is not straightforward as the genetic basis of stress tolerance in plants is complex and is typically governed by multiple genes. For that reason, while traditional breeding strategies appear to provide only limited benefit, genetic engineering with genes responsible for stress tolerance started to make a big impact. Incorporation of bacterial cold shock protein (Csp) gene into maize and wheat improved grain yield under water-deficit conditions in multi-year field testing (Nuccio, Michael L, et al.). Csp genes help plant cells to produce proteins that are essential for growth, which supports grain formation when water is scarce. Expression of a trehalose phosphate phosphatase (TPP) gene, a sucrose regulator, also shown to improve maize grain yields by 9-49% under mild or no drought conditions and up to 123% higher yielding under more severe drought (Yu, Tai-Fei, et al.). These are exciting results and more research is needed to improve yields and assess the safety of

these transgenic crops. For significant and quicker advances in the stress-resilient crops, there needs to be a coming together of different disciplines of research. The fundamental research being conducted in the universities and institutions should be followed up with large scale field evaluations of the private sector or NGOs. Resources, especially genetic information should be shared in closer collaborations between institutions. The power of genomics, coupled with the knowledge of key genes that limit crop yields, would be the route to the delivery of a new green revolution.

Lastly, a possible solution to the water scarcity problem in India is to conserve more water. India's most common form of irrigation is flood irrigation, an ancient method of watering crops that is thought to be the first form of irrigation used by humans. True to its name, flood irrigation is done by flooding the entire field with water. Although flood irrigation is very efficient— entirely because it simply supplies as much water as possible to the plants— it has shown to be very inefficient. According to the Alliance for Water Efficiency, "with flood irrigation, it is generally assumed that only half of the water applied actually ends up irrigating the crop. The other half is lost to evaporation, runoff, infiltration of uncultivated areas, and transpiration through the leaves of weeds." Instead of continuing this wasteful process, a better method would be spray irrigation. In spray irrigation, water is sprayed over the crops, similar to how someone might use a hose to water their garden. It can be done with a system of spray guns, or a center-pivot system, which sprays water while turning, creating a circular area of watered crops (Perlman). This process uses much less water than flood irrigation, making it a much more logical form of irrigation. Another example of a smarter, more controlled way to irrigate crops is drip irrigation, a process in which water drips directly to the roots of the plants. This is done through drip emitters or above-ground pipes with holes in them, which slowly release water at the root of the plant. Using drip irrigation minimizes evaporation and prevents excess water from being wasted as runoff, making it a much better alternative to flood irrigation. Drip irrigation saves up to 1/4th of the total water used, compared to flood irrigation. Several countries, including Israel, have taken advantage of these irrigation methods and as a result, they have conserved an enormous amount of water while maintaining a very successful agricultural system.

India's water resources are rapidly depleting and the country is unable to meet the demand for water. However, this can be managed by effectively capturing the surface water and replenishing underground water tables. Most importantly, the country needs to conserve water. The development of drought-resistant crops would be very beneficial to this, but even more so, farmers need to change their irrigation practices. Reversing the extreme water scarcity in India is a goal that requires a collective effort from the government, outside organizations, and everyday people. With these methods, there is hope for this goal to be achieved and ensure food security for India's future.

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