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India, Water Scarcity

The Future Solutions of Water Scarcity Lie in Data Science

In the scorching heat of the unforgiving summer day, the noon sun shines down directly upon the thirsty children. Imagine living in a household with your two brothers, sisters, grandmother, father, and mother and not having access to any clean water. One out of every two children are malnourished and children in 100 million homes in India lack water [14]. It is horrible to think that only half of the 1.4 billion populace in India has access to clean, pure water. The reality is that close to half the world's population will face an extreme water crisis by 2040. All water will be considered on the verge of nonexistence and groundwater will not be sufficient enough to facilitate entire countries.

Many families in India live like Rehana's family in a small village south of Bhubaneswar. For the families in her village, there is a huge lack of human necessities. While her husband and children leave for work and school respectively, she walks more than six hours a day to a government-issued water pump that provides water for her cooking, laundry, bathing, and drinking [11]. All four of these tasks should be regular acts of daily life, but for Rehana, it is a grueling task that forces her to save and use the water as sparingly as possible. Without clear access to clean water or sanitation necessities, the ordinary tasks that we take for granted everyday are privileges for her and her family. To retrieve clean water, Rehana must hike a grueling six hours to reach the village's water pump. Her village's water pump source is not always consistent either, as some days she finds that there is no water coming from the pumps. Sometimes she would walk to the pump and find the water to be unavailable which would then prompt her to buy the overpriced water given by a nearby store. Most families in rural India must take these long walks to retrieve water with only two or three jugs in tow to survive [11].

Unfortunately, not only is it the mother's duty to carry water back home but many children also have the responsibility of making the incredibly arduous journey across dangerous terrain just to reach their daily source of water. These journeys can take close to half a day so children may not even have time to attend school. According to the National Sample Survey Office (NSSO), 32 million Indian children up to age 13 have never experienced a proper education [4]. When children finally have access to safe and reachable water at home, they can receive their deserved education and forget about having to walk miles to collect water for their families [11].

By 2030, 40% of the populace will not have access to clean water [12]. The global water crisis devastates the entire country causing severe water stress and drought. No one should ever have to worry about when the next time they will get a sip of clean drinkable water. The next generation should not have to worry about what will happen if our groundwater resources were to dry out. Within just a few days without water, we could die. Our most important nonrenewable resource lies in the very drops of H2O that we consume and take advantage of every day.

Pollution through industrial development, largely ambitious agricultural production, and grave hydrological government mismanagement are major contributors to the rapid water consumption in India [12]. India is one of the largest grain and sugarcane producers which require an abundance of water supply to support these commodities. Due to the decreasing water supply, rural communities have no choice but to drill wells in the aquifers and underground water resources. In fact, more than 90% of India's groundwater is used for agricultural irrigation. By such a large percentage, it is clear that not enough water is being managed to reach the mouths of those people in the rural outskirts of India. India

uses more than 600 billion cubic meters of water annually and 245 billion cubic meters of this intake are extracted from aquifers [12]. These aquifers have accumulated over millennia and once all their precious water is dried out, it will take another millennium to refill the aquifer [10]. The usage of groundwater must be better restricted and only be utilized in times of drought or major arid seasons. This presents an enormous challenge for India as they are more dependent on aquifers than any other nation in the world.

Especially now more than ever, during these unprecedented times with the international COVID-19 pandemic, the economic perils that India faces are much larger than ever before. As the economic crisis deepens in these tough times, water is bound to be used more carelessly to further compensate for the drop in GDP over the past year. It is now more than ever that government planning must be reinforced and water security must no longer be ignored. Along with social distancing at the pumps and washing one's hands, the use of water is a true luxury for families living in India today. UNICEF and the CDC strongly recommend washing one's hands at least 10 times a day, which is already 80 liters of water for a single family of four just for handwashing [2]. The global pandemic is hitting the water crisis harder than ever and this calls for a more urgent and dire solution to this situation.

To address this looming water crisis, many would first turn to desalination as a method for effective conversion of salted seawater to potable water. However, this solution, although it provides an accurate and secure way of getting clean water, the environmental and cost setbacks make it a difficult choice to choose out of all the methods to battle the water crisis. The cost-intensive and energy-draining process requires a large manufacturing plant that vacuums seawater into its high-pressure and high-tech machinery. In addition, desalination can affect marine life by releasing unhealthy amounts of brine back into the ocean. Brine is the direct waste product of desalination and once it is spread in quantities throughout the ocean, it can directly affect marine life on the ocean's floor as it has a denser concentration of salt than seawater [3].

In a century of growing technology and innovation, data science poses a promising, sustainable, and efficient solution to battling the global water crisis. Data science can be utilized to extrapolate water stress trends to make specific predictions for the future. These predictions may include guidance for future water policies or analyze the rapid decline of nonrenewable water resources. In addition, the predictions will lead to finding solutions to expand the availability of renewable water resources. In the summer of 2020, I conducted a data science project that would analyze water stress trends in South Asia and the Middle East [15]. This study dove deeper into the use of analytical data science to track water stress trends within these countries in order to predict hydration or sanitation needs in high-risk water shortage countries, and project future outcomes in the decline in water resources. By visualizing relevant datasets, the study will project future actions that should be taken to meet the necessary hydration and water supply needs in the Middle East and Southern Asia by applying these findings to current public policy.

One of the most useful features of data science is that it can cover an abundance of data and knowledge with a few simple programming methods. Most of the data from my study originated from the Aquastat dataset from the Food and Agricultural Organizations of the United Nations [1]. By plotting linear regression models using a computer algorithm, I was able to illustrate a strong correlation between the "agricultural water withdrawal as a % of total renewable water resources" and the decline in "India's total water resources per capita". This indicated the large role agriculture plays in draining the region's water resources. Additionally, when "agricultural water withdrawal as a % of total renewable water resources" was plotted against "India's agriculture, value added (% GDP)", there was a strong correlation to the decrease in % GDP. This shocking relation demonstrates just how mismanaged the water resource is and how much of the water withdrawn for agriculture is being either wasted or used improperly [15].

The results from visualizing the data are also helpful in guiding shocking graphs for the public to understand how water availability is changing. As the data I looked at spanned a 55 year period

(1962-2017), the regression models are able to accurately extrapolate predictions for the future. The rapid declination in one of our most valuable nonrenewable resources is displayed right for us to see exactly how the privilege we take for advantage could one day disappear. In addition, visuals and line plots are easier for people to comprehend and learn from since they clearly demonstrate decline in water resources over time. To bring about more awareness to this current world issue, data science visualizations could be the next steps to promote expediting the movement to prevent water depletion.

Another significant variable would be the National Rainfall Index, which data was also found from the Food and Agricultural Organizations of the United Nations [1]. Some may argue that drought or arid weather may be a large cause of the decline in total water resources [13]. However, based on the R^2 values, there is no correlation between the two variables at all. R^2 values closer to 1.0 have stronger relationships between the variables than those closer to 0.0. The Pearson correlation (R) measures the strength of the correlations while the R^2 value measures what percentage of the variability in the output variable can be directly explained by the input variable. For India, there was a R^2 value of 0.008 which shows no correlation at all between the decline in water resources and rainfall. This highlights the fact that agriculture is playing one of the largest roles in draining water resources. The National Rain Index (mm/year) is not directly affecting the run out of total water resources per capita.

Rainwater harvesting should be advertised nationally to generate a trend within the civilians in order to create greater equity in water distribution as well. This harvesting can be important because based on the National Rain Index, there is no significant decrease in internal water resources due to lack of rainfall, which supports the idea that rainwater is another natural resource that can be utilized.

After reading through the public policies India has released on water policy, it was clear that the country actually is seeking a better understanding of their water resources situation in terms of bigger data and improved visualizations [5,6,7,8]. India and Pakistan are specifically looking for a well-developed information system, for water-related data in its entirety, at the national/state level [5,6,7,8]. Using data visualization methods, a standardized national information system could be established with a better understanding of data banks and comprehensive projections of future demands for water. Especially during these times when the pandemic is preventing major organizations from traveling and our technological resources are ever increasing, data science that can be directly applied from the comfort of one's home presents a viable, cost-effective, and accurate way of identifying major factors of water consumption today in addition to predicting future outcomes of various prevention methods or factors.

National Water Policies are already improving as seen through India's three policies from 1987, 2002, and 2012. From 1987 to 2002 and 2002 to 2012, the total water resources per capita decreased by approximately 20% and 15% respectively. However, from 2012 to the present, the total water resources decreased by approximately 6% which shows advancements in better management of water [5,6,7]. As the second-largest country and the seventh-largest economically, it is difficult to make drastic changes.

Although irrigation is ultimately necessary for these countries' economies, it is important to adjust in terms of effective usage. Applying seasonal changes can benefit the annual loss in water resources as well as creating specific hydrological units that will be precisely planned to keep track of the water being used, wasted, or conserved in the farms or through other agricultural needs on a yearly basis. In addition, it is important to note that for these countries, it is difficult for the policy makers to communicate with the rural populace. Due to the lack of internet in remote places and unfamiliarity with the opportunities data science presents, it is imperative that the knowledge of the impact of data science becomes widespread. It is through major organizations such as the UN or UNICEF that messages and initiatives like those presented in this study can be brought to attention. What makes the UN/UNICEF unique is the fact it connects over 190 different countries and territories, while also spreading the message of nutritional aid and human welfare.

India also faces policy changing dilemmas as Indian farmers and their government do not get along with diplomacy. Especially with the coronavirus, tensions are high and demonstrations are increasing in a fight for voice and equality. To convince farmers to possibly begin to change some of their water/irrigation habits, smaller sectors or organizations devoted to promoting environmental justice could create smaller presentations or pamphlets for the communities. Even just a small amount of impactful and reputable information can go a long way for those who value the necessary resource. Inequity in our natural resources and water availability is reaching a tipping point in countries like India and it is imperative that the populace recognizes just what the future could bring merely ten years from now.

Internet and education infrastructure in rural India is not fully established, however, the best part about data science is that it connects people from all around the world. Many of the prerequisites to data science, especially the type I needed in my study, are quite simple. Most of the tools are open source data sources, meaning anybody has access to these datasets, and a general knowledge of python. You don't need to be proficient in coding either because people also choose to upload their successful code onto forums and are willing to share data that could be applied in multiple different fields/areas. In regards to infrastructure, water quality happens to be an imminent issue in the world today and in India. If there is an abundance of polluted waters, this directs and emphasizes the urgency in protecting the water we have left.

With the illumination on the importance of following data science, it may seem as if regular people who have never heard of its benefits can not contribute. However, this is far beyond that case as anybody can place an effort in this field! From collecting at a local lake/river or simply taking the chance to read about the looming issue of water scarcity, the impact is larger than one can imagine. For people living in India, it helps data scientists when levels of water are recorded even in their nearby water sources as it provides a more specific, pinpointed scope for the researchers to experiment on. On the other hand, awareness is a huge step to making changes throughout the country as the messages become impactful when many smaller preventative actions are done. If many people come together to change their actions gradually, the effect is better than one would expect, especially since India has one of the largest populations in the world.

In fact, there are already efforts in India related to utilizing data science to change the course of the water crisis [9]. An IoT, AI-Operated Water Distribution Network is one the efforts being promoted in India. A team of professors in India are working with the Internet of Things (IoT) technology to formulate an intelligent water supply network called EQWATER to provide and spread equitable distribution of water in densely populated cities experiencing degrees of water scarcity [9]. The younger generation is up next to proceed with guiding the mission to protect drinking water, but the path is already being paved as many skilled data scientists dive into complex data analytics to change public policy for the better.

Data science can be that extra push to guide India and other struggling countries towards a brighter future with computer science at the helm. By outreaching to various world health organizations like the UN and UNICEF and presenting various findings from these projections, their efforts can be better guided as well for the near future. At a time when our world is in pieces and blight is manifesting our people, it is up to us to pioneer the next generation solution so that our grandchildren may still be able to drink from a glass of water comfortably. We must act now with a solution to empower the fight against the water crisis because although it is difficult to look ahead 20-30 years from now, it is essential to remember that we never truly understand the value of something until it is gone.

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