Ria Shivam

Hunter College High School

New York City, USA

India, Water Scarcity

August 31st, 2025

Artifical Intelligence Enabled Early Warning System for Water Scarcity Management in India

On a Tuesday evening, in late June of 2025, the district water office of Bundelkhand stared at a weather forecast, and saw only green lights. The monsoon had arrived on schedule and was in stable quantities, and as per their reports no action needed to be taken. In only five days, however, the reality became apparent. Two blocks were experiencing flash-foods, while three others, just forty miles away, were unable to ration their water as wells fell faster than expected. Pumps were turned off, sluice gates were opened, but there was no way to fully stop the damage that had already ravaged the population of Bundelkhand (Soz and Raza). None of this was anyone's fault, it was neither incompetent nor malicious. It was reactive. This is not just one village's story, but the truth of the water crisis for almost all villages in India. Water stress is a commonly used metric for water scarcity describing any situation where the demand for freshwater exceeds the available supply. Nearly 600 million Indians are under severe to serious water stress. ("People Experiencing Water Stress, Graphic") The human toll of such issues is stark, about 200,000 people die each year due to lack of safe water access in India alone. ("Press Release: Press Information Bureau") The United Nations has warned that by 2030, India's water demand would be twice the existing supply if nothing changes. (Mukeri) These stark figures don't just reflect chronic shortages, but a fundamental unpredictability of water conditions. India's water supply swings violently from flood to drought, while erratic monsoons and warming climate are driving more extreme dry spells than ever before. (World Bank Group) For example, in 2015, Chennai was victim to deadly floods. Then, only four years later, Chennai's reservoirs ran bone-dry in 2019. This switch was completely unexpected, and as a result, thousands died because the government took little to no proactive action to help conserve water before the drought. (Frayer) Preventing this growing water crisis is extremely difficult, but not impossible. By utilizing a comprehensive solution: an AI-powered crisis prediction and water management model that will provide accessible, targeted, and location specific information to Indian governments and NGOs, as discussed in this essay, India has the opportunity to turn the tide.

With a population of approximately 1.46 billion as of 2025, India ranks seventh in the world in terms of size. ("Population of India (2025)) 62.9% of Indians live in rural areas, while 37.1% live in cities. (Population of India (2025)) This demographic illustrates India's varied and unique development challenges in terms of size and the distribution of rural and urban areas. The federal government and the states share authority in this federal parliamentary democracy. The Rajya Sabha, or Council of States, and the Lok Sabha, or House of People, make up the bicameral legislature of the national government. (Ahmad 3) India still lags behind the rest of the world in providing its people with enough water, even with this strong and functional system.

India's water stress stems from several overlapping issues. The most prevalent of these issues is actually management factors, ones that have significantly contributed to the crisis. India's *water use efficiency* is only around 30-40%, far lower than global best practices (Rao). In fact, within more urban areas, 40–50% of water is non-revenue water, meaning lost in distribution through leakages and theft. ("India Water Use Efficiency - Insights, Updates, Research") Another aspect of mismanagement is the lack of adequate storage and capture. India receives about 4,000 billion cubic meters of rain annually, but only a small fraction is stored in reservoirs or recharged into aquifers. The rest is allowed to run off to the sea or cause floods. In fact, if India had better conservation, they would likely not be in the situation they are right now. (Rao) The Indian government is struggling to manage such large scale issues given the lack of timely and accurate information. The second cause of this crisis is the over-extraction of groundwater and pollution. One-sixth of India's districts have been classified as critical or over-exploited for groundwater. For example, in Punjab and Haryana, which make up most of North-West India, current groundwater use is ~165% of annual recharge. (Vivek et al.) This is not uncommon, as over 13% of India is "overexploited" for water, particularly rural regions in the North, who lack infrastructure or knowledge to stop this over-extraction. (Vats) The quantity of water available is further curtailed by severe pollution. It is estimated that 70% of India's surface water is contaminated. (Patir) Finally, critical among all factors, is the unpredictability of water itself. India is inherently variable in its climate, even a normal monsoon has localized droughts and floods. Climate change is only amplifying this. There has been a sharp increase in drought-prone areas and more extreme rains. Furthermore, India's capacity for predicting these water crises is low: the government's response remains largely reactive. ("How is India addressing its water needs?") The meteorological service, the India Meteorological Department (IMD) warns of events like cyclones days ahead, but seasonal forecast accuracy is limited. IMD's own statements concur this fact, as they state even five days ahead, their accuracy is far less than even 90%. (Mukherjee) Without better prediction, even sound policies and infrastructure are undermined: the system simply reacts when floods inundate villages or drought scorches crops, rather than staying one step ahead. The combination of mismanagement, overuse & pollution, and high water variability is compounded by the lack of timely information. This has created a severe and complex water scarcity challenge in India.

The human toll of India's water variability falls heaviest on the rural and female communities, who are some of the largest stakeholders of this issue. Farmers who depend on timely monsoons and irrigation, suffer crop failure for years after the crisis occurred. Agriculture uses 80% of water, so when it fails, rural livelihoods are disrupted. Additionally, rural communities do not have a backup for wells and boreholes, as 75% of them have no piped water (Doulton). Traditionally, during times of crisis, water trucking is immediately sent to these locations, but it is near impossible to fully help all rural communities who need it in such a short timeframe. In much of India, women are the primary water stewards, a part of their duties in the household. Women must travel far to fulfill this requirement, and walk over 10 miles a day, carrying an average of 15 liters each trip. ("Clean drinking water | UNICEF India") The physical strain leads to health issues, like chronic back pain, or in more serious cases, skin and other cancers from the work (Barton). Most critically, this chore keeps women out of school. When water is scarce, girls are forced to help their mothers with water collection. In drought affected states, for instance, school dropout rates for girls have spiked during these crises by 22%, as families cope by reallocating girls labor to water fetching. Overall, while this issue impacts all those in India, it disproportionately impacts rural communities and women.

In recent years, the Indian government, another key stakeholder, in collaboration with state and municipal authorities, has developed a variety of policies and measures to address the intensity of the water situation. One of the most ambitious undertakings is the Jal Jeevan Mission (JJM), which began in August

2019. By 2024, JJM intends to provide every rural family with a functional family tap connection. (Press Release: Press Information Bureau) Significant progress has been made in the few years following launch: according to the government, as of February 2025, 79.74% of rural homes had a tap water connection, up from just 17% in 2019 (Press Release: Press Information Bureau). One shortcoming, however, is water quality and source reliability. In many cases, tap connections are being fed from groundwater or local reservoirs that can be seasonal. According to accounts, even though some towns have tap infrastructure, the water only flows occasionally since the source runs dry throughout droughts and needs to be switched to other sources quickly. Since there is no accurate way to predict where droughts will strike, this leaves these taps dysfunctional for weeks, as JJM scrambles to switch the water source of the taps to trucks after the drought has occurred. Urban slums are another drawback; JJM focuses on rural areas, but many urban poor people still do not have access to piped water. The administration has tried more comprehensive solutions. In the past, unrestricted extraction of groundwater resulted from India's legal system (the 1882 Easements Act) treating it as the private property of the landowner above (Chandra and Janakiraman). Fortunately, the government has adopted a more active stance in recent years after realizing the situation. States were encouraged to license and regulate groundwater use, particularly in over-exploited areas, by means of a Model Groundwater Bill (Chandra and Janakiraman). It is evident from analyzing these government responses that there is a high level of intent and some progress, particularly in the area of infrastructure provision. However, there are a number of drawbacks, including inconsistent application, inadequate asset upkeep, and a failure to address fundamental causes like the demand for water in agriculture. The recent course indicates that although new legislation and pipelines have made strides forward, the water situation is still far from resolved and calls for not only top-down government but also creativity and initiative from all parties involved.

Confronting India’s water crisis therefore requires going beyond usual prescriptions. To get ahead of the crisis, India must leverage tools that handle complexity and provide timely and actionable insights to governments and decision makers, while still being culturally accepted. It will require outreach to a new branch, one currently at the forefront of global development, and that is artificial intelligence. In a country as vast and populous as India, monitoring systems have harsh limitations. AI can aid with this, optimizing and predicting issues before they occur, rather than using reactive management. This section outlines a single solution: a robust AI-powered crisis prediction and water management system, predicting disasters six months out from when they occur, and acting as an early warning system for water resources from the district level to national scales.

While India has attempted to put in place crisis prediction technology, current accuracy remains limited: less than 90% certainty even five days out. (Mukherjee) By contrast, AI used abroad is far surpassing these benchmarks. GenCast, Google’s new AI model, outperformed traditional forecasting in 97.2% of the test scenarios. (Kasanmascheff) Aurora, Microsoft’s AI model was 24% more accurate than the European Centre’s top numerical weather model. (Stillman) Put plainly, AI driven forecasting is the future. By not utilizing it, India is falling behind, and only continuing to worsen the water crisis they are currently in. Putting into place the AI prediction model developed would spur a jump in accuracy from five days to six months, changing the whole system from being caught-off guard only days before an event to having a reliable, long term warning system.

To support my solution, I've coded and created a prototype to display the disasters that will likely occur in four districts across India, Moga, Barmer, Kedar, and Nandurbar. In the next few pages, I'll describe how it works, as well as an implementation plan, the cost of it, and the many advantages it poses.

At its core, the proposed AI model is a predictive analytics system that takes into account a range of factors that are readily available, and computes the risk probabilities of various water crises, translating data into insight. The model continuously assesses the likelihood of adverse events: over extraction of water in a district, infrastructure failure, like pump breakdowns or pipe bursts, the onset of a drought, flooding, and even systemic issues, like water theft. It presents the percent likelihood of these issues occurring in the next six months in a specific district, and thereby allows the Indian government to react accordingly. This allows for authorities to move from reactive behavior, such as evacuating an area when a flood occurs, to a proactive stance. Crucially, the model is designed to use simple, already tracked inputs district-by-district, providing quick and specific, but also accurate results. These include: (a) Rainfall anomalies, which is how above or below normal precipitation an area receives; (b) Non-Revenue Water percentage, the share of water lost to leaks and theft; (c) Groundwater stress levels; and (d)/(e) Reservoir status, current reservoir storage as a percentage of its target capacity and how that compares to country-wide average (see figure 1). These five factors capture the pulse of the system, rainfall indicates natural supply, reservoir and groundwater indicates stored reserves, and NRW reflects efficiency. Using these inputs, the AI model uses machine learning and a rule based algorithm to estimate risk and put it into a percentage value.

Inputs						
District	**State**	**Rainfall Anom.**	**NRW Percent**	**Groundwater Overextraction**	**Resevoir Storage**	**Resevoir Storage vs. Average**
Moga	Punjab	-10	35	0.78	45	−20
Barmer	Rajasthan	-60	55	0.72	20	−35
Kheda	Gujarat	-30	18	0.09	65	−10
Nandurbar	Maharashtra	-25	35	0.03	40	−25

Figure 1:The data inputs put into the prototype AI algorithm. (CGWB)

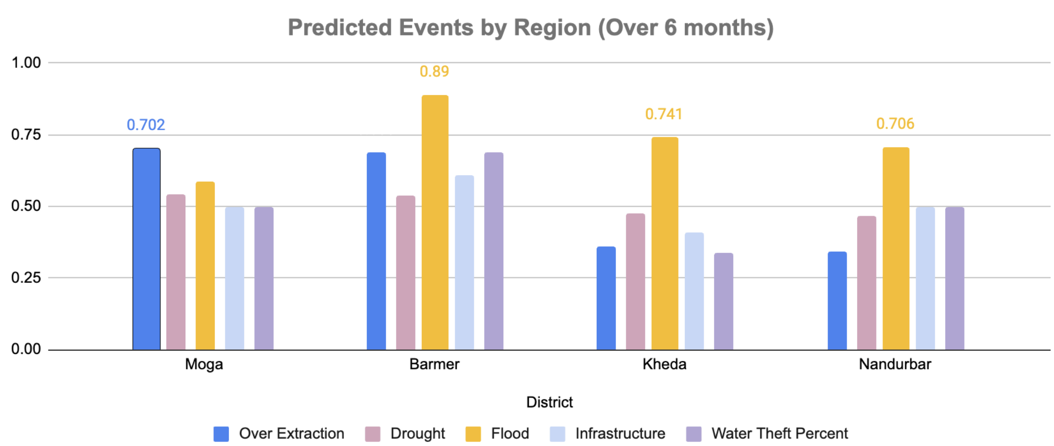
Example outputs from my prototype AI model illustrate the predicted risk from September 2025 to February 2026. Here, we see the tool flag over-extraction risk and water theft issues in Moga, Punjab, versus high monsoon failure (drought) in Barmer, Rajasthan, and significant flood and infrastructure failure in Kheda, Gujarat. With this, governments are empowered to make better, informed choices and quickly protect water security in targeted ways each district needs. A district official in Barmer would see that in the next six months, there is a 89% chance a flood will occur (see figure 2) and therefore, they must implement better storage capacities to prevent it. A district official in Moga could move groundwater extraction away from their district to prevent overuse, and a potential drought. These are both things the government typically would have done after a crisis already occurred. Early reports indicate that when used in other locations, models just like this one have pinpointed neighborhoods where crisis was going to strike, and been successful in intervening, rationing use and preventing the predicted crisis from occurring ("AI-based Groundwater Monitoring System To Revolutionize Water Management In City | Bengaluru News - Times of India").

Outputs						
District	**Over Extraction**	**Drought**	**Flood**	**Infrastructure**	**Water Theft Percent**	**Most Likely**
Moga	**0.702**	0.543	0.586	0.5	0.5	**over_extraction (0.70)**
Barmer	0.688	0.537	**0.89**	0.608	0.69	**flood_event (0.89)**
Kheda	0.361	0.474	**0.741**	0.408	0.336	**flood_event (0.74)**
Nandurbar	0.343	0.467	**0.706**	0.5	0.5	**flood_event (0.71)**

Figure 2:The data outputs given from the AI prototype, giving a likelihood percent of crises over one. (CGWB)

This AI model is tailored for use by district-level planners and water managers. The intention has never been to create a black-box supercomputer that sits in Delhi, but a network that spans across India's 700+ districts. Districts will receive an easy to use dashboard of key indicators and risk levels, updated weekly with automated data feeds from established IoT sensors and data from across the districts (see figure 3). Planners will simply look up a district they operate in and receive quantitative, data-driven visuals to gauge specific vulnerabilities and address them accordingly, something that siloed monitoring often misses. Alerts and recommendations will be local-specific. This is consistent with India's government and the reality of water difficulties in the country; in such a large country, water concerns require local solutions. By providing these predictions to local decision makers, the model hopes to close the information gap that precludes timely and effective action. This will save thousands, if not millions of lives across India. Those who would've experienced evacuation due to floods, lost their livelihoods because of drought, or even died due to lack of water will now gain the ability to plan ahead, an ability that cannot be understated.

Figure 3: A sample dashboard that could be given to district leaders.



India's infrastructure is already equipped to accommodate these advancements, making this technology appropriate for their country. India already has widespread connectivity, with over 615,000 villages having 4G coverage, and extensive digital systems, over one-hundred and thirty-six million Indians now have digital IDs. ("Press Release: Press Information Bureau") Smart cities exist all across India, and rural digital initiatives have laid down fiber and sensor networks. Jal Jeevan Mission's Internet of Things pilots use GIS and already made sensors to get real-time data on water supply, like groundwater stress levels, and other exact data the AI model requires to operate. Finally, Mission Mausam's emphasis on AI, satellites and supercomputers display the political commitment to high-tech forecasting. In conclusion, India has the data sources (radars, satellites, groundwater monitoring), connectivity, and political aspirations to run an AI-driven water information system nationwide. It is the best candidate possible for this predictive technology.

The concept of deploying an AI system for water management is based on worldwide precedents and rising accomplishments, making it both current and viable. Globally, data-driven water management is gaining traction. Japan, for example, was on track to reduce its net water losses (NRW) from 22% to roughly 7% by combining policy and technology, optimizing their networks using acoustic sensors and AI. (Prakash) In South Africa, post the Cape Town "Day Zero" crisis, the government employed predictive models, managing demand and avoiding dam depletion. Even in India itself, a recent IoT pilot in Goa used an AI algorithm and smart meters to cut leakages from 38% to 15%. (Malkarnekar)

To scale and implement the AI-powered water management tool nationwide, a phased, yet cohesive infrastructure strategy that is backed by current digital initiatives is essential. A three phase implementation strategy is more than possible to accomplish this. Phase 1: Connecting the Data. The process should begin by building on India's existing digital infrastructure. Through BharatNet and PM-WANI, over 218,000 Gram Panchayats are broadband-ready, with 692,676 km of fiber and over 12 million FTTH links. (Dharmaraj) The government will use this network to gather water data, and only add IoT devices where needed, allowing the model to be installed and utilized sooner rather than later. This connectivity will ensure real-time data flow into a central cloud AI platform, maximizing efficiency of this AI model. Phase 2: Smart Sensors and AI. Feed the collected data into machine-learning models. More advanced algorithms can be programmed through readily available inputs, increasing accuracy of projections as more and more data flows in. Phase 3: Dashboards and Alerts. Deliver actionable warnings to local officials. The government should build simple web/mobile dashboards for each district, showing key metrics and easily readable colored risk levels. The government should also roll out a program to train and help district leaders to understand what these alerts mean, and how to navigate dashboards to maximize efficiency.

From a cost-effectiveness perspective, this AI model is relatively inexpensive compared to hard infrastructure. Playing to the strengths that India already has rather than creating a whole new system is key in the strength of this solution. For context, The Ministry of Jal Shakti's entire budget is 11.9 billion dollars, and the India AI Mission, a government sector aimed at advancing AI innovation has a budget of 1.25 billion. (PRS India) Building on the already created AI analytics platform (cloud servers + software) would cost about one hundred rupees/hr per GPU, or about one dollar twenty cents per hour. Running this 24/7 would therefore only cost $10,500/year. In addition, a development and engineering team for dashboard development would cost five million dollars. An estimated seven million dollars per year can be allocated as a buffer for any errors that need to be addressed. Finally, workshops, district onboarding and training would cost roughly eight million dollars over rollout. This totals up to twenty-one million dollars at most, even in the early establishment of this program, less than 0.2% of India's available funding. If there are still remaining concerns about monetary issues, international collaboration is available. For India the best example would be the India-Israel Industrial R&D and Technological Innovation Fund (I4F), which offers grants for joint projects, including those focused on water management technologies. (Business Standard) With all this backing, this project is more than doable. This solution will conserve money throughout India, as water loss is a huge revenue loser throughout the country. Even saving just 5% of urban water losses or preventing a modest drought loss would save hundreds of millions of dollars annually, far exceeding the system's cost. In that sense, this AI model is a high-leverage, low-cost intervention.

The main limitation of the model is that some communities may resist the AI-based model, in preference for traditional practices. However, the key to this solution lies in the fact that it is not prescriptive. It does not require or even suggest a single course of action, informing, rather than dictating. The choice on how to respond is fully in the hands of community leaders, who understand the culturally appropriate approach that will suit their circumstances. Drought warnings may prompt government officials in one location to limit groundwater extraction, while in another, they may place water trucks. By separating prediction from prescription, this model enhances decision-making while keeping cultural autonomy. The other limitation could be the government's fluency with AI and technology. However, the outputs of this algorithm are made to be user friendly, and easily teachable. The onboarding process and training will give support and detail how the AI model works, and those who need help further can ask for it during this time. Overall, this solution embodies a broader principle applicable to aiding the water crisis: *leverage appropriate technology and local empowerment* to succeed.

As a whole, using AI-powered water crisis prediction is a solution well-fit for India. It is feasible, efficient, and cost effective. It leverages the country's technological development to transform raw data into tangible, actionable steps. International precedent already demonstrates that data-driven water management works, and India's expanding digital infrastructure makes large-scale implementation achievable. A baseline version of this system has already been made, and could assist Indian leaders immediately. Its flexibility is its strength: the model warns and informs while still delegating decision-making to local governments and communities, ensuring that solutions are culturally relevant. This self-learning AI prototype can even be further evolved throughout its lifespan by broadening the source of input variables and incorporating specific, targeted recommendations as an additional output. India's water scarcity is more than just protecting a vital resource; it's also about enhancing public health, empowering women and rural communities, boosting agriculture, and letting fear turn into proactive solutions, months before a crisis arises. By utilizing this solution, India can modernize its water management and create a strong foundation for coming generations. As the saying goes: "Jal hi jeevan hai," or "water is life" in English. For India's more than a billion people, ensuring access to water is essential to preserving life itself. The time to act is now, so that taps do not run dry, fields remain fertile, and every family can quench its thirst with dignity and hope.

Works Cited

Ahmad, Tariq. "National Parliaments: India." *The Law Library of Congress, Global Legal Research Center*, vol. The Law Library of Congress, Global Legal Research Center, 2017, 3,6, https://maint.loc.gov/law/help/national-parliaments/pdf/india.pdf. Accessed 2025.

"Ai-based Groundwater Monitoring System To Revolutionize Water Management In City | Bengaluru News - Times of India." *The Times of India*, 23 April 2024, https://timesofindia.indiatimes.com/city/bengaluru/ai-based-groundwater-monitoring-system-to-revolutionize-water-management-in-city/articleshow/109512541.cms. Accessed 1 September 2025.

Barton, Alexandra. "Water in Crisis - Women in India." 2024, https://thewaterproject.org/water-crisis/water-in-crisis-india-women#:~:text=Indian%20women%20can%20take%20up,able%20to%20get%20a%20proper. Accessed 2025.

Business Standard. "Business Standard." 31 August 2024, https://www.business-standard.com/india-news/google-backed-fund-selects-4-indian-firms-for-ai-driven-climate-solutions-124083100585_1.html. Accessed 2025.

CGWB. "Central Ground Water Board, Ministry of Water Resources, RD &GR Government of India." *CGWB*, https://cgwb.gov.in/old_website/reportspublished.html. Accessed 1 September 2025.

Chandra, et al. "Groundwater Regulation: A Challenge To Make the 'Invisible Visible' in India." 21 March 2022, https://wri-india.org/blog/groundwater-regulation-challenge-make-%E2%80%98invisible-visible%E2%80%99-india. Accessed 2025.

"Clean drinking water | UNICEF India." *Unicef*, https://www.unicef.org/india/what-we-do/clean-drinking-water. Accessed 1 September 2025.

Dharmaraj, Samaya. "India: Expanding Digital Access for an Inclusive Future – OpenGov Asia." *OpenGov Asia*, 22 April 2025, https://archive.opengovasia.com/2025/04/22/india-expanding-digital-access-for-an-inclusive-future/. Accessed 1 September 2025.

Doulton. “India stares at Water Scarcity, Extreme Heat Stress: Is there a Solution?” *Doulton*. Accessed 2025.

Frayer, Lauren. “Digging Wells, Skipping Showers: Life In A Water Crisis : Goats and Soda.” *NPR*, 18 July 2019, https://www.npr.org/sections/goatsandsoda/2019/07/18/742688141/the-water-crisis-in-chennai-whos-to-blame-how-do-you-fix-it. Accessed 1 September 2025.

“How is India addressing its water needs?” *World Bank*, 17 March 2023, https://www.worldbank.org/en/country/india/brief/world-water-day-2022-how-india-is-addressing-its-water-needs. Accessed 1 September 2025.

“India Population (2025).” *Worldometer*, https://www.worldometers.info/world-population/india-population/. Accessed 1 September 2025.

“India Water Use Efficiency - Insights, Updates, Research.” *Energy Alternatives India*, https://eai.in/ref/da/130. Accessed 1 September 2025.

Kasanmascheff, Markus. “The AI Weather Prediction Revolution: Forecasts Sharpen Amid Data Access Crisis.” *WinBuzzer*, 19 May 2025, The AI Weather Prediction Revolution: Forecasts Sharpen Amid Data Access Crisis. Accessed 2025.

Malkarnekar, Gauree. “IoT, smart meters bring down water use, leakages in Panaji pilot project.” *Times of India*, Times of India, 5 August 2024, https://timesofindia.indiatimes.com/city/goa/iot-smart-meters-bring-down-water-use-leakages-in-panaji-pilot-project/articleshow/112270711.cms. Accessed 2025.

Mukeri, Zafer. “By 2030, India's water demand to be twice the available supply indicating severe water scarcity: Report.” *The Economic Times*, 21 June 2018, https://economictimes.indiatimes.com/news/economy/agriculture/by-2030-indias-water-demand-t o-be-twice-the-available-supply-indicating-severe-water-scarcity-report/articleshow/64679218.cms?from=mdr.%20Accessed%2027%20February%202025. Accessed 1 September 2025.

Mukherjee, Sanjeeb. "Vision Document 2047: IMD aims for zero-error forecast up to 3 days." *Business Standard*, 14 Jan 2025, Vision Document 2047: IMD aims for zero-error forecast up to 3 days. Accessed 2025.

Patir, Mukesh. "Impacts of a changing climate on water resources – consequences for Indian cities | C-cube." *NIUA*, 1 September 2021, https://niua.in/c-cube/blog/content/impacts-changing-climate-water-resources-%E2%80%93-consequences-indian-cities. Accessed 1 September 2025.

"People Experiencing Water Stress, Graphic." *Population Education*, https://populationeducation.org/resource/percentage-of-people-experiencing-water-stress-infographic/. Accessed 1 September 2025.

Prakash, Bhawna. "How Artificial Intelligence Can Help Solve India's Water Utility Problems." *CSIS*, 23 October 2024, https://www.csis.org/analysis/how-artificial-intelligence-can-help-solve-indias-water-utility-problems. Accessed 1 September 2025.

"Press Release: Press Information Bureau." *Press Release: Press Information Bureau*, 1 February 2025, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2098487. Accessed 1 September 2025.

PRS India. "Demand for Grants 2024-25 Analysis : Jal Shakti." *PRS India*, https://prsindia.org/budgets/parliament/demand-for-grants-2024-25-analysis-jal-shakti. Accessed 1 September 2025.

Rao, Dharma. "Water Use Efficiency." *MINISTRY OF WATER RESOURCES, RD & GR*, Ministry of India, 2022, https://nwm.gov.in/sites/default/files/1.%20National-water-mission-%20%20%20water-use-efficiency.pdf#:~:text=,as. Accessed 2025.

Soz, Saifuddin, and Shahid Raza. "Disruption in Agricultural Pattern Due to Unpredictable Weather Conditions and its Effect on Farmer's Family of Kishanganj District of Bihar." *Department of Social Work, Maulana Azad National Urdu University*, 2024. *Department of Social Work, Maulana Azad National Urdu University*.

Stillman, Dan. "How an AI weather model by Microsoft produces faster, more accurate forecasts." *The Washington Post*, 21 May 2025, https://www.washingtonpost.com/weather/2025/05/21/microsoft-ai-weather-model-study/. Accessed 1 September 2025.

Vats, Sukriti. "14% of India's groundwater assessment units over-exploited, 4% critical, says new govt report." *ThePrint*, 15 November 2022, https://theprint.in/india/14-of-indias-groundwater-assessment-units-over-exploited-4-critical-says-new-govt-report/1217090/. Accessed 1 September 2025.

Vivek, et al. "Groundwater depletion in Haryana a cause of serious concern." *Mongabay-India*, 19 July 2021, https://india.mongabay.com/2021/07/groundwater-depletion-in-haryana-a-cause-of-serious-concern/. Accessed 2025.

World Bank Group. "How is India addressing its water needs?" *World Bank*, 17 March 2023, https://www.worldbank.org/en/country/india/brief/world-water-day-2022-how-india-is-addressing-its-water-needs. Accessed 1 September 2025.