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# Water Scarcity Around The Globe

New Hope, Pennsylvania — February 2021  
Honors Environmental Science

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## Ganges River Pollution

How does the pollution of the Ganges River in India relate to Hinduism's religion

India is well-known for its exotic culture that always reminds people of the beautiful traditional costume, various religious cultures, amazing ancient buildings and so on. It is hard to believe that their water scarcity issue had been so serious that the government should take care of it as soon as possible, or it would threaten uncountable families. The river in the photo above is called the Ganges River. It had lost its original appearance and turned into a brown river with garbage floating on it - people even wade through the "garbage water" or take a bath in it.

Water scarcity in India has been getting worse for the past few decades because of a variety of reasons. Lack of governmental regulations and overpopulation contribute to the problems. Overpopulation is one of the most serious issues in India for a long period of time. India is set to surpass China as the world's most populous nation by as early as 2024. What's more, India's largest cities have centralized sewage systems, complete with underground pipes, pumping stations, and treatment plants. These systems are expensive to build and to operate, requiring uninterrupted power, skilled operators, and extensive maintenance and so on. As a result, most of the sewage would be directly dumped into rivers, lakes, and ponds. However, the water problem is also intertwined with Indians' religious beliefs. "We don't follow bacteria, we don't think about it," said Jagdish Vaishnav, a 30-year-old English teacher who said he swam and drank the water, where tons of raw sewage can be seen flowing into the river.

The Ganges River, or Ganga, is a trans-boundary river in Asia which flows through India and Bangladesh. The 2,525 km river rises in the western Himalayas in the Indian state of Uttarakhand, and flows south and east through the Gangetic Plain of North India into Bangladesh, where it empties into the Bay of Bengal. Because of its geographical benefits, more than 500 million people depend on Ganges as their main source of water.

The Ganges River has become one of the planet's most polluted rivers. It is full of urban sewage, animal waste, pesticides, fertilizers, industrial metals and rivulets of ashes from cremated bodies. "The Ganges is living proof that antibiotic-resistant bacteria are almost everywhere.

The river offers powerful insight into the prevalence and spread of drug-resistant infections, one of the world's most pressing public health problems." Introduced by New York times.

India is the home of several religions, but Hinduism is practiced by 80 percent of the population. The water from the Ganges River is considered holy by both Hindus and Buddhists. They believe that the water from this river can wash off sins and remove their pain, and they even pour the ashes of the dead into the river in order to protect the souls of the dead, and accelerate Moksha (freedom from the endless cycle of transmigration into a state of bliss). Hindus believe drinking water from the Ganges brings good luck, and that taking shower in the river or immersing their belongings brings purity. These practices or rituals may help people feel spiritually clean, but the pollution of the water afflicts thousands with diarrhea, cholera, dysentery, and even typhoid each year.

When people try to introduce the potential threat from a science perspective, the Hindus seem to mainly focus on the spiritual support from their mother river. "It cannot be said, it is to be felt," said an Indian citizen who was interviewed by a VICE News reporter.

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Today, the river flows through well-populated regions of India, providing water to the millions of people living in these regions. The river is also used for fishing, irrigation, and bathing, and it is worshiped in the Hindu religion as the Mother Ganga. However, from Hindus' perspective, science and religion seemed to be contradictory sometimes. "Ganga is our mother — drinking her water is our fate," said Jairam Bhai, a 65-year-old food seller who held two small jugs as he waited to pour into the river. "If you have faith, you are safe." "Water scarcity in India is expected to worsen as the overall population is expected to increase to 1.6 billion by 2050," according to The Water Project website. "To that end, global water scarcity is expected to become a leading cause of national political conflict in the future, and the prognosis for India is no different." Because of the deep-rooted religious belief and its wide influences, even though the technical difficulties had been solved, it would be extremely hard to let the citizens pay attention to this serious water scarcity issue.



By Maria Sun



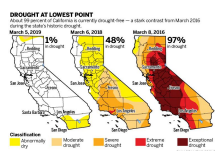
# No Downfall Brings California's Downfall

In the last decade we have seen the United States struggle to supply enough water to dry highly populated areas in the west like California. When there are more problems than solutions for water shortages, we start to see people struggle. From decreased shower time to increase in wildfires, many California residents have been severely affected. If this goes on with no real action taken, California won't be the only ones who will start to feel the effects of water scarcity. If you enjoy almonds, artichokes, olives, pistachios, pomegranates, raisins or walnuts, be ready to say goodbye to all those exclusively California grown foods. Not to mention California grows up to 70% of the country's greens. It takes a lot of water to feed the whole country and a lot of the world. From taking five gallons of water to grow one singular walnut to 1,800 gallons of water for a single pound of beef. This isn't just a California issue, this is a global issue.

## How Did This Happen?

**Climate Change:** California relies heavily on snowpack each winter to resupply surface water streams and lakes. Because of high temperatures these past winters, due to climate change, snowpack is at an all time low. Climate change has also caused increased levels of water vapour in the atmosphere which makes water availability less predictable. This led to dry regions like California to face more severe drought conditions than the usual geography would experience.

Figure 1: Map of drought severity over time



## Groundwater Depletion:

When surface water supplies are low, groundwater is drilled to make up the shortfall. A large aquifer under the Central Valley is rapidly depleting because they have been taking more water out than they can put back in. Once aquifers are depleted, the state will have no backup supplies to surface water.

**Agriculture:** Most of the water in California is used for farming, which, as we mentioned already, produces and exports a huge amount of the country's food. Farmers have been drilling groundwater to compensate for surface supply shortages.

Figure 2: California Farm



**Increased Population:** When California faced a major drought in the late 1970s, they were able to come back from it but back then they had fewer than 20 million people living in the state. Now nearly 40 million live there.

## What are the Effects?

**Damage:** When Farmers relentlessly pump groundwater to irrigate their crops. The clays compress, roads, bridges, and irrigation canals crack, causing extensive and expensive damage. The research shows that in some places the ground is sinking nearly two inches each month.

## Workers Are Being Laid Off:

Since farmers are unable to water their crops due to the dry weather, some are leaving acres of farmland unplanted and laborers are either losing their jobs or facing a reduction in hours because of the drought.

**Pollution:** Excessive pumping also jeopardizes water quality, as pollutants accumulate in groundwater and the clays release arsenic. It is estimated one million Californians lack clean drinking water, generally those who live in impoverished rural communities with small water systems and limited budgets.

## The Story of Oasis Mobile Home Park

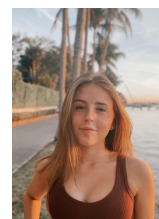
A community of roughly 1,900 residents, located on Torres Martinez Indigenous land, Oasis is home to low-income people. Many are farmworkers and undocumented.

Many residents use bottled water for drinking and cooking. But for showers, dishwashing and brushing their teeth, they still depend on the tap. Residents usually leave the shower with red eyes and clumps of hair falling out.

In August 2019, water monitoring detected arsenic in the park's groundwater supply at nearly 10 times the legal limit. The Environmental Protection Agency cited, fined and ordered the park's owner to provide an alternative supply of drinking water for violating the Safe Drinking Water Act.

In late May, the EPA declared the water safe again but residents remained suspicious of the tap water. One resident said it sometimes came out "oily, like butter." After months of complaints, the Leadership Council for Justice and Accountability, conducted its own tests and detected high levels of arsenic in Oasis's water, over eight times the legal limit. That prompted another EPA investigation.

Today the arsenic problem continues. Even though California law states that water is a right, the story of Oasis just shows how difficult it is to ensure clean drinking water for everyone.

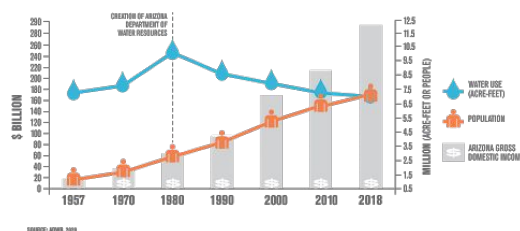


BY ELIZABETH SULLIVAN-CROWLEY

## Arizona in Crisis: Day Zero Is Approaching as Fast as the State's Population is Increasing

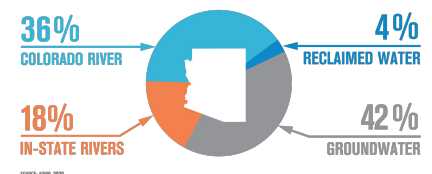
When you think of Arizona, beautiful and stunning landscapes, national parks, and exotic wildlife come to mind. With an incredibly low population density outside of a few urban areas, Arizona is not the place you would think suffers from an extraordinary water scarcity crisis, let alone suffers any water concerns at all. In fact, climate change has resulted in snowpack from the Rocky Mountains shrinking to record lows in recent years, resulting in the Colorado River downstream in Arizona becoming bone dry, affecting farmers and reservoirs throughout the state. With little in-state water supplies because of the state's naturally arid desert climate, the state is currently facing a crisis unlike anything seen in modern history. Per the National Drought Mitigation Center's National Drought Monitor, 73% of the state was in an exceptional drought the week of 1/12, the worst possible type of drought. Currently, state populations in the dry Western states are skyrocketing, with Phoenix adding more residents than any U.S. city in 2018. Complicating the situation even further is the state's rapid transition from farming to a largely urban presence focused around metropolitan Phoenix and the fact that agriculture actually uses the highest amount of water, not urban areas.

Not everything is bleak for Arizona residents, given that an agreement was reached between representatives of different states and Native American groups to sustain the water levels of nearby Lake Mead and prevent water shortages throughout the river system. However, every mitigation strategy comes with someone losing out. In this case, around 500 local farmers were forced to have water cuts which is problematic because Arizona's crop types take 70% of the water allocation from the Colorado River. Their way of life has transformed into monitoring the water levels of Lake Mead to see how much water will eventually be allocated to them. Local communities especially in urban areas do not realize that cutting water to farmers decreases the crop yields that the state including urban residents as well as residents nationwide consume. Farmers are displaying urgency by digging deeper for groundwater, with aquifers sinking further and further below the surface.



*Arizona's population has increased steadily for decades despite the state's equally steadily decreasing water supply, with 2018 marking the turning point in environmental sustainability (Arizona Water Facts).*

According to Leslie Meyers, the manager of the Bureau of Reclamation's office in Phoenix, "Farms use as much as 8 feet [of water] per acre per year" and "Three homes might use 1 acre-foot." Arizona is allocated 2.8 million acre-feet of water from the Colorado River every year and 70% of that is used by farmers across the state. It is most certainly impossible to have both a booming population and rapidly expanding urban areas as well as a heavy dependence on agriculture that uses the vast majority of the state's water allocation. Eventually the water supply will become unsustainable forcing the state's residents to either move out or face the most severe water restrictions with no running water. State officials have continued to ignore the needs of farmers not only to produce food but to sustain their quality of life. Expenses for farming families in Arizona have increased more than 20% from 2012-17 yet the state ensures that cities and native tribes have priority access to water over farmers.



*Arizona's above-ground freshwater resources only account for 18% of the state's total water composition. With the Colorado River becoming increasingly unreliable and groundwater being rapidly depleted, the state is facing an impossible scenario (Arizona Water Facts).*

For the future, farmers must adapt or face permanent unemployment within the state's borders. Given that the major city of Phoenix seems to be completely oblivious to the state's dire and imminent water shortages, with water availability (acre-feet) recently falling below the state's population size, farmers will be forced to adapt to not only a lack of water to support their seasonal crops but also a changing climate in other ways. The desert Southwest faces blistering extreme heat during summer months, and dozens upon dozens of more days per year up to 2100 are expected to see 100+ degree temperatures. Due to the need to adapt to changing circumstances, a local farmer partnered with the University of Arizona to monitor the water levels of different areas of crop fields to minimize the water usage as well as create more resistant crops that require little water to be sustainable.

By Alexander Li

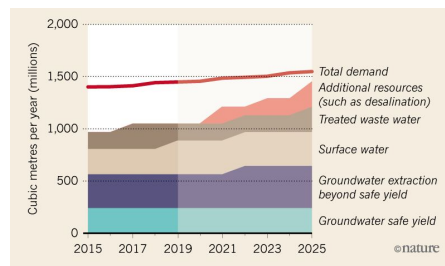




# The 'Water Mafia' and Other Water Challenges in Jordan

The water supply of Jordan, one of the world's driest countries, is steadily decreasing at an incredible rate. The United Nations defines any nation with a mean annual water supply below 500 cubic meters per resident to be experiencing 'absolute scarcity.' Jordan's annual water supply is 150 cubic meters per resident. While the country's population approaches ten million, estimates show that Jordan's water supply can only support two million people. Because of this predicted population boom, the government encouraged expansion of the agriculture sector, which overall only exacerbated the water problem. Approximately 45% of water use is attributed to the agricultural sector.

Much of Jordan's water comes from its aquifers, which in the past would have been naturally recharged by the scarce but existent rainfall. Climate change has made rainfall much less predictable, and so just as Jordan continues to over pump its aquifers, the rate at which they recharge could reduce by up to 37%. Jordan (and the Middle East in general) is one of the regions most affected by climate change, but we aren't quite sure why. Marwan Al-Raggad, a Jordanian hydrogeologist says "Fifty years from now, we'll be pumping from the bottom of the aquifer." The water shortage isn't just theoretical. It could come to pass in the very near future. Because Jordan realizes this, it is now one of the most monitored water-scarce areas in the world. While that is good for the future, it doesn't help that many previous records are unspecific or .



Jordan's total water demand far outpaces its actual water resources. /Jordanian Ministry of Water and Irrigation

nonexistent. Climatologists can't predict rainfall or weather patterns in order to help take advantage of them unless they have data. The current monitoring is for the future scientists.

Part of the population boom is the sheer number of immigrants that have come into Jordan. There are currently 750,000 registered refugees in Jordan, and that number does not include those that have gained citizenship or are unregistered. According to Ali Subah, secretary-general of the Ministry of Water and Irrigation, "All the refugees came from an area that is rich with water, and they're not used to rationing water." So, in addition to the sheer number of excess people refugees comprise, they also use more water than the average Jordanian.

In addition to all of these other things, the infrastructure in Jordan is also at fault. As much as half of the municipal water supply is lost into the sand through leaky pipes. One estimate states that the amount of water lost each year could satisfy the basic needs of 2.6 million people. In rural areas, the water supply is so inconsistent that many people rely on tankers of water controlled by tanker operators or the 'water mafias.' These people keep water prices high, no matter the quality of the water. Because of this, murmurs of political unrest spread throughout the community, and some threaten to take on the government. This was only added to with rumors of corruption in the water sector. Up to two-thirds of Jordan's boreholes are illegal, but government connections keep groups from facing punishment.

But not all is bad.

Jordan has no rich oil or natural gas deposits, which generally means that operations like desalination would be much too expensive. But teamwork could possibly help with that. In 2013, an agreement was signed between Jordan and Israel to build a water desalination plant that would desalinate water from the Red Sea, pump it to Jordan (where Israel would buy half of it at cost), and send the excess brine into the Dead Sea. Although this could be beneficial, environmentalists have pushed back, fearing damage to organisms in the Red Sea and potential disturbances to the ecosystem of the Dead Sea. As such, the project has been postponed many times, but scientists believe it could be a temporary solution to stave off Jordan's impending 'day zero.'

In addition, Jordan's 2008-22 national water strategy was supposed to limit the amount of free water given to farmers, stop over-pumping groundwater, and use the water more efficiently. Jordan has achieved some of its goals, but the main one of reducing over-pumping has made no progress as of yet.

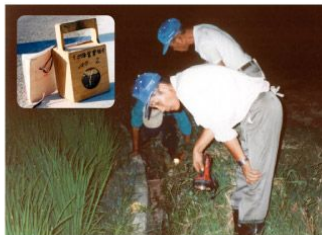
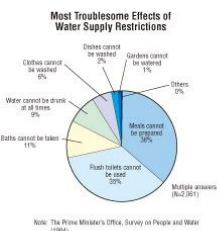
If Jordan can't get its water act together, it could perhaps face war. Researchers have speculated that an awful drought sparked the Syrian civil war in 2011 by creating crop failures and increasing the amount of people in cities. This fact is highlighted by the unrest the government is currently facing in rural areas. If Jordan continues on its current path, it will have devastating consequences.

By Adam Mohn



## Tokyo's Water Shortage Threatens Thirsty Growing Population

Water is a critical foundation of life and in Tokyo, Japan, a source for economic stability and growth. In cities with well-known fish markets that are a main source of income, the problem of water insecurity is common. Droughts and bad water quality are the main reasons for Tokyo, Japan's water shortages. With water insecurity related to these shortages comes instability of livelihood, which is "defined as adequate and sustainable access to income and resources to meet basic needs, which include adequate access to food, potable water, health facilities, educational opportunities, housing, time for community participation and social integration" (Frankenberger et al, The household livelihood security concept.). With overpopulation, an additional crisis faced by the Japanese population, a troubling dynamic is produced. The water shortage has impacts that range from household cleanliness to agricultural worries. Having a shortage of clean water resources placed a huge strain on the once comfortable life in the city of Tokyo. The lack of water caused families to lose the ability to properly cook meals, while additionally threatening the cleanliness of their homes.



Pie chart: showing the "troublesome" issues that would be faced by a typical family. Major problems with improper irrigation systems and the inability to cook meals for family units. The picture to the right of the chart: This image is of people inspecting the quality of the "water-sharing" equipment, along with an image of the actual "water-sharing clock." Multiple agricultural industries were also left with immense shortages in water forcing them to either reduce or completely halt production. Water is a driving tool of agricultural adaptation by Japanese farmers.

A system designed by local farmers was the "water-sharing" method. This system was designed to aid in the distribution of water, with a structure to be able to periodically use the limited resources of water given to them. The downside of the water sharing method is the amount of expensive equipment and labor force needed to properly maintain it. However, this method of irrigation and water control is expensive to maintain and would leave the company at risk of losing even more profit. Proving that limited water causes economic havoc for both Tokyo city and large corporations residing in it.

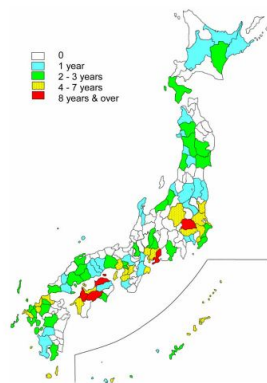


Fig. 1. Domestic water supply areas disrupted or halted due to droughts over the past 30 years.

Heavily populated cities of Japan are more susceptible to serious arid climates. This sets a massive strain on the fishing industries in these busy cities, including Tokyo. Without water, most of our industries would not be able to function because their wealth depends on it. There would no longer be enough potable water to be able to host as many tourists, that Tokyo regularly receives. The top source that keeps Tokyo as wealthy as it is--the immense amount of tourism that feeds their economy.

Tokyo has been suffering from droughts every couple of years since the early 1960s. Ever since the first warnings, it became the new norm to see less rainfall and snowfall in the city. Additionally, the temperature would fluctuate frequently and create perfect conditions for lengthy droughts and arid conditions with increased temperatures. There were attempts made to combat the weather and water shortage. In 2019, the local Metropolitan government sought to raise water levels for Tokyo and other surrounding areas in time for the 2019 Olympics.

The sources they were planning to take from were several eastern Japanese dams such as the Tone River, the Sagami River, and the Arakawa River. According to *Recurring Dry Spells Fuel Water Worries in Tokyo* by Kayla Ritter, 70% of Tokyo's water resources come from nearby rivers, lakes, and melting snowfall--the rest come from groundwater. The Tokyo Metropolitan Government intended to solve the over contamination with E.coli Bacteria without causing flooding infamous Olympic competition sites. However, due to COVID-19, the Olympics were not able to occur as planned.

What is the Tokyo Metropolitan Government looking forward to setting in place in regards to water conservation? Tokyo has already declared a construction proposal in a district that has continually struggled with water poverty, Sumida. For the landmass of Sumida, a proposed plan of covering 90,000 square miles of Ryogoku Kokugigan Arena with well-constructed basins to collect rainwater. The water could be used for nonpotable water tasks. Another idea that is still considered an extremely controversial and unlikely long-term solution for Tokyo's forgoing water crisis, which is Cloud Seeding. Essentially what Cloud seeding does is inducing rainfall. The factor that makes this route highly unreliable would be the unknown amount of water that could come from the 'artificial' showers.

Tokyo's water shortage has caused numerous threats to Japanese citizens whose livelihood depends on an efficient water supply. With the expected fluctuation of precipitation, new tactics of water collection are in plans to be implemented by the government. This preparation should be the top priority to Tokyo's Metropolitan government. If Tokyo continues down this path of inconsistent water supply and unnecessary water spending, the future of this city is in grave jeopardy.

By: Jojo Pineda-Angon





# A sinking city that's running out of water



Many residents get water delivered somewhat regularly because they are not connected to the city's main water supply.

For years, Mexico City has been on the eve of “Day Zero”, but that day may come sooner for some than it is for others. Mexico City is home to approximately 21 million people, or 20% of the total population of Mexico, and because of its large population, there is a constant, costly strain on the city's water supply.

But even though the water is running low, many citizens are unaware of the impending crisis, despite all the damage it has already done. The biggest issue right now is not the water running low, but the problems that it causes.

Heavy rains and frequent flash floods cause many problems including traffic stops, and the sewage system to overflow, along with sewage pipes bursting, filling houses with dirty water. Yet despite these heavy rains and frequent flash floods during the wet season, which lasts from June to October every year, the cities aquifers are not being replenished at the same rate at which they are being emptied. These aquifers, when filled, support the ground above, but due to the water levels constantly being lowered, they are no longer able to do so, and so the city has begun to sink at about 30cm, or 12in, annually.

Beyond that, these aquifers, along with the city's other natural water supplies, are predicted to dry up completely in the next thirty years if nothing is done to limit water usage.



Citizens who get their water delivered often use donkeys to help carry it to their houses.

In fact, more and more people are now trying to find solutions to the problem, and ways to get these people cleaner, more accessible water, along with solving the water crisis the entirety of the city is facing. “Therefore, we need to revise [how people get water] and understand that access to water is a human right,” says Arnoldo Matus Kramer, the city's chief resilience officer. One way this will be done is by modernizing the infrastructure of the city's water supply, which the Comisión Nacional del Agua (CONAGUA) in Mexico mobilized quickly in the start of 2020 to do.

Not only will they help modernize the city's infrastructure, but they will also replenish the depleted groundwater in the Mexico Valley Aquifer.

Improving the cities infrastructure will be great not just when it comes to solving the water crisis, but also to help fix other problems that are affecting the water supply. Currently, due to the city's out of date and aging infrastructure, 40% of the water is lost when people simply try to get it, which is one of the biggest factors in the water shortage. But beyond that, it would help the sewage systems, and with flood control.



Workers must go into the sewer tunnels to clean out blockages, though new tunnels are being built to help modernize the sewer system

One of the largest issues with the sewage system, and the biggest factor into sewage pipes bursting during floods, is all the trash that gets into the system, clogging it up. These clogs require workers to get into the drainage system and clean it out. By modernizing the system, both these problems could be solved, leading to less damage during floods, and, most importantly, more accessible water for the entire city.

So, while Mexico City is on the eve of their “Day Zero,” new initiatives will hopefully push it back long enough for the city to start thinking about ways to continue pushing it back and, eventually, prevent it indefinitely.

**By: Addy Santianni**

