

In India, one dam shapes the fate of millions

Many rely on the Mullaperiyar. Many fear it, too.

BY SARAH KAPLAN,
SREEKANTH SIVADASAN
AND APARNA GANESAN

THEKKADY, INDIA — Deep in the mountains, shrouded by dense forests and tropical mists, the Mullaperiyar lurks like a creature from legend. Few locals have seen the massive dam that was erected here 130 years ago, plugging one of South India's most important rivers. But nearly everyone who lives within 100 miles knows its power.

To the east, in the farmland of Tamil Nadu, the Mullaperiyar is sacred. Via a tunnel that winds beneath the surrounding mountains, the dam provides drinking water to millions of people, and its reservoir irrigates hundreds of thousands of acres of fruit

orchards and rice paddies. When seasonal rains fail, and the red soil turns cracked and dusty under a blistering sun, the dam ensures that water still flows through pipes and fills up wells.

“Mullaperiyar is my life,” said Salethu Innaci, 66, a farmer in the village of T Sindalacherry. “If someone said die for Mullaperiyar, I would.”

But to the west, in remote communities tucked among Kerala's hills, the Mullaperiyar is a monster. When heavy monsoon rains fill the reservoir, forcing excess water to be released into the Periyar river, these areas often flood. Locals live in terror that the century-old structure — built without advanced engineering techniques or modern

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A view of the Periyar river flowing through the Western Ghats in India. When heavy rains force excess water to be released into the Periyar, remote communities tucked among Kerala's hills often flood.

Climate change tests the limits of the Mullaperiyar dam

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concrete — may one day collapse, unleashing an almighty torrent that obliterates thousands of homes.

"When the water level rises, we can't sleep," said Nabeesa Moosa, a 65-year-old day laborer who lives on the banks of the Periyar, a few miles below the dam. "We hold our lives in our hands."

The dispute between these two Indian states has raged for decades. But increasingly extreme weather, supercharged by climate change, is raising the stakes like never before.

A Washington Post investigation shows that warming has boosted the flow of water vapor through the atmosphere, providing more moisture to fuel unprecedented rainfall — and Kerala is among the world's hardest-hit regions. The strongest vapor plumes the state experiences each year have intensified twice as fast as the global average rate. The Post found, increasing the likelihood of storms that could push the dam past its breaking point.

Millions of people worldwide live downstream of dams like the Mullaperiyar — structures that have long served as vital lifelines for communities but that age, poor maintenance and a changing climate could transform into threats.

Of the world's roughly 62,000 large dams, most were built at least 50 years ago, before engineers understood the effects of human-caused warming. Surging rainfall means these dams may face extremes they were not designed to handle — forcing managers to weigh escalating demand for water against the looming danger of collapse.

In few cases is this conundrum more stark than the fight over the Mullaperiyar. Officials in Kerala, where the dam is located and at least 75,000 people could be affected if it gave way, say the structure must be dismantled and replaced. A recent uptick in dam failures, particularly in countries like India where precipitation tends to occur in concentrated bursts, has amplified their concerns. In the past seven years, India has seen three dams break amid floods.

Yet leaders in Tamil Nadu, which controls the dam under a colonial-era arrangement, say it is stable and should be allowed to hold even more water. They point to studies suggesting that rising temperatures will increase the chance of drought, making reservoirs more essential.

The dispute illustrates the thorny choices posed by aging infrastructure in a warming world, experts say. What one community sees as its salvation, another fears will be its doom.

'Someday it will break and kill all of us'

In Kerala's Idukki district, where the Mullaperiyar stands, June marks the start of a season of fear.

That's when plumes of warm, moist air begin to stream eastward from the Arabian Sea, filling the sky with roiling gray clouds. As these waterlogged currents reach the peaks of the Western Ghats, they are forced upward. The rising air cools, the water vapor within it condenses, and rain starts to fall on the land below. The southwest monsoon has arrived.

Whenever the downpours pound her home's thin roof, Moosa imagines the water level rising in the Mullaperiyar reservoir and feels her chest contract.

In the riverside town of Up-pathara, Sibi Joseph seals his important documents in a plastic bag and reminds his children of the evacuation route through the hills above their home.

Priya TV, village officer for the community of Manjumala, always moves a mattress into a building near the village headquarters. With the dam just five miles upstream, someone must always be on duty in case disaster occurs.

For the rest of the six-month rainy season, "all we are thinking about is Mullaperiyar," said P.N. Sebastian, a cardamom farmer in Vandiperiyar who is active in

protests over dam safety. "Someday it will break and kill all of us, that is the feeling."

The anxiety Sebastian and his neighbors feel is exacerbated by the secrecy that surrounds the dam. The Mullaperiyar sits in the middle of Periyar National Park, a vast wilderness inhabited by elephants, tigers and snakes. A Kerala police checkpoint blocks the only road to the facility, and boat access is forbidden. Sharp mountain peaks surround it like a fortress, shielding the dam from all public view.

Much of what residents know about the Mullaperiyar comes from legal filings and second-hand reports. The main dam is 155 feet high and made of lime-surkhi mortar — a precursor of modern cement that dates back to ancient Rome. Behind it lies a 10-square-mile reservoir containing enough water to fill 177,000 Olympic swimming pools. To the side of the dam, a spillway comprises 13 shutters that can be opened and closed to control the water level. And at the opposite end of the lake, a mile-long tunnel carries water under the mountains, toward the cities and farms of Tamil Nadu.

This unusual setup stems from an agreement inked before either state existed. In the 1880s, the maharaja of what is now Kerala granted the British a 999-year lease to build the Mullaperiyar and divert all its reser-

voir water. The Tamil Nadu government inherited the lease after independence and maintains complete control over the dam's operation.

Many dams show signs of wear and tear after 50 to 100 years, said James Wilson, a veteran dam safety expert and chief adviser to the Kerala government on interstate water issues. Though routine maintenance can keep dams safe for centuries, some older structures, particularly those built before the development of modern engineering standards, may develop weaknesses that cause them to give way under the weight of too much water. Older dams are also less able to withstand earthquakes, which pose a risk in Kerala, he said.

The Kerala government has said it will cover the cost of constructing a new dam and pledged that Tamil Nadu would receive just as much water from a replacement structure. In the meantime, it wants to limit how much water can be stored to avoid putting excess pressure on the dam.

Maintaining a lower storage level also creates more cushion during heavy downpours, Wilson said, reducing the need to open the spillways when the river is already swollen by rain.

In August 2018, after Idukki district was soaked by twice its usual amount of monsoon rain,

Shaji P. Joseph received a call from a police officer friend warning that all 13 spillway shutters were about to be opened.

Joseph — a community leader in his home village of Chappathu — raced to the banks of the Periyar, knocking on doors and telling people to evacuate. As the river rose, he swam through churning red waters to rescue several elderly residents.

By the following morning, the flood had affected the homes of roughly half the village's 15,000 residents. All roads to the community had been washed out; electricity and cell service were obliterated. The bloated bodies of drowned dogs and cattle drifted in the murk — though, miraculously, no one from his village died.

The experience hardened Joseph's conviction that the Mullaperiyar must be replaced, and he became chairman of the Mullaperiyar Protest Forum two years later. The 50-year-old has pledged not to marry until the issue is resolved; before he can start his own family, he said, he must ensure his community is safe.

Disasters like the 2018 flood, which killed more than 400 people across Kerala, are expected to become even more severe in a changing climate, research suggests. The Post's analysis found that the biggest moisture plumes in the region have increased 7.5

percent in just the past three decades. This surge allows greater amounts of rain to fall in a shorter period of time, increasing the chance that infrastructure becomes overwhelmed.

Kerala officials say the Mullaperiyar is not equipped to handle even today's downpours. A study from the Indian Institute of Technology in Delhi, commissioned by the Kerala government, found that an exceptional rainstorm would cause water to flow into the reservoir more than twice as fast as it could be released. In a worst-case scenario, the study found, water might gush over the top of the dam for as long as 14 hours — potentially causing the entire structure to fail.

"My simple question to any person of logic is: Would you live in a 130-year-old house if the status of the roof and the walls is questionable?" said Sekhar Kurikose, Kerala's chief climate resilience officer and head of the state disaster management authority.

Yet many Idukki residents say they have no other choice. Fear of the dam has lowered property values, they say, making it impossible to sell their homes and relocate. And those who face the greatest flood risk are mostly low-income farm workers, like Moosa, who don't have the resources to move even a few yards farther from the river.

Her home was one of thousands washed away during the 2018 floods. The only replacement she and her family could afford was a rental property on the opposite bank of the Periyar, which was once again inundated with mud when heavy rains prompted another spillway opening this October.

Moosa blames the Mullaperiyar for the deluges she can't seem to escape, and she wishes she could move somewhere safer. The family is trying to build a new house on stilts, but they have run out of money to finish construction. Moosa's husband is unable to work, and she and her son barely scratch out a living as day laborers. Any extra income goes toward her granddaughter's school fees.

"We were born and brought up here," said Moosa, who has worked as a tea and spice picker since she was 10 years old. "We have nowhere else to go."

And so she stays by the river, holding her breath against the dam break that seems inevitable. "Then," she said, "the whole world will be gone."

A human has to eat

Just over the border in Tamil Nadu, inside an impressive green building surrounded by trees, there stands a giant gilded statue of a mustachioed British man. CONTINUED ON NEXT PAGE



Rescue workers evacuate people from flooded areas on the outskirts of Kochi, India, in 2018.

SIVARAM V/REUTERS



PHOTOS BY SAUMYA KHANDELWAL/FOR THE WASHINGTON POST

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This is John Pennycuick, the engineer who oversaw the construction of the Mullaperiyar.

"I personally look at him as equivalent to God," said Madhusudhanan Ramachandran, an irrigation inspector who oversees the memorial. "Without him, none of us in this region would be here."

Though Tamil Nadu's fertile soil makes it ideal for agriculture, Ramachandran explained, it has long been plagued by drought. By the time monsoon winds cross the Western Ghats, almost all of its moisture has been squeezed out, creating a rain shadow that leaves the state dry. Tamils must wait for the shorter northeast monsoon, which sweeps down from the Himalayas in autumn.

If the rains come too late — or not at all — the consequences can be catastrophic. In the 1870s, a spate of failed monsoons contributed to a famine that killed between 6 million and 10 million people.

Then came Pennycuick, with his ambitious plan to divert some of Kerala's abundant water to Tamil Nadu's thirsty farms. Now his portrait can be found painted on buildings and framed in people's homes. Government buildings and bus stations and even children bear Pennycuick's name.

"This man was not our brother," Ramachandran said, "but he came to help us."

According to documents filed with India's Supreme Court, which is considering ongoing complaints about the issue, the dam supports the livelihoods of some 680,000 agricultural workers — most of them small-scale farmers growing rice, pulses, vegetables and fruits. Many of these foods, Tamils are quick to note, are eventually purchased by people in Kerala.

Access to this dependable water source can be transformational for small farmers, said 95-year-old Chenna Yosanai, who still cultivates five acres in the village of Pudukkottai. Since he began farming more than seven decades ago, Yosanai has seen the monsoon rains become less and less reliable. Many of his neighbors abandoned their land and sought jobs in the cities. He watched his own mango orchard wither and die.

But when a newly built canal brought Mullaperiyar water to the region in 2018, "it made my life abundant," Yosanai said. The canal gave him the confidence to start growing sugar cane, which requires year-round water but is less labor-intensive and more profitable than the rice and flowers he had been raising. Others in the area bought dairy cows, whose milk could be sold at markets to cover expenses between harvests.

Yet Yosanai's newfound abundance feels tenuous: His region receives water only in years of surplus, after villages with older rights have their fill. He supports raising the Mullaperiyar's reservoir levels so it can provide more water.

The storage level of the Mullaperiyar has been the subject of legal battles going back nearly 50 years. In 2014, India's Supreme Court ruled that the dam was



TOP: Penstock pipes carry water from the Mullaperiyar reservoir in Kerala to the neighboring state of Tamil Nadu. ABOVE: Salethu Innaci, 66, a farmer and leader of a local farmers association, stands near a bore well at his farmland in the village of T Sindalacherry, Tamil Nadu.

safe enough to maintain 142 feet of water — 10 feet below its original design capacity. The state was also ordered to implement guidelines mandating lower storage levels during the rainy season.

Tamil Nadu and India's Central Water Commission maintain that the Mullaperiyar is structurally sound. And a top engineer with the Tamil Nadu water resources department, who spoke on the condition of anonymity because he was not authorized to discuss the subject, said the state had made several upgrades to bolster the dam, including adding a reinforced concrete crown to the back of the main structure, installing cables to anchor the

dam to the bedrock and adding drainage systems to relieve pressure from water seeping through the masonry.

"When the flood comes, give me a camp cot and I will stay out on the dam," the engineer said. "I am that sure it will not harm people."

Farmers in the five Tamil Nadu districts receiving reservoir water say climate change has made the water-level issue even more urgent. Higher temperatures increase the rate of evaporation from plants and soil, putting more stress on crops. Changes in weather patterns may also make the monsoons less reliable, studies suggest, increasing the risk of prolonged dry spells and delayed

growing seasons.

The past year has been particularly hard in T Sindalacherry, a village tucked in the dry foothills of the Western Ghats. Innaci, who leads the local farmers association, said that many of his neighbors experienced total crop failures.

On the six-acre plot that Innaci has cultivated for most of his life, 15 lemon trees died from lack of water. His entire banana crop withered. Innaci spent 200,000 rupees (about \$2,200) installing a new, deeper well to draw up groundwater — and still it wasn't enough.

His family makes do with money from his son's job as a forest inspector and his wife's

teaching salary. But when he stood before one of his ruined lemon trees, dead leaves crumpling beneath his feet, Innaci's eyes filled with tears.

"I love this," he said. "I love my plants, even if they are dead."

The farmer blames the storage restrictions pushed by Kerala officials for the water shortages, and he is suspicious of the state's offer to build a replacement dam. Without the 999-year lease, he asked, what's to stop Kerala from keeping all the water for itself?

Perhaps, Innaci mused, farmers in Tamil Nadu should gather at the border and block food from going into Kerala — the same way Kerala has blocked water from reaching them.

"The hay for their cows, the vegetables they eat, the milk their children drink: It is all from here," he said. "A human has to eat. I would ask them, 'Are you a human?'"

A rising risk

When officials in Kerala picture a worst-case scenario for the Mullaperiyar, it looks like what happened in Libya in September 2023.

Over the course of a single weekend, a storm supercharged by warm Mediterranean waters dropped roughly eight months' worth of rain on the coastal city of Derna. The deluge overwhelmed two decrepit dams above the city, unleashing a tidal wave that killed more than 10,000 people.

An audit obtained by The Post found that Libyan authorities had failed to conduct even basic maintenance on the affected dams. A study performed shortly afterward found that the storm was made 50 times worse by human-caused warming.

The unfathomable destruction fed global fears about the fate of aging and neglected dams. Though conflict and political corruption made the Derna dams

exceptionally vulnerable, experts say that most countries — including the United States — do not invest enough in dam maintenance and are failing to strengthen their infrastructure against escalating weather extremes.

"Many people think that Libya was the exception," said Virginia Tech geophysicist Manoochehr Shirzaei, who uses satellite imagery to identify degrading dams. "But to my opinion Libya was the tip of the iceberg."

An analysis published this year in the journal *Nature Water* found that dams built more than 75 years ago have a much higher failure rate than those constructed later. The study also suggested that the rate of failures at newly built dams has increased slightly since 2000, backsiding from a century of progress. Most recent collapses were in lower-income regions, particularly those with monsoon climates, and they typically occurred amid unusual flooding.

It's difficult to disentangle the factors driving this increase, said study author Antonio Moreno-Rodenas, a hydraulic engineering specialist at the Dutch research institute Deltares. In countries with less dam-building experience, where most new dams are located, looser regulations and a shortage of accurate weather data can make the structures more vulnerable to floods even before climate change is considered.

Yet the combination of an older dam with intensifying rainfall patterns "raises a red flag," Moreno-Rodenas said — particularly in the case of the Mullaperiyar, where the intense political conflict may complicate efforts to assess the structure's safety.

Only an updated hydrologic analysis can show the true risk, Moreno-Rodenas said. But he noted that climate studies for Kerala consistently project an increase in extreme rainfall, boosting the likelihood of a storm beyond what the dam was built to handle. Even when they are reinforced with concrete, he said, masonry dams like the Mullaperiyar are not designed to withstand prolonged overflows.

Failure to account for extreme rainfall may exacerbate dam-related flooding even if the structure remains intact, said Sarah Suresh, a hydrologic engineer at the University of Washington. In a recent study of the world's biggest hydropower dams, he found dozens of cases where massive spillway releases made downstream inundation worse than it would have been if the rivers flowed naturally.

The Mullaperiyar was too small to be included in the analysis, but 10 other dams in India were classified as "likely flood-inducing."

And there is another kind of danger posed by dams like the Mullaperiyar — one that can't easily be quantified by scientists or modeled on a graph. The lack of transparency around the dam has fed conflicting narratives about the dispute, making it easy for residents to demonize those on the other side. Years of unresolved legal battles have left residents feeling attacked by the opposing states' leaders and abandoned by their own.

The combination of misinformation and mistrust can be combustible: At the height of the conflict, in the early 2010s, tensions ran so high that protesters in both Kerala and Tamil Nadu set cars ablaze and attacked people who attempted to cross the border.

Wilson, the adviser to the Kerala government, said the heightened emotions around the dam make it impossible for the two states to find a compromise.

"We cannot just tell people, 'This is what the science says,'" he said. It will take an outside force — another Supreme Court ruling, an independent safety assessment, perhaps even a weather catastrophe — to break the stalemate.

On a misty day this November, a group of officials from Kerala, Tamil Nadu and India's Central Water Commission gathered on a dock at the edge of the Mullaperiyar reservoir. No outside onlookers were permitted to watch as the officials clambered into boats and set sail for the dam's interior wall. The visit — like all inspections by the court-appointed supervisory committee — was closed to journalists and the public.

The following day, National Dam Safety Authority Chairman Anil Jain reassured reporters that the Mullaperiyar was "in good shape." He added that the two states had agreed to coordinate on some maintenance measures.

But it was not enough to quell the anxieties that raged beyond the Mullaperiyar's mountain barricades. Out of the forest, in Kerala's riverside villages and on Tamil Nadu's farms, residents continued to wait and worry — caught between the unseen dam and the unpredictable sky.



People drive past a picture of John Pennycuick, the engineer of the Mullaperiyar dam, at a junction in Pulikuthi, Tamil Nadu.