

# NEWS IN FOCUS

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India's hydroelectric projects, such as this dam on the River Teesta, are raising environmental concerns.

## ENVIRONMENT

# Flood of protest hits Indian dams

*Himalayan plans pose ecological threat, researchers warn.*

BY JANE QIU

The days when the gigantic Indian rivers — the Ganges, Indus and Brahmaputra — roar freely down the steep slopes of the Himalayas may be numbered.

Roughly 300 dams are proposed or under construction in the deeply cut valleys of India's mountainous north, part of a massive effort to meet the country's spiralling energy demands. But the projects are facing fierce resistance from local communities, as well as from scientists who predict that the dams' ecological impacts will be much greater than official environmental assessments suggest. "The magnitude of dam building in the Himalayas is overwhelming,"

says Kamaljit Bawa, a conservation biologist at the University of Massachusetts, Boston. "They are moving too fast without properly assessing the risks and alternatives."

Last week, the battle flared up once more in the Indian state of Sikkim, where the 520-megawatt Teesta IV hydroelectric project would block a tributary of the Brahmaputra (see 'A deluge of dams'). As the Indian government's Ministry of Environment and Forests started to review the environmental impact assessment (EIA) for the project, indigenous Lepcha and Bhutia communities redoubled their protest, saying that the dam would take away the last stretch of free-flowing river in the heart of their sacred land. Following previous

demonstrations, a petition objecting to the construction has now attracted more than 1,300 signatures.

Advocates say that the projects are a vital part of the drive to double India's electricity-generating capacity to 300,000 megawatts by 2022, a goal that is said to be essential for the country's economic growth. Electricity shortages are already wreaking havoc: in July, for example, a massive blackout across the country left 600 million people without electricity. Yet India is also the world's third-largest emitter of carbon dioxide, mainly due to the burning of coal for electricity, and its emissions are expected to double by 2030 if the country's energy mix does not change substantially. The government sees the largely untapped hydropower in the Himalayas as a panacea for both problems, and it plans to add another 110,000 megawatts of hydroelectric capacity by 2025, an eightfold increase<sup>1</sup>.

According to a study published this month<sup>2</sup>, that would create a dam for every 3,000 square kilometres of valleys in the Indian Himalayas, 62 times the global average density for hydroelectric stations. "The consequences would be dire," says Maharaj Pandit, an ecologist at the University of Delhi, who led the study. Most of the dams would be in regions of high biodiversity, and about 1,700 km<sup>2</sup> of forests would be either submerged or damaged by new infrastructure and other dam-related activities. Pandit's ecological modelling suggests that, by 2025, this would reduce tree biodiversity in the region by more than one-third, and lead to the extinction of 22 flowering plants and 7 vertebrate taxa.

Although hydroelectric projects in flatter terrain create huge reservoirs, providing a substantial head of water to generate power, most of those in the Indian Himalayas would use run-of-the-river dams, which require smaller reservoirs. Such dams divert water through tunnels to the turbines, and return it to the river downstream. Developers argue that the approach reduces a dam's environmental footprint — but ecologists say that a series of barriers along the rivers would seriously fragment both terrestrial and aquatic ecosystems.

"The blow would be fatal to fish biodiversity," says Pandit, whose studies show that the volume of water in a river is the key determinant of the ►

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damming the  
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► richness of fish species<sup>3</sup>.

Dulal Goswami, an environmental scientist at Gauhati University in Guwahati, Assam, worries that the geological hazards of the region have not been properly considered. “The Himalayas are fragile and dynamic,” he says. Earthquakes of magnitude 7 or 8 are not uncommon, and increasing glacial melts due to climate change are causing more floods, both of which can damage dams and tunnels.

And the rivers’ heavy sediment loads could clog the dams. According to Goswami, the Brahmaputra carries 400 million tonnes of sediment each year, peaking at 25 million tonnes a day during extreme monsoon events.

The Indian government has required EIAs for the projects, but these are lax, says Neeraj Vagholikar, a conservationist at the non-governmental organization Kalpavriksh in Pune. For example, he says, the EIA of a dam project on the Siyom River lists just five bird species in an area that ecologists say has more than 300; similarly, the EIA for the Lower Subansiri dam lists 55 fish species in a river that has at least 156.

The assessments usually cover a radius of only 10 kilometres from the dam and reservoir, and do not consider downstream effects or secondary impacts caused by the influx of labour and infrastructure such as power lines. And the cumulative impact of multiple dams along the

## A DELUGE OF DAMS

The Indian state of Sikkim, deep in the Himalayas, plans dozens of hydropower projects, and hundreds more are springing up across the country’s mountainous north.



same river is not assessed before individual projects are approved. “This is particularly important for areas with densely clustered dams,” says Bawa. Even if the impacts of individual projects are acceptable, the cascading effects on ecosystems and the geological hazards of dams stacking on top of one another along the same

river may be serious, he says. “It’s based on such poor assessments that 99% of the projects get approved,” adds conservationist Samir Mehta, south Asia programme director of International Rivers, a non-governmental organization based in Berkeley, California.

Some also argue that the assessments are not sufficiently independent. “Agencies that conduct the EIAs are selected and paid for by dam developers and deliver favourable assessments in order to be invited back,” says Mehta. The Ministry of Environment and Forests did not respond to *Nature’s* questions about the allegations.

India is not alone in its rush to build dams in the Himalayas. Other countries, especially China, Pakistan, Nepal and Bhutan, plan to add hundreds more dams along the rivers, prompting similar concerns about their EIAs. Damming rivers upstream could have significant impacts on downstream nations, but “every country behaves as if the river is 100% theirs”, says Edward Grumbine, an environmental-policy researcher at the Chinese Academy of Sciences’ Kunming Institute of Botany. “This is a recipe for disaster.” ■

1. Bawa, K. *et al. Science* **327**, 1457–1478 (2010).
2. Pandit, M. K. & Grumbine, E. *Conserv. Biol.* **26**, 1061–1071 (2012).
3. Bhatt, J. P., Manish, K. & Pandit, M. K. *PLoS ONE* **7**, e46237 (2012).

NEERAJ VAGHOLIKAR/UMESH BOBADE/SANCTUARY ASIA, ADAPTED FROM A MAP OF DEPT HYDROPOWER, GOVERNMENT OF SIKKIM

## MATERIALS

# Nanoparticle blast caught on film

*Combustion could help to make minuscule matter.*

BY EUGENIE SAMUEL REICH IN BOSTON

It was a pretty explosive premiere for a movie about a chemical reaction. A microscopic droplet drifted across the screen — almost in homage to the panning gun barrel of the James Bond movies — and then: bang!

Scientists watching the scene last week at a meeting of the Materials Research Society (MRS) in Boston, Massachusetts, were gripped, because the death of the droplet was also an act of creation. Lutz Mädler, a process engineer at the University of Bremen in Germany, had, for the first time, captured on camera a process that makes beautifully

homogeneous metal oxide nanoparticles (see ‘Blow up’). His goal is to pave the way for faster, cheaper ways to make these fragments of matter, measuring just billionths of a metre across, which are finding uses as catalysts, medical imaging probes and more.

Mädler’s presentation was part of the first MRS session ever to be dedicated to the combustion synthesis of nanoparticles. The technique aims to improve the process of making nanoparticles, which generally requires multiple, complex steps from expensive precursors. The solution, say Mädler and others, is to create the particles in bulk by simply igniting tiny droplets of precursor

materials — a strategy that industry has used for decades to make carbon black for tyres and silica for optic fibres.

“This is a field that mushroomed out of industry, and didn’t have an academic following,” says Sotiris Pratsinis, a process engineer at the Swiss Federal Institute of Technology (ETH) Zurich. “These are beautiful fundamental studies.”

Mädler’s work aims to overcome a key drawback of combustion synthesis: the process is little understood and tends to be poorly controlled. In 2002, and working with Pratsinis, Mädler developed a way to make metal oxide nanoparticles by burning organometallic complexes dissolved in organic solvents (L. Mädler *et al. J. Aerosol Sci.* **33**, 369–389; 2002). The approach worked well in the lab, but the ingredients were too expensive for most commercial applications. Mädler resolved to pick apart the process so that he could replicate it with cheaper precursors, such as metal nitrates, which can be produced directly from ores.

At present, metal nitrates yield nanoparticles that are inhomogeneous — often with hollow areas inside — but Mädler says that his high-speed videos reveal how mixing processes in the combustion of organic