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Study finds river sand mining is outstripping nature's supply

by Nanyang Technological University

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Researchers analysing river-depth and flow data on board a survey boat on the Tien River near Long Khanh Island, Vietnam, on Dec 5, 2025. The team used acoustic and bathymetric survey tools to map the riverbed and assess changes linked to sand extraction. Credit: Nanyang Technological University

The sand used to build cities, roads and other infrastructure is being removed from many rivers faster than nature can replace it, according to a global review led by researchers from Nanyang Technological University, Singapore (NTU Singapore).

The authors said the problem can be better managed if governments track where mining is taking place, measure how much sand and gravel is removed, and set extraction limits based on how much sediment rivers can naturally replenish.

The review, published in the journal *Reviews of Geophysics*, looked at 411 peer-reviewed studies published since 1974.

It found that river sand and gravel mining is a growing global sustainability challenge linked to urbanization, infrastructure development, river degradation and the security of communities living along rivers and deltas.

Where reliable measurements exist, annual extraction of sand and gravel often exceeds natural sediment supply by several times.

This can deepen riverbeds, weaken riverbanks, lower groundwater levels, worsen water quality and push saltwater further inland in coastal and delta regions.

These changes can damage bridges, roads and buildings; harm river habitats; and affect farms, fisheries and livelihoods.

The paper was written by 26 international authors who are leading researchers in river sand mining, sediment transport, deltas, ecology and sustainability.

The team brought together evidence from Southeast Asia, South Asia, China, Africa, Europe and South America.

The NTU team was led by associate professor Edward Park from the National Institute of Education (NIE) and a principal investigator at the Earth Observatory of Singapore (EOS).

Other senior NTU researchers involved include professor Adam Switzer from the Asian School of the Environment and EOS, and professor Chu Jian, chair of the School of Civil and Environmental Engineering.

As the corresponding author, Park said the team not only showed that river sand mining is a serious global problem but also set out practical ways to manage it.

"Sand is essential to the growth of cities, including in Singapore and Southeast Asia, but its extraction can place pressure on rivers and the communities that depend on them," said Park.

"Our review shows that governments can better manage this by treating sand mining as a river-basin issue, using satellite monitoring, field surveys and sediment-budget analysis to decide where extraction can take place, how much can be removed, and which areas should be protected."

A data gap in sand mining

Sand is one of the world's most widely used natural resources, forming a key ingredient in concrete, roads, land reclamation and other infrastructure.

Demand has grown as cities expand and countries build more housing, transportation networks and coastal protection.

Yet the review found that many countries still lack the basic data needed to manage river sand mining. Only 27% of the studies reviewed quantified the extent of extraction, while 24% analyzed what drives demand. In contrast, 69% focused on impacts.

"You cannot solve a problem you cannot see. When sand mining is poorly tracked, governments are often left responding after rivers have already changed and communities have already been affected," said Park, whose team demonstrated a satellite-based method for tracking sand mining in the Mekong River in 2024.

Using the Mekong River as an example, the team estimated that more than 50 million metric tonnes of sand had been extracted, compared with a permitted amount of about 20 million metric tonnes.

This was more than 150% above the permitted limit, with about 60% of the total amount extracted illegally.

"Better data would help regulators act earlier, from setting extraction limits and enforcing permits to identifying illegal or unsustainable mining before the damage spreads," he added.

Managing sand mining at river-basin scale

To organize the evidence, the researchers developed a new driver-to-management pathway for a sustainable sand and gravel mining framework.

It links the demand for sand to where extraction takes place, how rivers and surrounding ecosystems are affected, and what governments can do in response.

The review found a scale mismatch: Demand is often driven by regional and global construction markets, while the impacts are usually felt by local rivers and communities. In some cases, these effects move downstream and spread beyond the mining site.

The authors said this means sand mining should be managed at the scale of river basins, with extraction limits based on sediment budgets, which estimate how much sand and gravel a river can naturally supply and replace over time.

Satellites, drones and river surveys can help manage sand mining

The authors said monitoring systems should combine satellite imagery, drone surveys, sonar mapping, field surveys and river modeling.

Satellite imagery can help identify dredging vessels, sediment plumes and active mining areas across large and remote river networks, while drone surveys and high-resolution aerial images can help map smaller or harder-to-detect mining sites.

Bathymetric mapping, which measures the shape and depth of riverbeds, can show the scars left by dredging, including pits and deepened channels.

Repeated sonar surveys can help governments measure how much sediment has been removed and how riverbeds are changing over time.

These data can be combined with river models to estimate how rivers may respond to different extraction levels.

Having such a combination of technologies can help regulators identify areas where controlled extraction may be less harmful and exclusion zones where mining should be restricted to protect erosion-prone or environmentally sensitive stretches.

Why it matters for Southeast Asia

The findings are especially relevant to Southeast Asia, where rapid urban development continues to drive demand for construction materials.

For cities such as Singapore, the issue is not only local construction demand but also the wider regional supply chains that provide sand and other building materials.

As alternative materials will take time to scale up, sand is expected to remain a major construction material.

The authors, including senior research fellow Dr. Dung Duc Tran, research associates Kai Wan Yuen and Sonu Kumar, said more transparent sourcing and more responsible use of sand will therefore be important as countries continue to build housing, transportation networks and coastal protection.

They added that demand-side measures may also help ease pressure on rivers, such as using sand more efficiently in construction and developing suitable alternatives, like processed construction waste, recycled glass and treated bottom ash from waste incineration.

At NTU, researchers from the School of Civil and Environmental Engineering have been studying ways to turn waste materials into construction resources, including treated incineration bottom ash and other recycled materials.

As part of the solution, Park's team has developed a sustainable sand-harvesting technology that can help identify where sand and gravel may be extracted, and in what quantities, while reducing environmental and social impacts.

More information

Edward Park et al, River Sand and Gravel Mining: Global Drivers, Impacts, and Pathways for Sustainable Management, *Reviews of Geophysics* (2026). DOI: 10.1029/2024rg000868