New land creation on waterfronts is increasing, study finds

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Shanghai in 2019, with new land additions visible along the city's coast. Credit: NASA Earth Observatory

Humans are artificially expanding cities' coastlines by extending industrial ports and creating luxury residential waterfronts. Developers have added over 2,350 square kilometers of land (900 square miles, or about 40 Manhattans) to coastlines in major cities since 2000, according to a new study.

The study reports the first global assessment of coastal land reclamation, which is the process of building new land or filling in coastal water bodies, including wetlands, to expand a coastline. The researchers used satellite imagery to analyze land changes in 135 cities with populations of at least 1 million, 106 of which have done some coastline expansion.

The study was published in the journal *Earth's Future*.

"Population growth is not the only driver of coastal land reclamation," the study's authors said. "We expect that reclamation would continue to be popular in places that not only experience urban growth but also are eager to re-brand themselves for reputation and revenue."

Coastal land reclamation today is most common in the Global South, where many economies are rapidly growing. In the previous century and earlier, the Global North dominated the use of coastal land construction. The study found China, Indonesia and the United Arab Emirates added the most land area, with port extension being the most common reason for development. Shanghai alone has added about 350 square kilometers (135 square miles) of land. In the United States, by comparison, only Los Angeles has noticeably added land area in the last 20 years, with 0.29 square kilometers (0.1 square miles) built.

"It's quite important to capture this," said Robert Nicholls, who researches climate adaptation at the University of East Anglia and is not an author of the study. "There are more and more people, and our footprint is going up. Inevitably, there are ecologic consequences."

Lead author Dhritiraj Sengupta, a physical geographer at the University of Southampton, and his co-authors found that industrialization and a need for urban space have driven much coastal land reclamation, while a smaller proportion of expansion projects are for "prestige," such as the palm tree-shaped islands of Dubai.

About 70% of coastal land expansion has been carried out in low-lying regions that are likely to be exposed to extreme sea level rise by the end of the century. Both environmental impacts and projected coastal inundation suggest these developed coastlines are not sustainable, but cities will likely continue to build them, the authors said.

Some cities, including Shanghai, are building new land while considering future sea level rise, Sengupta said. However, selling a development as "green" is easier than selling it as an adaptation to sea level rise, he said. Evaluating the height of new land on a global scale is difficult. Doing so remains an interesting research question for scientists like Sengupta.

Ecological impacts

New land is typically created by piling sediments in the ocean, building cement sea walls and structures to contain sediments or cement, or by filling in wetlands and other shallow water bodies near the coast. These methods require vast volumes of sediment and disturb ecosystems irreversibly, as other research has established.

"The ecological impacts of reclamation are immense. Reclamation is a massive civil engineering project that fundamentally alters the

characteristics of the space that it targets," Sengupta and his co-authors said. Coastal wetlands are particularly hard-hit. "In the Yellow Sea, for example, more than half of tidal flats were lost mainly due to reclamation."

"Environmental consequences should be considered as part of the overall approval process" for coastal land construction, Nicholls said. "The creation of land will make sense where it's needed, but you have to do it in a responsible way … and think about whether it is really needed. Those are value judgments." Nicholls also noted that these projects make up a small fraction of the world's coastlines and are often on already urbanized shores. By comparison, an estimated 14% of shorelines in the United States alone are "armored" by seawalls and jetties.

Other environmental impacts include adding sources of point-source pollution, changing the patterns of sediment movement and altering the biosphere, all of which can impact ocean-based economies such as fishing and tourism. And unequal access to newly created shoreline can exacerbate class divides.

Reclamation also impacts distant ecosystems where fill materials such as sand and gravel are quarried. With a global shortage of sand, Sengupta noted, construction companies are quarrying sand and clay from the seabed, which destroys benthic ecosystems.

More information: Dhritiraj Sengupta et al, Mapping 21st Century Global Coastal Land Reclamation, *Earth's Future* (2023). DOI: 10.1029/2022EF002927

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