# Scientists see order in complex patterns of river deltas

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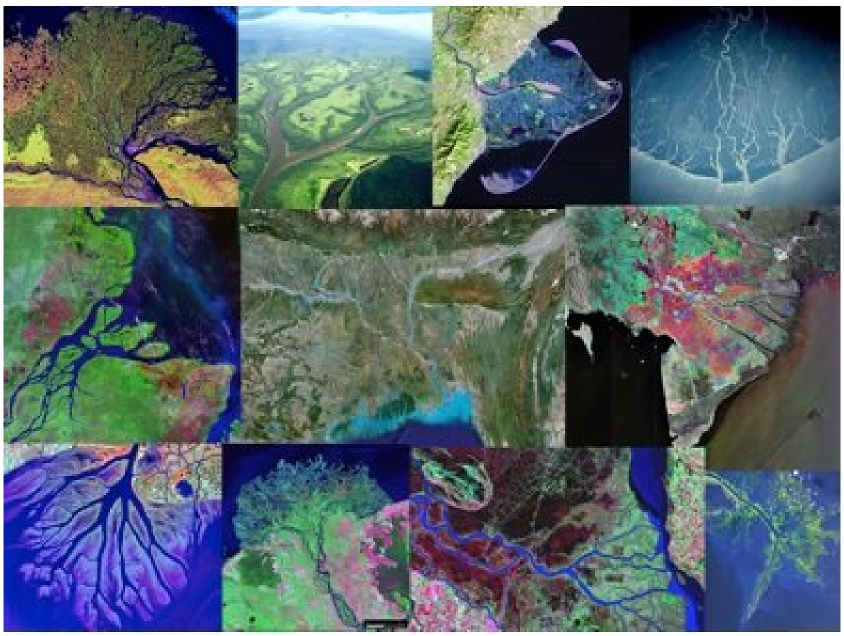

The world's river deltas come in many complex and diverse patterns, as demonstrated by those depicted above (from top to bottom, left to right): the Lena (Russia), Mossy (Canada), Ebro (Spain), Niger (Nigeria), Amazon (Brazil), Ganges-Brahmaputra-Meghna (Bangladesh and India), Mekong (Vietnam), Wax Lake (Louisiana), Colville (Alaska), Parana (Argentina) and Mississippi (Louisiana) deltas. Yet nearly all "self-organize" to increase their resiliency in the face of human and natural disturbances, the UCI-led study found. Credit: Efi Foufoula-Georgiou

River deltas, with their intricate networks of waterways, coastal barrier islands, wetlands and estuaries, often appear to have been formed by random processes, but scientists at the University of California, Irvine and other institutions see order in the apparent chaos.

Through field studies and mathematical modeling, they have concluded that deltas "self-organize" to increase the number, direction and size - or diversity - of sediment transport pathways to the shoreline, boosting their ability to withstand human disturbances and naturally occurring factors. The research team's findings have been published in *Proceedings of the National Academy of Sciences*.

"With their entangled channels that split and rejoin multiple times before entering the sea, deltas are amazingly complex and varied, leading us to wonder if they're hiding some simpler order," said lead author Alejandro Tejedor, research associate in UCI's Department of Civil & Environmental Engineering. "Could there be some common 'goal' on the part of deltas to sustain their existence by diversifying the spread of their fluxes to build land on their way to the ocean?"

The researchers sought to solve this riddle by applying statistics and mathematical modeling. Looking at 10 major river deltas around the world, they determined the probability of flows dividing into smaller channels and merging again at confluences, discovering that all but one, the Niger Delta in Africa, exhibited a high "nonlocal entropy rate," meaning a large diversity of delivery pathways to the sea.

The team confirmed these findings through numerical models, demonstrating that even when major channel avulsions take place - leading to network reorganization - flows tend to re-create diverse water routes.

"By adopting concepts from information theory, we showed that a range of deltas from different environments obey an 'optimality principle' that suggests a universality across almost every natural occurrence of these landforms," Tejedor said.

Many of the world's deltas have come under threat in recent decades from rising sea levels, local development and the construction of upstream dams that limit the flow of sediment.

"River deltas occupy only 1 percent of the world's land surface but are home to more than half a billion people and are the source of vast amounts of food and other natural resources," said Efi Foufoula-Georgiou, Distinguished Professor of civil & environmental engineering at UCI, who directed and co-authored the PNAS study. "So it's imperative that we establish a better understanding of these vital earthscapes and how human and climate stressors might adversely impact their self-maintenance."

**More information:** Alejandro Tejedor et al. Entropy and optimality in river deltas, *Proceedings of the National Academy of Sciences* (2017). DOI: 10.1073/pnas.1708404114

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