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Rising seas threaten to drown important mangrove forests, unless we intervene

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**Abstract**
Mangroves are some of the world’s most important trees. They provide food and resources for people and animals, protect coasts, and store huge amounts of carbon. The world’s largest mangrove forest - the Sundarbans in the Bay of Bengal - supports millions of livelihoods. In terms of the services they provide, they are worth nearly US$200,000 per hectare per year. But these coastal forests are threatened by rising seas and human development. In a study published today in Nature, we show that some of these forests will drown unless we help them.

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Mangroves put their roots down where few other plants will. Catherine Lovelock, Author provided

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Catherine Lovelock explains her new mangrove study

Getting to the root of it all

Mangroves grow along tropical coasts. Unique amongst the world's plants, they can survive in salt water and can filter seawater. The rain of leaf-fall from tropical mangrove forests provides food for crabs and other herbivores, the foundation of a food web that extends to fish (and therefore people) right across the tropics.

One of the distinguishing characteristics of mangroves are their roots, used to anchor the plant on unstable ground and buttress against wind, waves and currents. The form of root architecture varies greatly between families of mangrove, including the dense prop-roots (Rhizophora), cathedral-like buttresses (Bruguiera), and numerous pneumatophores - literally narrow breathing–tubes - of the common grey mangrove of southeast Australia (Avicennia).

A high proportion of the living mass of mangroves exists below-ground. This means mangroves are the most efficient ecosystem globally in the capture and sequestration of atmospheric carbon dioxide. The uniquely oxygen-poor, salty characteristics of mangrove soil provides the perfect setting for long-term preservation of carbon below ground. The typical mangrove forest sequesters several times more carbon dioxide than a tropical rainforest of comparable size.

Mangrove roots trap sediment as currents carrying suspended particles are intercepted and slowed. Between the carbon sequestered below-ground, and the sediment trapped within the tangle of roots, mangroves are effectively able to raise the height of the land over time.
Keeping up with rising seas

Analysis of these sediments shows mangroves can deal with low to moderate sea-level rise by building up land. But how will mangroves respond to future rising seas when people are in the way?

We and other colleagues measured how fast mangrove forests in the Indo-Pacific region increase the height of the land. We used a tool called Surface Elevation Table-Marker Horizon, as you see in the video below.

Mangroves also build up land height by accumulating roots below ground. Previous studies have focused on this. Our study, using up to 16 years of data across a range of coastal settings, shows that sediment build up is also important.

We also compared the rate of land height increase in mangroves to local tidal gauges, to assess whether mangroves were keeping pace with the local rate of sea-level rise.

In most cases (90 out of 153 monitoring stations) mangroves were lagging behind. This is not an immediate problem if mangroves are already high enough to delay the effect of expected sea-level rise. However, mangroves at the low end of their elevation are highly vulnerable.

We used this insight to model how long mangroves might survive rising seas across the Indo-Pacific. We used a range of sea-level rise projections from the Intergovernmental Panel on Climate Change, including a low-range scenario (48 cm by 2010), high-range (63 cm by 2100) and extreme (1.4 m by 2100).

Mangrove forests with a high tidal range and/or high sediment supply such as Northern Australia, eastern Borneo, east Africa and the Bay of Bengal proved to be relatively resilient. Most of these forests will likely survive well into the second half of the century under low and moderate rates of sea-level rise.

The prospect of mangrove survival to 2070 under the 63 cm and 1.4 m scenarios was poor for the Gulf of Thailand, the southeast coast of Sumatra, the north coasts of Java and Papua New Guinea and the Solomon Islands.

Dams holding mangroves back

Our results imply that factors that prevent sediment building up may prevent mangroves responding to sea-level rise. This might include dams holding sediment within water catchments.

This impact is already being felt. An 80% reduction in sediment delivery to the Chao Phraya River delta has, for example, contributed to kilometres of mangrove shoreline retreat.

Similar developments are planned for the Mekong River. These threats compound those already being felt, including the widespread conversion of mangrove to aquaculture.

Appreciation of the financial contribution of mangroves has been slowing the trend of decline. However, long-term survival will require planning that includes both the continued provision of sediment supply, and in many cases the provision of retreat pathways, to allow mangroves to respond to sea level in ways they always have.
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