Seawalls, coastal forests in Japan help reduce tsunami damage

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Researchers who analyzed a history of tsunamis along the Pacific coast of Japan's Tohoku region have learned that seawalls higher than 5 meters reduce damage and death, while coastal forests also play an important role in protecting the public.

The analysis was performed by researchers at Tohoku University, Maryland Institute College of Art, the University of Michigan and Purdue University. The researchers studied data from tsunamis in 1896, 1933, 1960, and 2011.

"These events have caused large loss of life and damage throughout the coastal region, and there has been uncertainty about the degree to which seawalls reduce deaths and building damage," said Jeremy D. Bricker, an associate professor in the International Research Institute of Disaster Science at Tohoku University in Japan.

The Japanese have embarked on a 10-year reconstruction project costing about 31.5 trillion yen, or about $255 billion, which includes the construction of tsunami seawalls along Tohoku's Pacific coast. Critics of the program have voiced skepticism about the effectiveness of seawalls.

However, new findings detailed in a research paper appearing on Aug. 10 in the journal *PLOS ONE*, may bolster support for seawalls and coastal forests.

"Some have suggested that seawalls cause a sense of complacency in

residents, leading to lower evacuation rates and the tendency to develop residences in hazardous low-lying areas," said Seth Guikema, an associate professor in the Department of Industrial and Operations Engineering and the Department of Civil and Environmental Engineering at the University of Michigan. "However, our results cast serious doubt on this theory. The presence or size of seawalls and coastal forests does not strongly influence residents' decisions on whether or not to evacuate."

The new research findings demonstrate that both seawalls higher than 5 meters and coastal forests do, in fact, reduce damage and death from tsunamis. The paper's lead author was Roshanak Nateghi, an assistant professor in Purdue's School of Industrial Engineering and Division of Environmental and Ecological Engineering. She co-authored the paper with Bricker, Guikema and Maryland Institute College of Art student Akane Bessho.

The heights and construction methods of sea walls vary widely from one community to another, and even within the same town.

"In fact, there are many sub-municipalities that still don't have seawalls," Nateghi said. "We analyzed these four tsunamis and found that statistically, seawalls above 5 meters are related to a decrease in destruction rate."

Nateghi used a modeling method called Random Forest, which harnesses numerous "decision trees" to capture complex non-linear relationships of data. Seawalls more than 5 meters high were shown to reduce the destruction rate, and, more specifically, a 10-meter increase in height was associated with about a 5 to 6 percent decrease in the destruction rate.

Findings also showed the protective value of coastal "tsunami control"

forests.

"We saw that in the areas with a lot of coastal forest you have reduced damage and destruction, and the extent of flooding is a big predictor in our models," Nateghi said.

Moreover, the presence of coastal forests was found to reduce death and destruction rates by displacing development that would otherwise have been damaged.

The findings showed the extent of flooding is a critical factor in death rates and building damage rates, suggesting that additional measures, such as multiple lines of defense and elevating topography, may have significant benefits in reducing the impacts of tsunamis.

The same analysis method also could be used to study tsunamis in other regions.

"All the insights are conditioned on the type of infrastructure you have in place, the topography and intensity of the tsunami," Nateghi said. "But the methodology is extendable. You could do similar analyses for other regions using this method."

More information: Nateghi R, Bricker JD, Guikema SD, Bessho A (2016) Statistical Analysis of the Effectiveness of Seawalls and Coastal Forests in Mitigating Tsunami Impacts in Iwate and Miyagi Prefectures. *PLoS ONE* 11(8): e0158375. DOI: 10.1371/journal.pone.0158375

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