Small Islands Threatened by Sea Level Rise

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Sea level, like the weather, varies considerably from year to year for island nations.[1] (See Table 1.) A combination of many factors, including wind, ocean currents, ocean temperature, and periodic oceanic oscillations like El Niño, bring about this annual variation.[2]

Long-term trends make it clear that for most islands, as for the world in general, the sea is rising. In the twentieth century, global sea level rose 10–20 centimeters, averaging 1–2 millimeters per year.[3] The sea level rises from melting continental ice masses and from the expansion of the oceans due to climate change.[4]

LINKS pp. 40, 50, 92, 102

Over the next century, global sea level rise is expected to accelerate. According to the Intergovernmental Panel on Climate Change (IPCC), the sea level will rise 9–88 centimeters in the next 100 years, with a mid-estimate rise of 50 centimeters.[5] This translates into 5 millimeters per year—two to four times faster than during the twentieth century.[6]

In terms of culpability for global sea level rise, the small-island states are beyond reproach; in terms of vulnerability, they are the most at risk. Although plagued by their own internal environmental problems, these small nations account for less than 1 percent of global greenhouse gas emissions.[7]

Accelerated sea level rise brings up the possibility that, for the first time in history, an entire sovereign country could be lost due to environmental change.[8] The height of low-lying atolls, like those in the Pacific and Indian Oceans, rarely exceeds 2 meters, with maximum heights of 3–4 meters.[9] New Zealand has drawn up a plan to accept immigrants from the tiny Pacific island country of Tuvalu, where residents fear losing their homes to future sea level rise.[10] And the Indian Ocean nation of the Maldives—65 percent of which is less than 1 meter above sea level—has evacuated residents from four of the lowest lying islands to larger ones over the past few years.[11]

One study notes that the impact of sea level rise on the Marshall Islands, Tuvalu, and Kiribati would be "profound," including disappearance in the worst scenario; the impact on the Federated States of Micronesia, Nauru, and Tonga would be "severe," resulting in major population displacement; and the impact on Fiji and the Solomon Islands would be "moderate to severe."[12] Indeed, in 1999, Kiribati lost two uninhabited islets, Tebua Tarawa and Abanuea, to the sea.[13]

Sea-level-rise scenarios have been compiled for a few small-island states, with most focusing on the impact of a 1-meter rise—the "worst-case scenario" for the next 100 years. Such a rise would inundate or erode 940 hectares in Antigua, 1,000 hectares in Mauritius, 3,700 hectares in Tonga, and 340 hectares in Nevis.[14] A recent study calculated that a 1-meter rise in the Caribbean would inundate 98 coastal communities in Cuba, threatening more than 50,000 persons.[15] Majuro Atoll, in the Marshall Islands, would lose 8.6 percent of its total land area with a rise of this magnitude, and 12.5 percent of Betio Island, Kiribati, would be vulnerable to annual flooding.[16]

While the long-term threat to these islands is inundation, the more immediate and pressing problems are those associated with storm surges, flooding, coastal erosion, saltwater intrusion into freshwater supplies, coral bleaching, and economic attrition.

Storm patterns are heavily connected to local weather patterns, most notably El Niño, strongly affecting islands in the Caribbean and the Pacific. According to the IPCC, the warm episodes of El Niño, which affect rainfall and periods of drought for small-island states, have been more "frequent, persistent and intense" since the mid-1970s.[17] Cyclones cause storm surges, which can reach up to 6 meters in height. With elevated sea levels, these surges are predicted to be more destructive, and even more so if cyclone intensity increases due to climate change.[18]

Individual studies suggest an increase of 10–20 percent in the intensity of tropical cyclones under enhanced atmospheric carbon dioxide conditions.[19] In June 1997, Cyclone Keli destroyed an islet of Tuvalu—Tepuka Savilivili—washing away all the vegetation and rendering the islet uninhabitable.[20] Some flood-risk mod-

els suggest that by 2080, the number of people facing severe floods in the Caribbean, Indian, and Pacific Ocean regions would be 200 times higher than if there were no sea level rise.[21]

Accelerated coastal erosion has caused some beaches in Trinidad, where sea level has risen four to eight times faster than the global average, to retreat by as much as 2 meters a year during the past 15 years.[22] In Fiji, where sea level has risen at the average global rate, beaches at Viti Levu and Taveuni have retreated by about 75 centimeters per year.[23] Coral reefs, which provide sand and a buffer for the beach, suffer severe impairment or death with ocean temperatures of about 1 degree Celsius higher than the summer maximum. This condition, called bleaching, will be highest in the Caribbean and lowest in the central Pacific in the next few decades.[24]

Tourism is one of the most important economic sectors for island states. For a number of these countries, such as Antigua and Barbuda, the Bahamas, Barbados, Cyprus, Grenada, Jamaica, the Maldives, Malta, St. Kitts and Nevis, Samoa, and the Seychelles, tourist revenue makes up more than 20 percent of the gross national product.[25] In addition to the degradation of natural resources, equatorial islands worry that global warming will lead to milder winters in industrial countries in northern latitudes, decreasing the incentive to travel for a large number of tourists.[26]

Another economic concern for islands is the reduction of their exclusive economic zones (EEZ), which provide sovereign development rights over 370 kilometers (200 nautical miles) of ocean area surrounding the islands.[27] These nations typically include tens to thousands of islets; for some mid-Pacific states, the EEZs are a thousand times larger than the land areas.[28] Even if they are uninhabited, disappearing fringe atolls could lead to a reduction of the EEZ and, therefore, a reduction in fishing license revenues for the government.

Table 1: Current and Historical Sea Level Rise in Selected Island Countries

Country	Average Sea Level Rise, 2002	Long-Term Sea Level Rise
	(millimeters)	(millimeters per year)
Cook Islands	12	2.3
Fiji	2	4.0
French Polynesia	24	2.5
Galapagos	52	1.5
Japan	6	3.2
Kiribati	35	–0.2
Maldives	8	–
Saipan	6	–
Seychelles	6	–
Tonga	40	4.9
Tuvalu	38	0.9

Source: University of Hawaii, Permanent Service for Mean Sea Level, and the South Pacific Sea Level and Climate Monitoring Project.

SMALL ISLANDS THREATENED BY SEA LEVEL RISE (pages 84–85)

1. For islands with multiple sea level gauges, the data were averaged to obtain a single value. For some islands and chains of islands, however, only one sea level gauge was available and was used to represent the entire island nation. Month-to-month gauge data from the University of Hawaii Sea Level Center, GLOSS database, at <ilikai.soest.hawaii.edu/uhslc/woce.html>, viewed 28 November 2002. Long-term trends derived from the Permanent Service for Mean Sea Level, at <www.nbi.ac.uk/psmsl/datainfo/rlr.trends>, viewed 28 November 2002, and from the South Pacific Sea Level and Climate Monitoring Project, *Pacific Country Reports* (various), at <www.pacificsealevel.org/islandreport.htm>, viewed 28 November 2002.
2. Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: The Scientific Basis* (Cambridge: Cambridge University Press, 2001), p. 31.
3. Ibid., p. 4.
4. Jeff Williams and Virginia Burkett, "Forum on Sea-Level Rise and Coastal Disasters," *Soundwaves*, December 2001/January 2002, at <soundwaves.usgs.gov /2002/01/meetings2.html>, viewed 17 November 2002.
5. IPCC, op. cit. note 2, p. 16.
6. IPPC, *Climate Change 2001: Impacts, Adaptation, and Vulnerability* (Cambridge: Cambridge University Press, 2001), p. 847.
7. Ibid., p. 845.
8. Jon Barnett, "Adapting to Climate Change in Pacific Island Countries: The Problem of Uncertainty," *World Development*, vol. 29, no. 6 (2001), p. 978.
9. Ibid.
10. Kalinga Seneviratne, "Tuvalu Steps Up Threat to Sue Australia, U.S." *Pacific Islands Report*, 8 September 2002.
11. John Pernetta, "Rising Seas and Changing Currents," *People and the Planet*, vol. 7, no. 2 (1998); Robert J. Nicholls, "Synthesis of Vulnerability Analysis Studies," *Proceedings of WORLDCOAST '93*, August 1994, p. 34.
12. IPPC, *The Regional Impacts of Climate Change: An Assessment of Vulnerability* (Cambridge: Cambridge University Press, 1998), p. 350.
13. "Small Island States Meet Over Rising Sea Levels," *Environmental News Network*, 14 July 1999.
14. Synthesis and Upscaling of Sea-Level Rise Vulnerability Assessment Studies (SURVAS), *SURVAS Database*, at <www.survas.mdx.ac.uk/content.htm>, viewed 13 November 2002.
15. IPPC, op. cit. note 6, p. 856.
16. IPPC, op. cit. note 12, p. 346.
17. IPPC, op. cit. note 2, p. 4.
18. Barnett, op. cit. note 8, p. 986.
19. IPPC, op. cit. note 6, p. 854.
20. Angie Knox, "Sinking Feeling in Tuvalu," *BBC News Online*, 28 August 2002.
21. Leonard A. Nurse, "Climate Change and Coastal Vulnerability in Small Island States," prepared for the AOSIS Inter-Regional Preparatory Meeting for the World Summit on Sustainable Development, 7–11 January 2002.
22. Ibid.
23. Ibid.
24. IPPC, op. cit. note 6, p. 858.
25. Ibid., p. 862.
26. Ibid.
27. Barbados Programme of Action, *Report of the Global Conference on the Sustainable Development of Small Island Developing States*, October 1994, p. 9.
28. IPCC, op. cit. note 12, p. 336.