EFFECTS OF SEA-LEVEL RISE ON SMALL ISLAND STATES

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Summary

This article focuses on the small island state members of the United Nations Alliance of Small Island States (AOSIS), which are located mainly in the tropical regions of the Indian, Atlantic, and Pacific Oceans. These islands can be grouped into trench/arc islands, oceanic islands, and islands associated with continental plate dynamics. Most of these islands enjoy a tropical maritime climate and are influenced all year round by the trade winds.

Sea level around those islands has been changing ever since their formation. However, the recent trend, with global warming and melting of the ice sheets in the Northern Hemisphere, is unprecedented. In the twentieth century, sea level has risen globally by 108 mm/yr^{-1}, but regionally and locally this rise has been found to be two to three times more. No long-term series of historical data exist for most small island states but the analysis of data available recently indicates an accelerated sea-level rise (ASLR) in the last decade of the twentieth century.

All models show that sea level will most likely rise by more than four times the present rate as a consequence of global warming because of the increase of greenhouse gases. Such a scenario will have negative impacts on coastal ecosystems including coral reefs, mangroves, shoreline, coastal tourism, infrastructure, and settlement.

The Intergovernmental Panel on Climate Change (IPCC) has designed a common methodology for assessing vulnerability to sea-level rise. It is presented in this article. Adaptation options—retreat, accommodation, and protection—are described with emphasis on soft technologies, which are becoming more and more popular. Hard engineering options should be used to protect mainly urbanized areas. Implementation of integrated coastal zone management should also be given high priority to mitigate the negative effects of ASLR.

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1. Introduction

Most of the world's small island states (SIS) are located in the tropical regions with a few exceptions such as Malta and Cyprus, which are situated in the Mediterranean Sea. They may comprise a single island (for example, Mauritius, Barbados, Malta), a few islands (examples are Tuvalu—nine islands, Vanuatu—12, and Cape Verde—15), or numerous islands (for example, Seychelles (115), Tonga (180), and the Maldives (1200). Most of them are concentrated between the Tropic of Cancer and the Tropic of Capricorn (Figure 1).

These countries have grouped themselves under the United Nations Alliance of Small Island States (AOSIS) established during the Second World Climate Conference in 1989 to form an entity to address environmental and socioeconomic issues of common concern and interest including projected sea-level rise. This article focuses on those islands. However, the impacts and projection of global warming and accelerated sea-level rise (ASLR) are also applicable to other islands that form part of large countries (e.g. the thousand islands of Indonesia or those under the control of a metropolitan country such as France, the United States, or the United Kingdom).

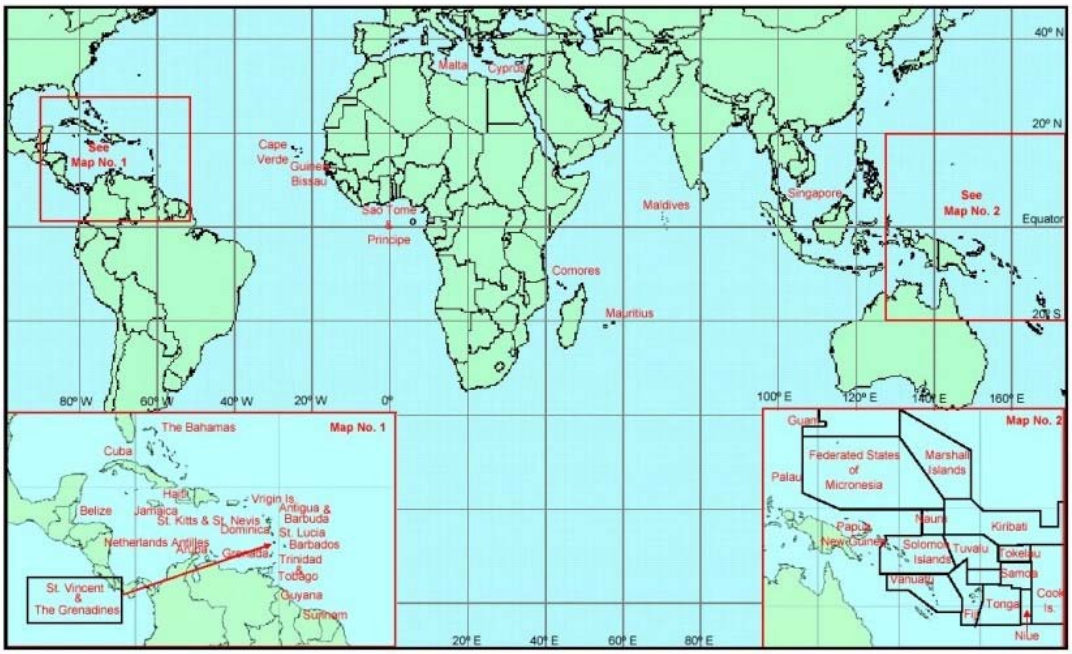

Figure 1. Members of the Alliance of Small Island States (AOSIS)

	Land area (km^2)	Population ('000s)	Coastal length (km)	Urban population in coastal cities ('000s)	People affected with 1 m rise (%)	Land at loss with 1 m rise (%)
1. American Samoa[b]	N/a	N/a	N/a	N/a	N/a	N/a
2. Antigua and Barbuda	280	66	153	N/a	50	1.0
3. The Bahamas	13 935	276	3 542	N/a	N/a	N/a
4. Barbados	431	262	97	100	N/a	N/a
5. Belize	N/a	N/a	N/a	N/a	35	8.4
6. Cape Verde	4 033	133	209	125	N/a	N/a
7. Comoros	2 171	653	340	89	N/a	N/a
8. Cook Islands[a]	236	N/a	120	N/a	N/a	N/a
9. Cuba	110 861	11 041	3 735	6 628	N/a	N/a
10. Cyprus	9 251	742	N/a	291	N/a	N/a
11. Dominica	750	71	148	N/a	N/a	N/a
12. Federated States of Micronesia	720	N/a	6 112	N/a	N/a	N/a

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13. Fiji	18 272	784	1 129	244	N/a	N/a
14. Grenada	312	92	121	N/a	N/a	N/a
15. Guam[b]	N/a	N/a	N/a	N/a	N/a	N/a
16. Guinea Bissau	N/a	N/a	N/a	N/a	N/a	N/a
17. Guyana	N/a	N/a	N/a	N/a	9	1.0
18. Haiti	27 750	7 180	370	1 771	N/a	N/a
19. Jamaica	10 991	2 447	1 022	1 016	N/a	N/a
20. Kiribati[a]	728	79	1 143	N/a	100	12.5
21. Maldives	300	254	644	N/a	N/a	N/a
22. Malta	316	366	N/a	303	N/a	N/a
23. Marshall Islands	181	N/a	370	N/a	100	80.0
24. Mauritius	1 850	1 117	177	410	<1	0.3
25. Nauru	21	11	30	N/a	N/a	N/a
26. Netherlands Antilles[b]	N/a	N/a	N/a	N/a	N/a	N/a
27. Niue[b]	N/a	N/a	N/a	N/a	N/a	N/a
28. Palau	497	N/a	N/a	N/a	N/a	N/a
29. Papua New Guinea	N/a	N/a	N/a	N/a	N/a	N/a
30. Saints Kitts and Nevis	269	41	135	N/a	N/a	1.4
31. Saint Lucia	616	150	158	N/a	N/a	N/a
32. Saint Vincent and the Grenadines	389	112	84	N/a	N/a	N/a
33. Samoa	2 842	171	403	N/a	N/a	N/a
34. Sao Tome and Principe	960	133	209	N/a	N/a	N/a
35. Seychelles	280	73	491	N/a	N/a	N/a
36. Singapore	N/a	N/a	N/a	N/a	N/a	N/a
37. Solomon Islands	28 446	378	5 313	N/a	N/a	N/a
38. Surinam[b]	N/a	N/a	N/a	N/a	N/a	N/a
39. Tonga[a]	697	98	419	N/a	47	2.9
40. Trinidad and Tobago	5 128	1 306	3 760	362	N/a	N/a

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41. Tuvalu[a]	26	10	24	N/a	N/a	N/a
42. U.S. Virgin Islands[b]	N/a	N/a	N/a	175	N/a	N/a
43. Vanuatu	14 763	169	2 528	N/a	N/a	N/a

[a] Non-U.N. members
[b] Non-U.N. members and observers
N/a: Not available
Source:

Table 1. Members of the Alliance of Small Island States (AOSIS)

Small islands can be grouped into trench/arc islands, oceanic islands, and islands associated with continental plate dynamics. Trench/arc islands are usually situated in lithosphere subjection zones associated with deep-sea trenches. These are often arcade chains of regularly spaced volcanic islands parallel to oceanic trenches in which the volcanic materials are primarily acidic and viscous, producing devastatingly explosive eruptions of varied ejecta (examples are Martinique, St. Vincent, and St Kitts in the Caribbean, the Maldives in the Indian Ocean, and the Federation of Micronesia in the Pacific Ocean).

Oceanic islands are isolated summits of large basaltic volcanoes linked to mid-ocean ridges or to lateral fracture zones that protrude above the ocean level. Coral reefs usually surround these islands if hydro-biochemical conditions are favorable. Ocean islands can be defined on their basis of origin, composition, age, size, and elevation. The main types of these islands are volcanic islands, low-lying coral atolls, and emergent limestone islands. Volcanic islands may be of recent formation or old complex type. The coastal type of the former may vary from rugged cliffs and pocket beaches (e.g. Western Samoa in the Pacific Ocean). They are usually small and have steep inaccessible coasts or tend to be fringed with a narrow coral reef (e.g. Rarotonga, Cook Islands in the Pacific). They are characterized by low biodiversity because of the island's short history. Older volcanic islands have been built up by several eruptions and then smoothed up by denudation producing a rich volcanic soil that has sustained agricultural development. Coral formation, initially fringing reefs, have been built up over the years, some with shallow lagoons (Mauritius and Seychelles in the Indian Ocean; Jamaica, Dominica, and St Vincent in the Caribbean; Ratting and Cook Islands in the Pacific Ocean), whereas many others have extensive barrier reefs with wide deep lagoons (examples are Vita Levi and Fiji in the Pacific Ocean). The coastlines are usually regular with extensive coverage of mangroves or sea grasses at times (e.g. Jamaica, Grenada, and Mauritius).

Low-lying islands, both atolls and reef islands, are coral reefs whose growth has kept them at the surface after the volcanoes on which they are founded either subsided and/or were submerged beneath the sea. The portion of land above sea level is usually limited to a few square kilometers. The highest elevation of the islets does not exceed 5 m, usually being between 1 m and 2 m. These islets form some of the smallest and most isolated habitable land areas on the earth and are extremely vulnerable to natural and anthropogenic environmental changes. Herbaceous plants as well as shrubs and trees

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including the coconut palm and animal populations with limited species diversity are typical of them.

Atolls are a common type of island in the Indian Ocean (e.g. Maldives), Atlantic Ocean (e.g. Eastern Caribbean, the Bahamas, and the islands in the westernmost Caribbean), and Pacific Ocean (e.g. Kiribati, Tuvalu, Marshall Islands, Federated States of Micronesia, Tolekan Islands, French Polynesia, and Northern Cook Islands). Because most of them are recently decomposed young conglomerates, the hypercalcic soils of these islands are poor and are made still poorer in some cases by significant amount of magnesium carbonate in addition to calcium carbonate. Infiltration is very high, resulting in a perennial problem of lack of water.

Emergent or elevated coral islands are former coral atolls or reef islands that have been lifted over the ocean surface leaving near vertical limestone cliffs or a very narrow limestone platform (e.g. Nauru and Kiribati). Some island groups are composed of chains of volcanic mountains and uplifted and tilted coral reefs (e.g. Tonga).

2. Regional Climate

In view of their insular nature and tropical location, most of the SIS enjoy a tropical maritime climate with mean annual temperature of the order of 25ºC. Diurnal and seasonal variations in temperature are usually below 5ºC. They are swept by trade winds almost all year round with only seasonal changes in intensity. Tropical cyclones (Indian Ocean), typhoons (Pacific Ocean), and hurricanes (Caribbean) are the most important weather systems influencing these regions during the summer months, causing extensive damage and disruption to the daily life of the people. They bring, however, great amounts of rainfall, which is an important source of water for most countries in the tropical regions (Mauritius, for example, depends on cyclones for 60% of its water resources). Other important weather systems are anticyclones, inter-tropical convergence zone, easterly waves, and cold fronts. Heavy swells from low pressures in the higher latitudes during the transition months of May/June and September/October are common and this gives rise to occasional flooding of the coastal regions. The El Niño–Southern Oscillation (ENSO) phenomenon has a strong influence on the climate of the tropical Pacific Ocean with associated extreme weather events. ENSO also influences the weather and climate of tropical islands in the Atlantic, as well as in the Indian Ocean.

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