

Can 'natural' adaptation save coral atoll islands from destruction by climate change and sea-level rise?

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Maldives
Archipelago

Problem:

Small island nations at the front-line of impacts from climate change & sea-level rise. Atoll island nations most vulnerable: Maldives, Chagos, Tuvalu, Kiribati, Marshall Islands, Tokelau
Why?

- Accelerated coastal erosion/land loss (Bruun rule)
 - Increased inundation / sea flooding
 - Sea water intrusion into fresh-water lens
 - Higher reach of king tides / storm surges
 - Destruction of settlements/ infrastructure
- [And ultimately island abandonment/out migration?]

Question:

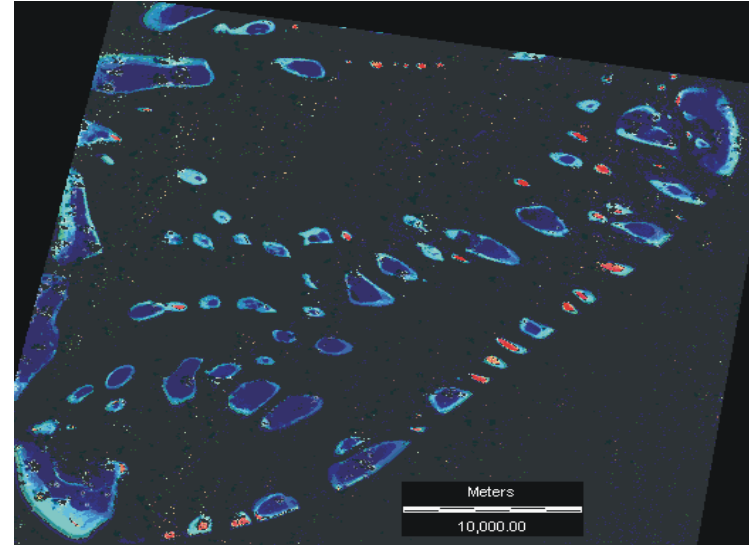
How can atoll islands reduce the potential impacts through adaptation? Can 'natural' adaptation save atoll islands from destruction by climate change and sea-level rise?

Answer:

Yes, where it is possible to maintain or develop the dynamic two-way linkages between coral reef ecosystems and atoll islands. Reefs need to be healthy and productive and the islands capable of persisting or building either upwards or outwards.

What are coral atoll islands? Why are they so vulnerable?

Atolls are ring-shaped coral reefs that partly or wholly surround a lagoon; atoll Islands - located on reef rim or patch reefs within lagoon.



Atoll islands are:

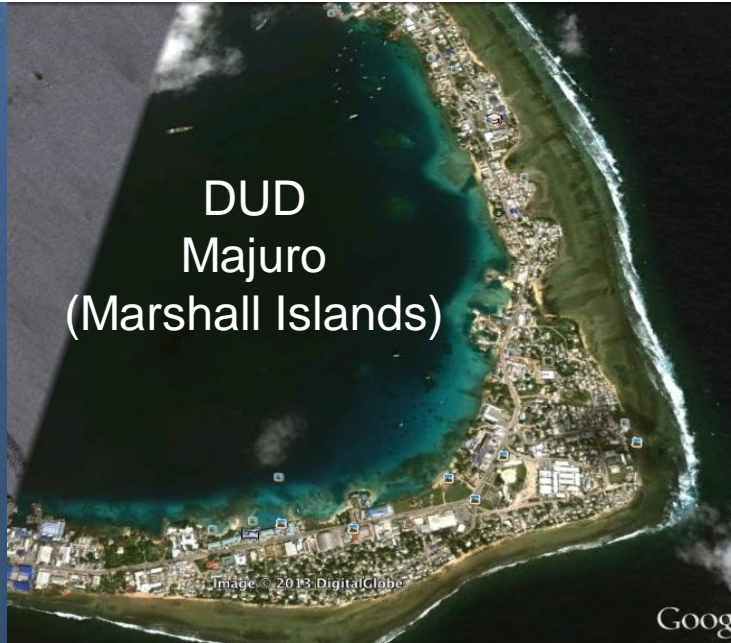
- wave built accumulations of bioclastic sediment-skeletal sands and /or coral rubble sourced from adjacent reef or lagoon;
- geologically very young having accumulated in the last few thousand years;
- small size and low elevation (<4 m above sea-level);
- shallow soils, limited terrestrial biota, no surface water;

And yet some atoll islands have high population densities notably on the 'capital' islands

Male (Maldives)



DUD
Majuro
(Marshall Islands)

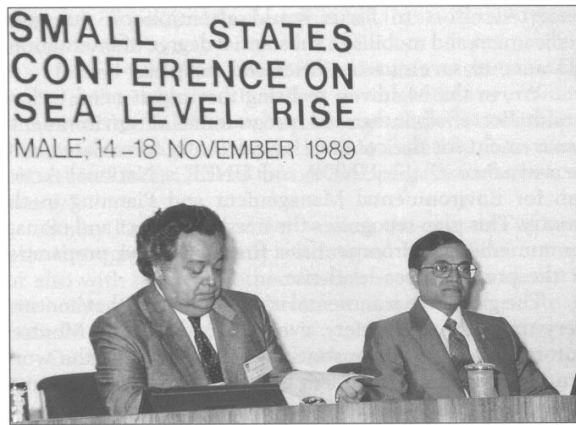


Fongafale
Funafuti
(Tuvalu)



Betio
South
Tarawa
(Kiribati)



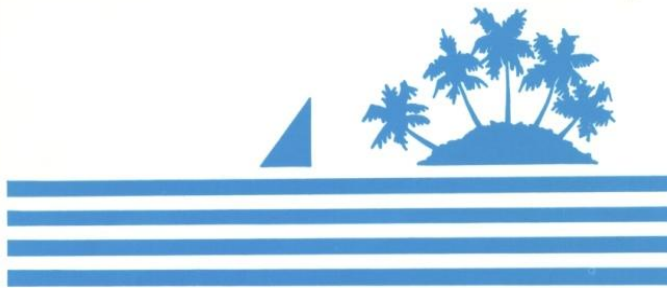


1989
24 years ago

"The alternatives before us can be summarized as follows: accept what is going to happen; try coastal defences; elevate the surface area of islands; retreat inland; migrate!"
- President Gayoom, Maldives, 16th Nov 1989



SMALL STATES
CONFERENCE ON
SEA LEVEL RISE
MALE', 14 - 18 NOVEMBER 1989



14 - 18 NOVEMBER 1989, MALE', REPUBLIC OF MALDIVES

SMALL STATES CONFERENCE ON SEA LEVEL RISE IS HELD WITH ASSISTANCE FROM THE COMMONWEALTH AND THE AUSTRALIAN GOVERNMENT.

PACIFIC ISLANDS

M O N T H L Y

APRIL/MAY 1989

THE GREENHOUSE EFFECT
SAY GOODBYE TO KIRIBATI, THE MARSHALL ISLANDS, TOKELAU, TUVALU, THE GREAT BARRIER REEF

New this issue 8-page Pacific Business Report

American Samoa	US\$2.00
Australia	A\$2.00
Cook Islands	NZ\$3.00
Fiji	F\$1.75
FRG	US\$2.50
India	A\$2.00
Kiribati	A\$2.00
Nauru	CP\$250
New Caledonia	NZ\$3.00
New Zealand	NZ\$3.00
Niue	NZ\$2.50
Norfolk Island	A\$2.00
Papua New Guinea	K2.00
Solomon Islands	S\$2.00
Tahiti	CFP300
Tonga	T\$2.00
Tuvalu	A\$2.00
USA	US\$3.00
USST and Guam	US\$2.50
Vanuatu	V\$2.00
Western Samoa	T\$2.75

*Recommended retail price only

Tuvalu Prime Minister warned his nation was in danger of disappearing under rising sea levels. "If this continues, there will be no Tuvalu at all."
- Bikenbeu Paeniu, April 1989

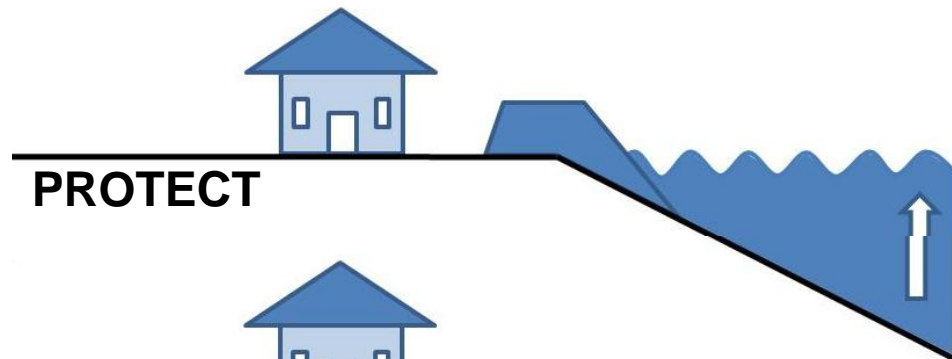
Adaptation: Three definitions

1. Autonomous adaptation: “adaptation that does not constitute a conscious response to climate stimuli but is triggered by ecological changes in natural systems...” (IPCC, WG2, 2007)

2. Planned adaptation: “adaptation that is the result of a deliberate policy decision...” (IPCC, WG2, 2007)

3. ‘Natural’ adaptation = Planned + Autonomous
“a deliberate policy decision to permit, and not impede, ‘natural’ ecological changes in reef systems and geomorphological changes in atoll island systems as a consequence of climate change and sea-level rise” (as used here)

Theoretical Adaptations in Atoll Island Nations



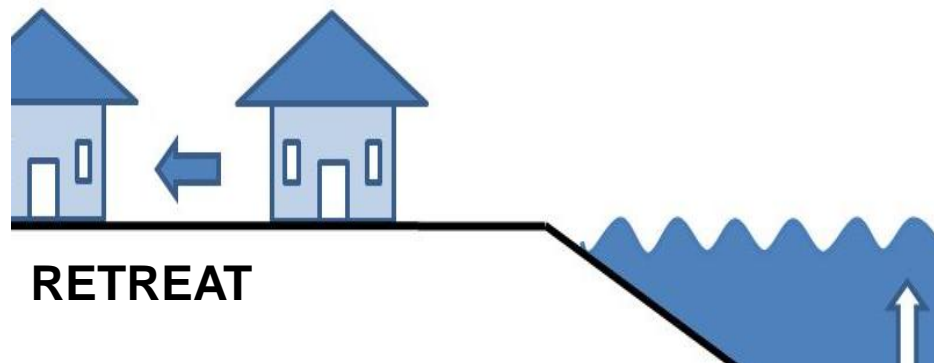
PROTECT

Most commonly used individually, community and government



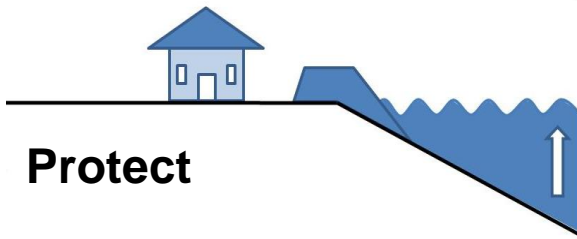
ACCOMMODATE

Planned accommodation rarely used though many local alternatives



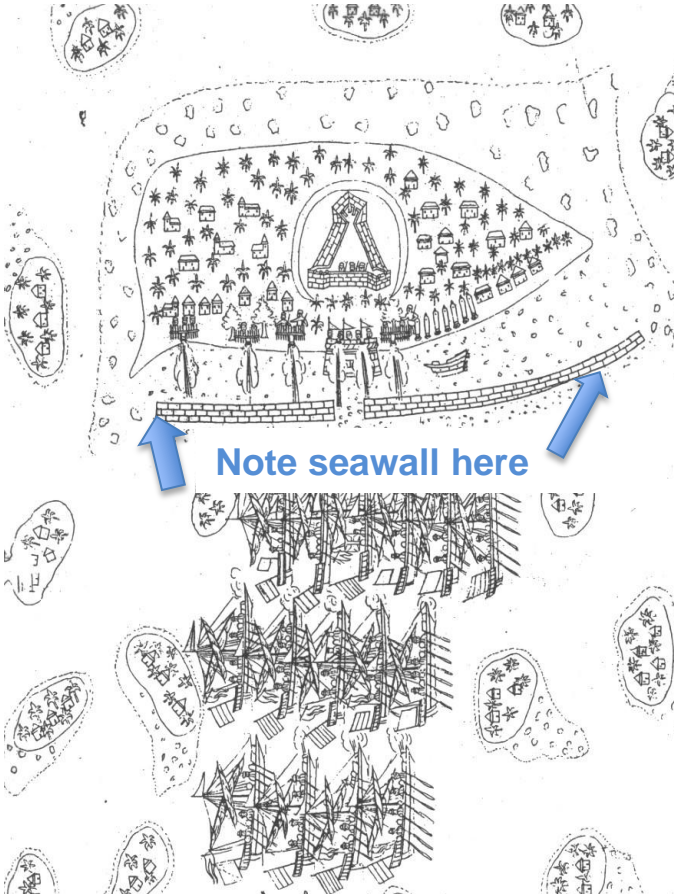
RETREAT

Retreat inland hardly an option given width of most atoll islands. Retreat to less vulnerable islands? Retreat through migration?



Protect

Male (Maldives)



Note seawall here



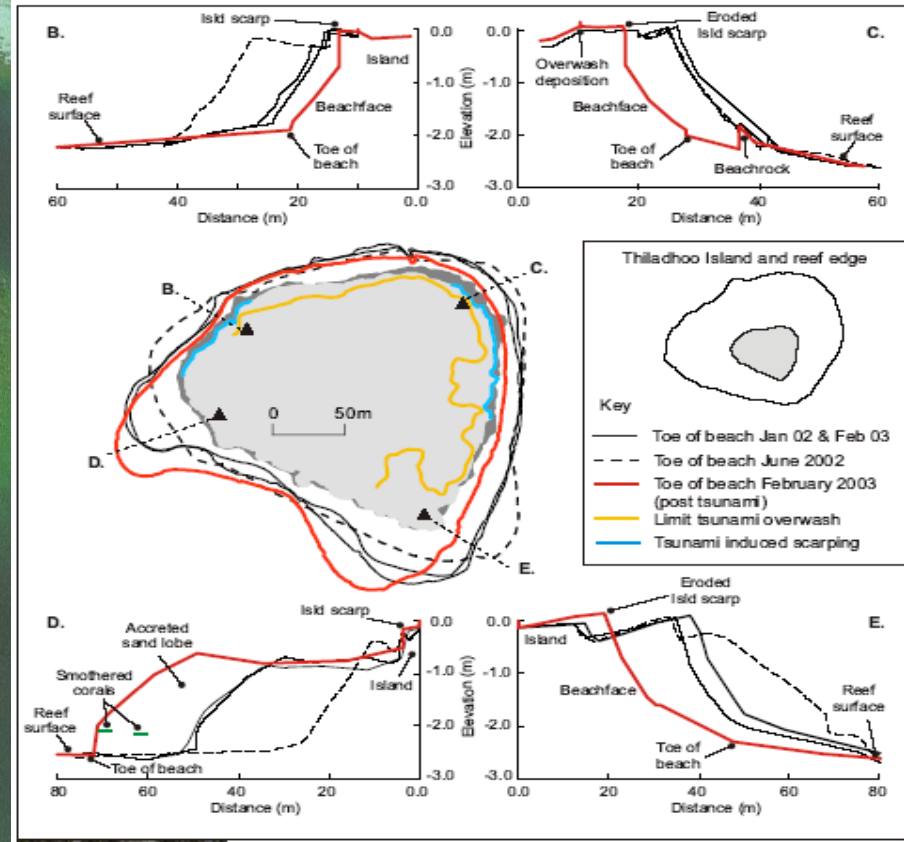
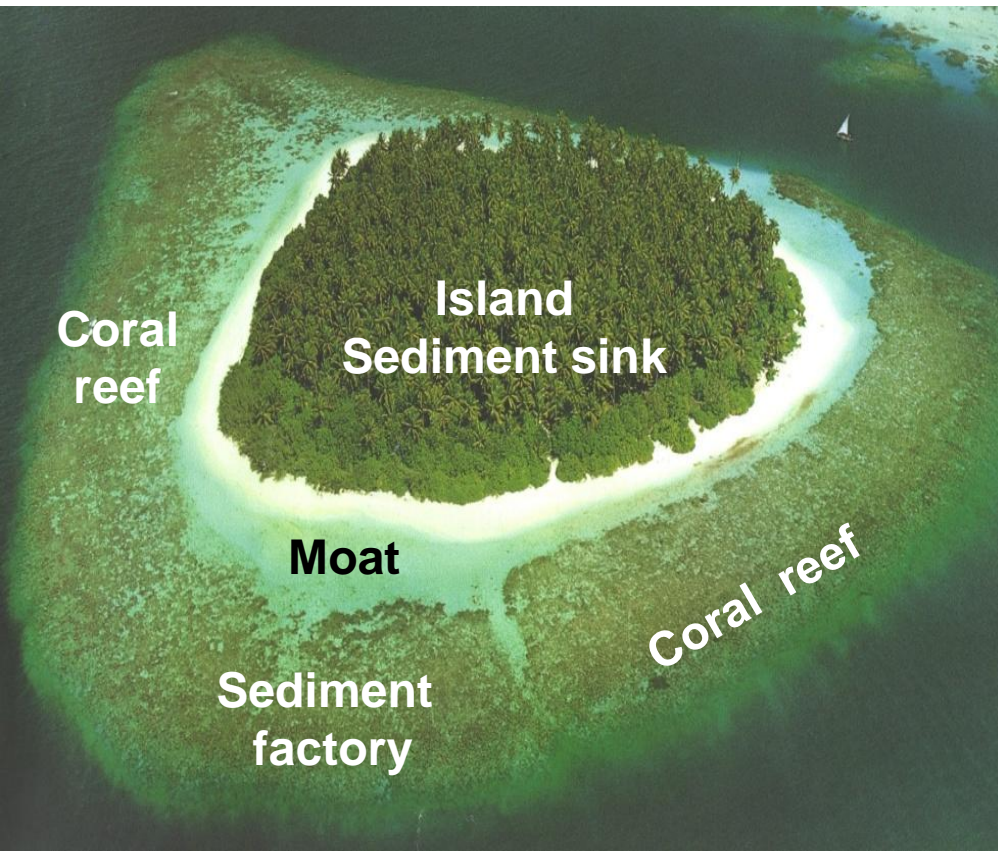
**Attack on Male under Bellagio
1631**

**Male today: Seawalls and tetrapod breakwaters
around most of the island**

Natural linkages between coral reef as source of skeletal sand and coral rubble (the sediment 'factory') and atoll island as a sediment sink

1. Moat marks extent of the island 'footprint' that represents the dynamic zone linking reef and island

2. Changing plan shape of island and profile surveys showing erosion and accretion across the island 'footprint'



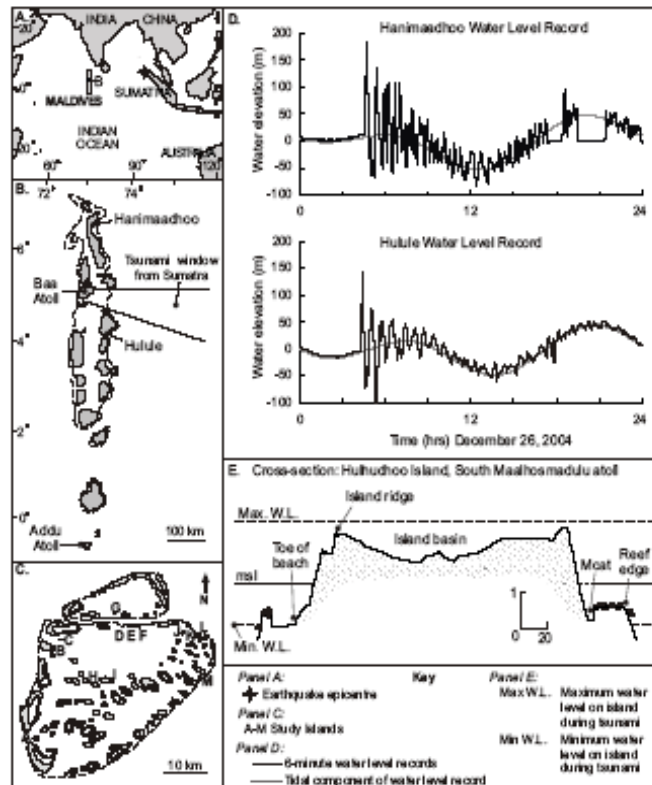
What can happen to reef islands with sea-level rise if the reef is healthy & there is no barrier stopping the sediment pathway between reef > island, and island > reef?

Example 1: December 2004 Tsunami Impact in Maldives

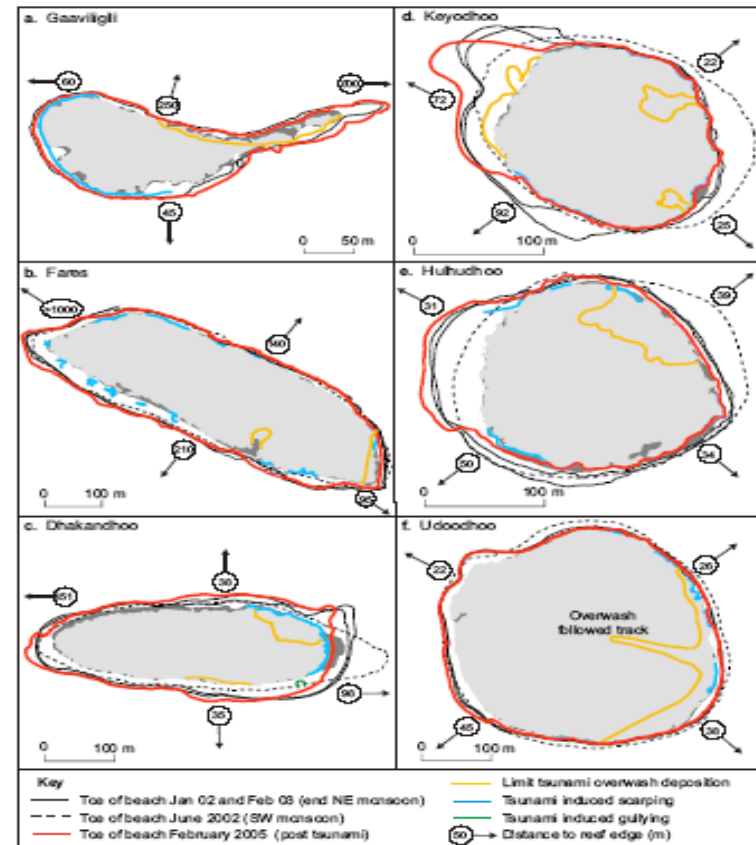
Tide gauge at Huluhule Male



Tsunami waves tide gauge records and level over island



Plan surveys of uninhabited Islands before and after tsunami

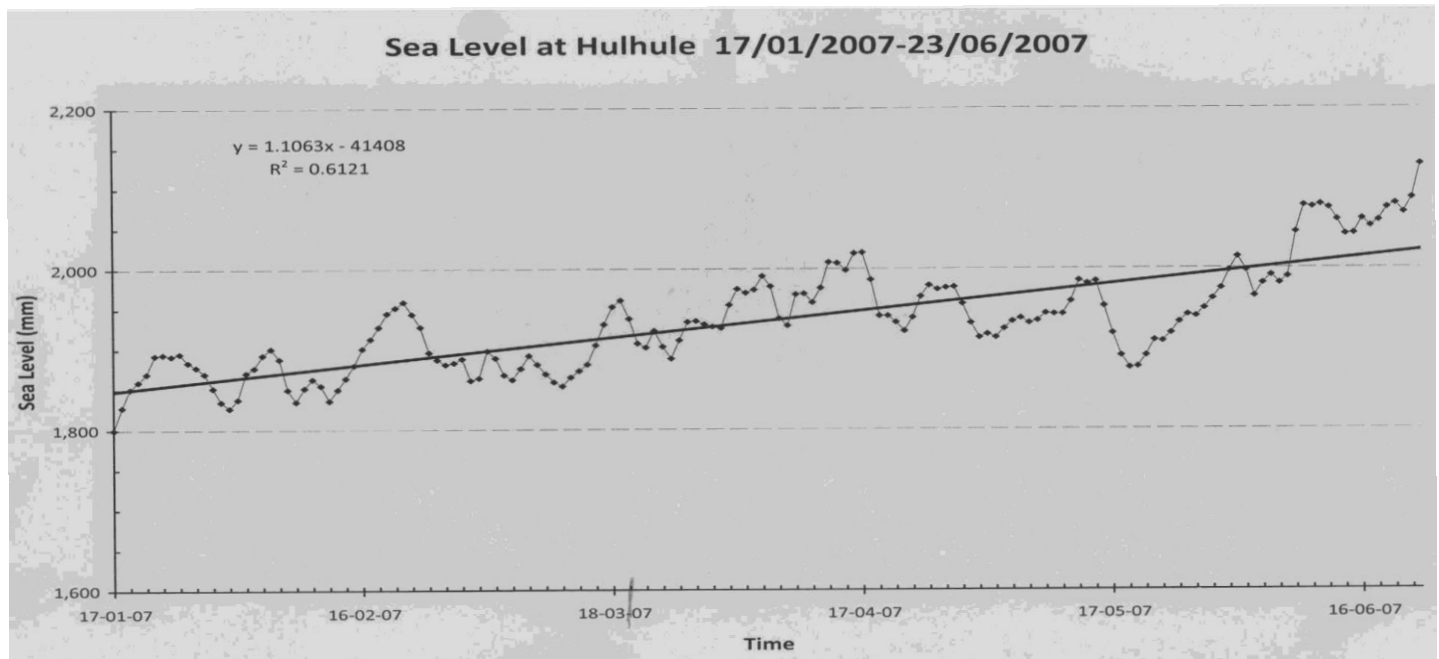




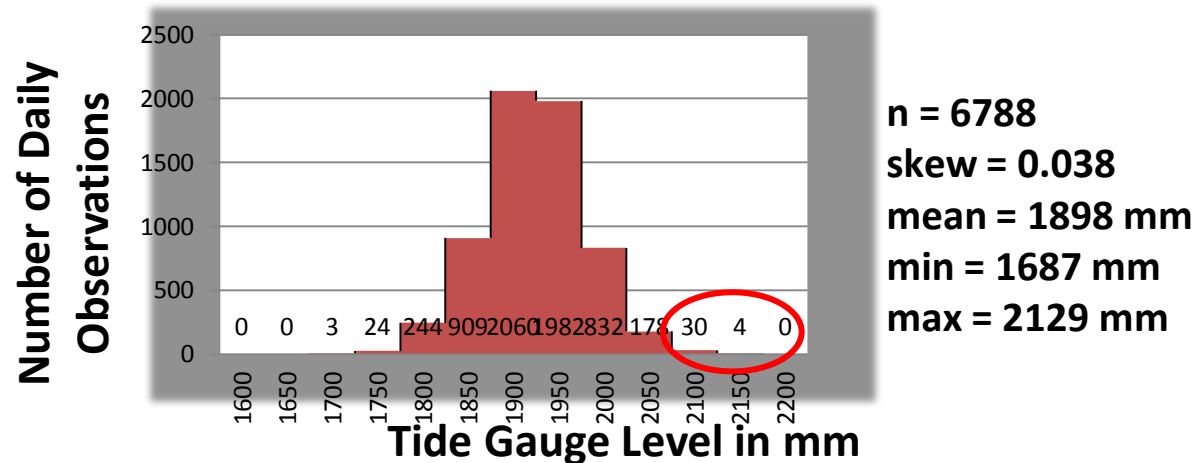
Beach accretion and on island fresh sand sheet deposition

Net result: increase in island area & elevation

**Example 2:
Short-term
sea-level rise
January to July
2007 in
Maldives**



**Frequency Distribution of Daily Sea Level at Hulhule,
Male, Maldives 1989-2008**



**Two highest levels ever: 23 June 2007 (2129 mm) 24 June 2007 (2110)
Maximum hourly values 2340 mm (23rd) and 2293 mm (24th)**

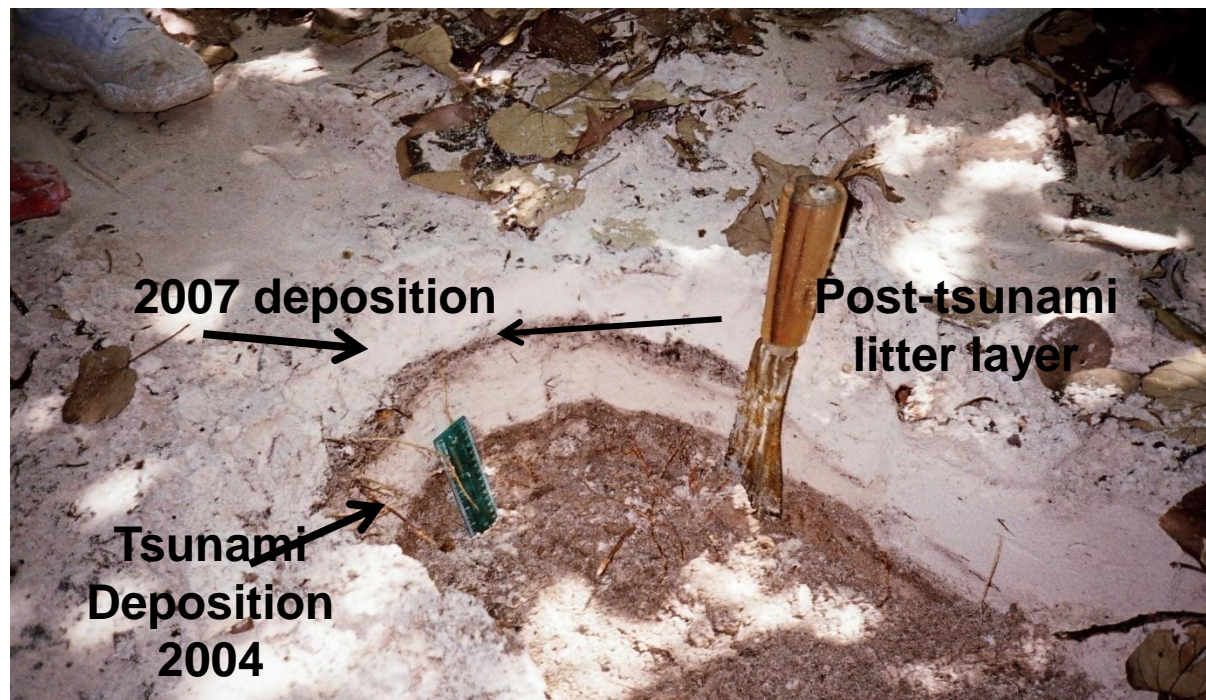
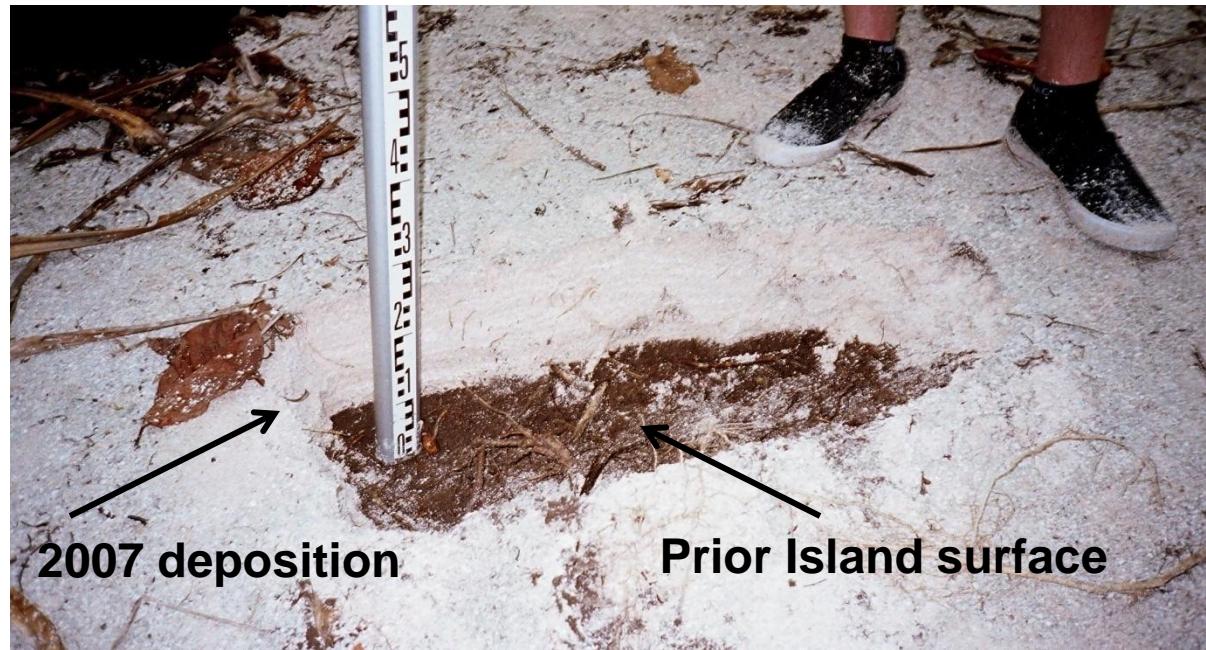
**Fresh deposition
on island surface;
new sand sheets and
sand lobes**



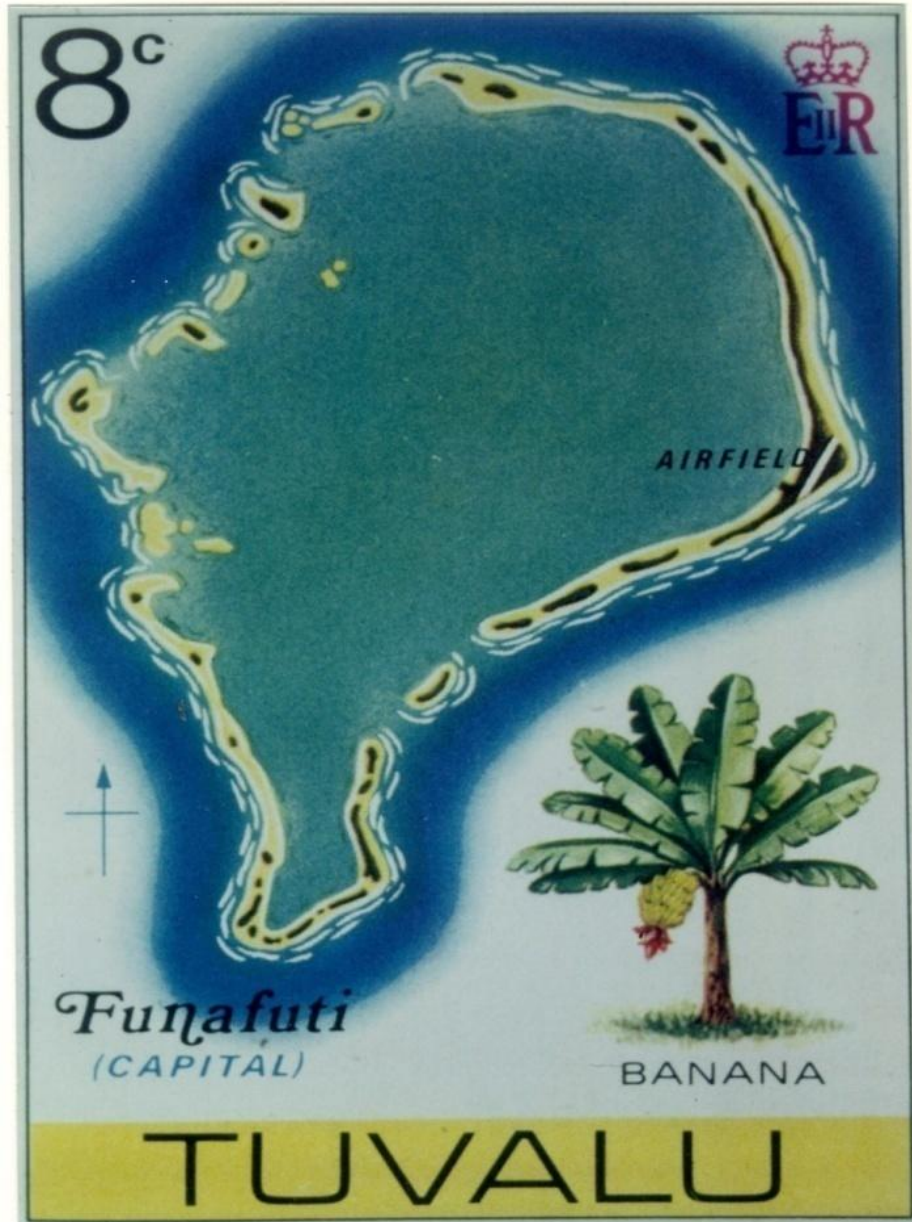
Fresh biogenic sediment

**Note: 2007 deposit
overlies tsunami
sediment**

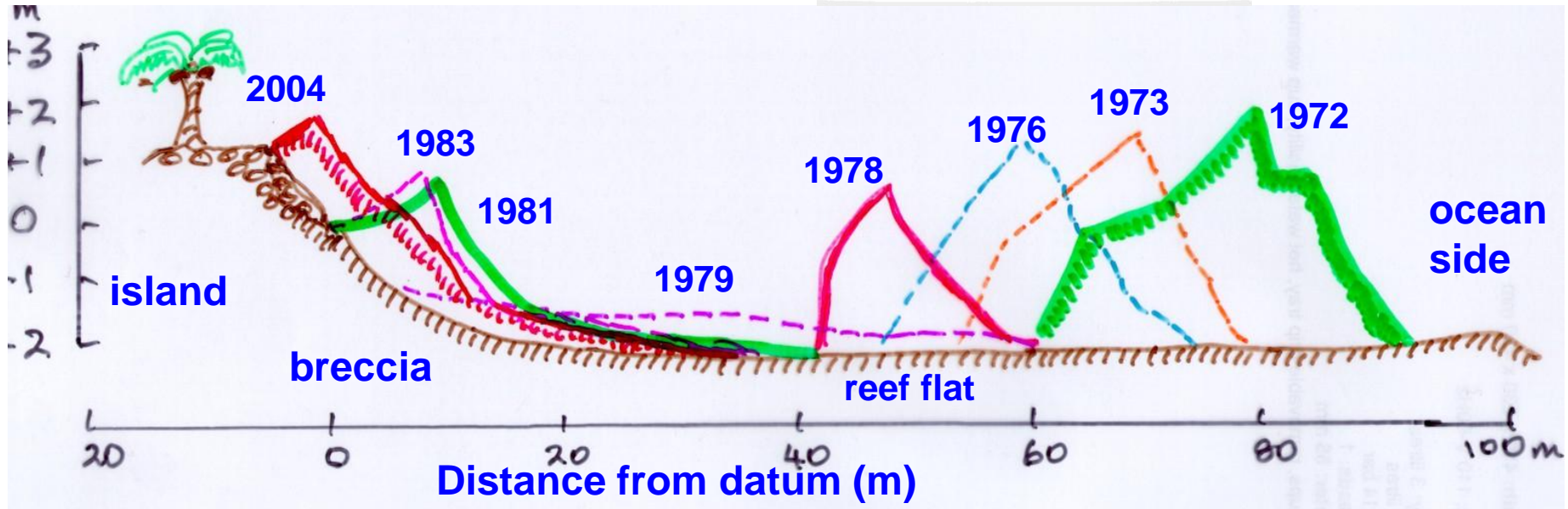
**Result: increase in
island elevation**



Example 3: Hurricane Bebe,
Funafuti Atoll, October 1972



**Post-hurricane
Bebe Surveys,
Funafuti atoll
Profile 3
1972-2004**



Need time to establish
new dynamic equilibrium

Key messages

- 1. Atoll islands are part of coral reef ecosystems with intimate and dynamic linkages between reef>island and island>reef.**
- 2. Atoll islands may be sustainable provided**
 - they are surrounded by healthy and productive reefs;**
 - the sediment pathways between reefs and islands are not obstructed; and**
 - they are given time to adjust ('naturally adapt') to the new and ongoing changes in climate, sea level and other drivers.**
- 3. It is possible to plan for autonomous adaptation of atoll reef and island systems.**
- 4. If this is done some reefs and islands in atoll archipelagos could be developed and maintained to serve as a safety valve if conditions on other islands deteriorate to such an extent that further occupation becomes unsustainable.**

**Surging tidal waves flood Male:
July 22nd, 2010 (Maldives News)**



Acknowledgements and thanks to:

- Governments of Maldives and Tuvalu for permission & support to undertake surveys over the years ;
- Local staff and many colleagues and collaborators who I have worked with in the field;
- The Ministry of Environment of Japan for inviting me to attend the International Conference on Climate Change and Coral reef Conservation at Okinawa Institute of Science and Technology Graduate University, 29th-30th June, 2013.

