Ecosystem-based coastal protection of atoll island countries against sea level rise

"Sustainable ecosystem management" is equal to "Sustainable land management (coastal protection)" against sea level rise in small island countries.

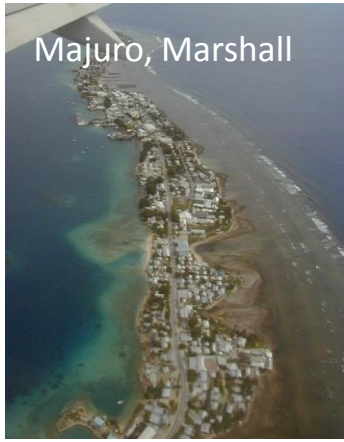
Hajime Kayanne (Univ. Tokyo)

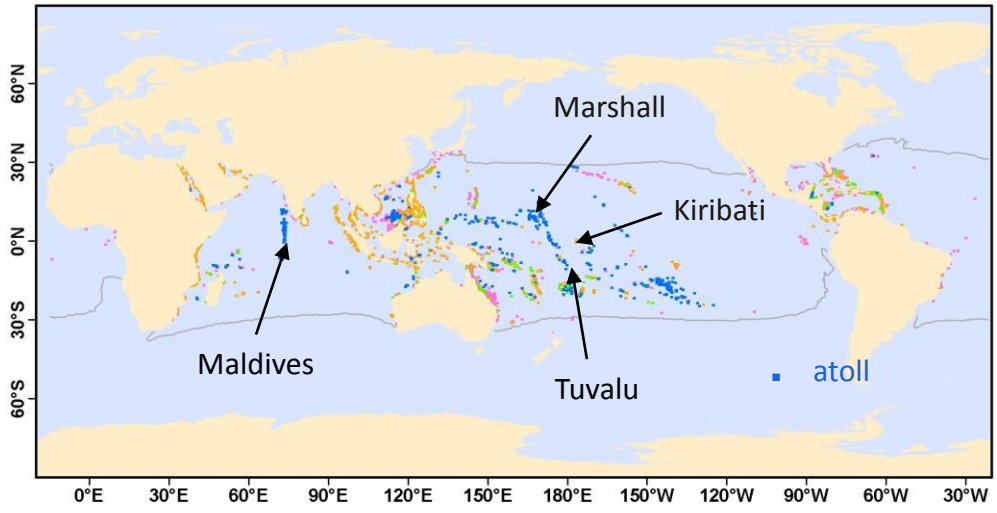
Fongafale Is, Tuvalu

Distribution of atolls

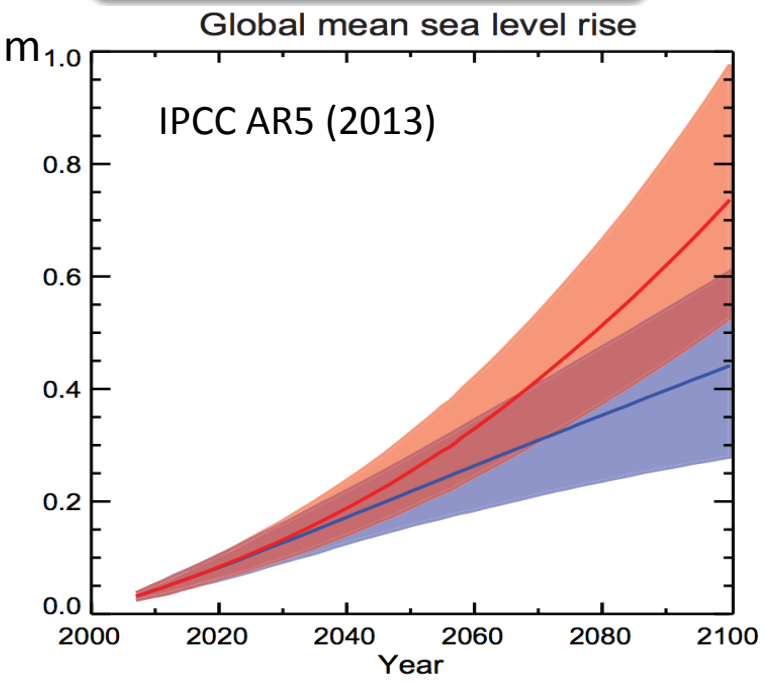
Number of atolls					
Pacific Ocean	392				
Micronesia	88	Polynesia	107	Melanesia	29
SE Asia	114	Australia	54		
Indian Ocean	67				
Central	41	West	25	Middle East	1
Atlantic Ocean	23				
N. Caribbean	4	W. Caribbean	15	E. Caribbean	4
計	482				

	Number of atolls	Population (10 thousand)
Pacific Ocean		
Federated States of Micronesia	30(29)	13.3
Republic of the Marshall Islands	28(20)	6.8
Tuvalu	6(5)	1.1
Republic of Kiribati	26(14)	9.2
Cook Islands	8(6)	2
French Polynesia	79(43)	24.9
Indian Ocean		
Republic of Maldives	22(22)	30.1
Total		87.4





Global threats

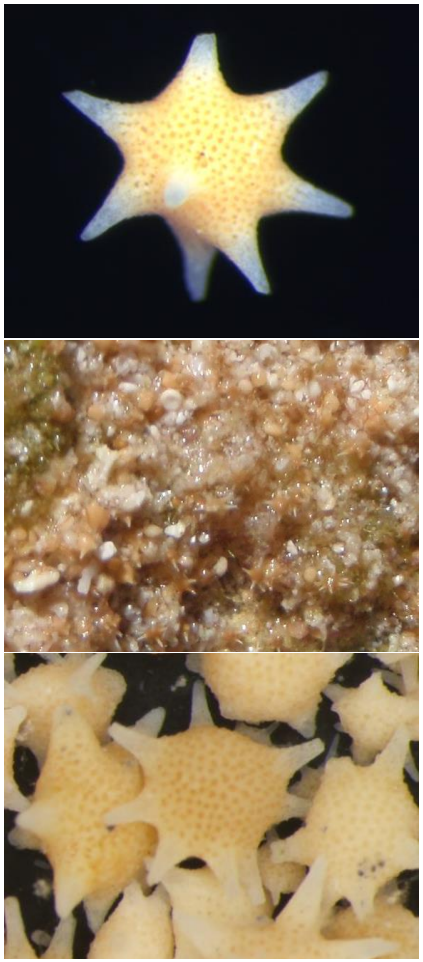


Nukutoa,Takuu Atoll, PNG

Funafuti Atoll, Tuvalu

Batio, Tarawa Atoll, Kiribati

Ecological process in island formation



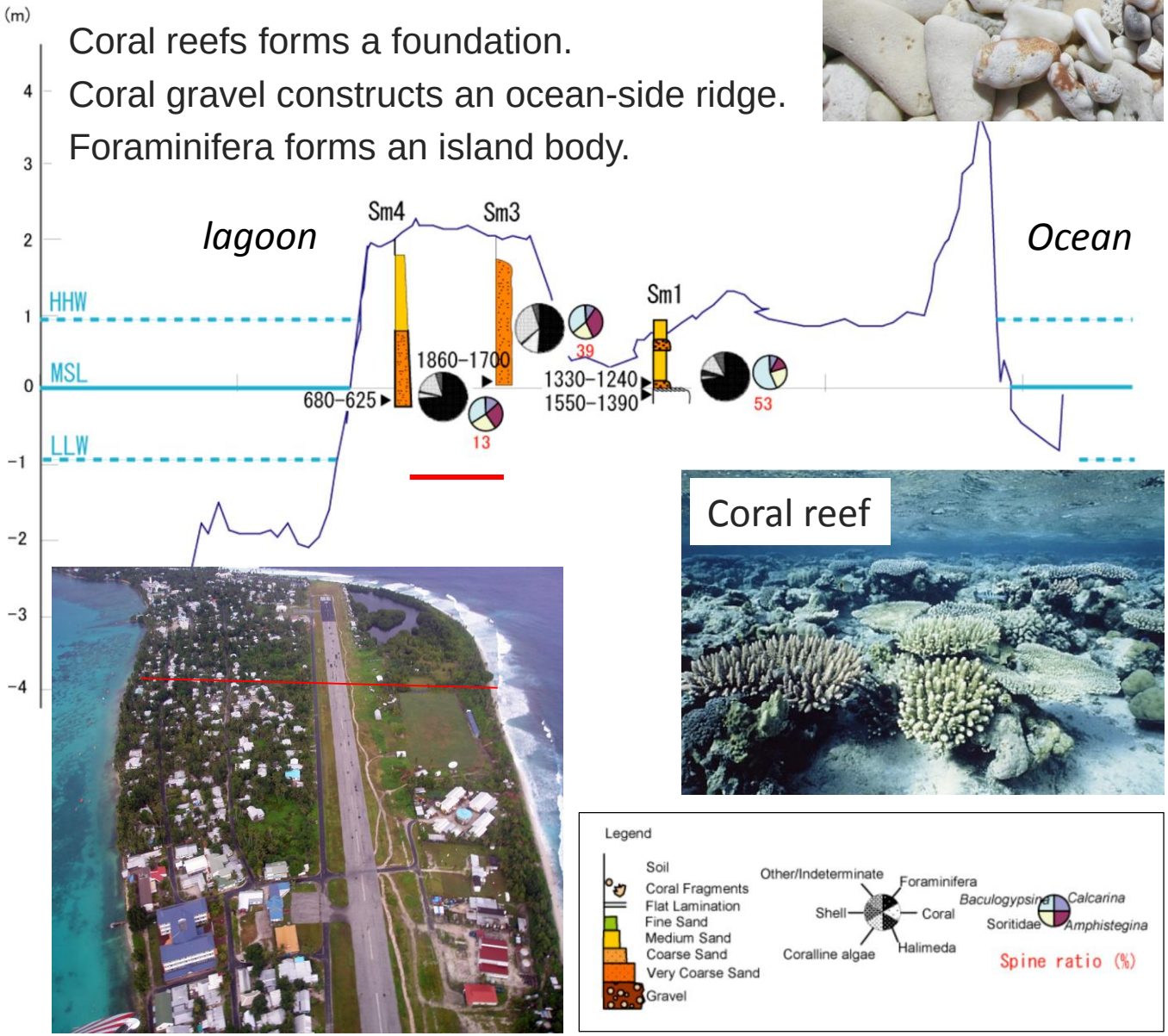
Foraminifera sand

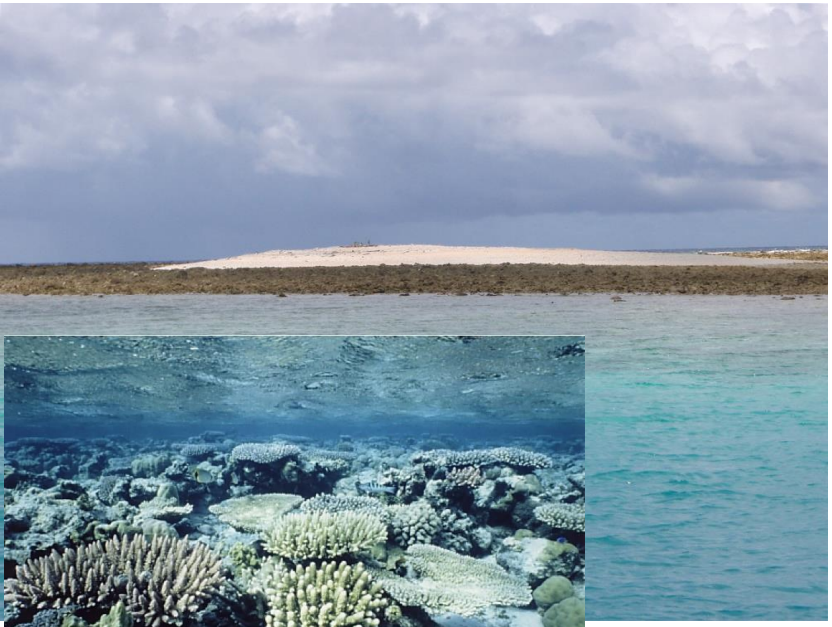
Fongafale Is, Funafuti, Tuvalu

Coral reefs forms a foundation.

Coral gravel constructs an ocean-side ridge.

Foraminifera forms an island body.





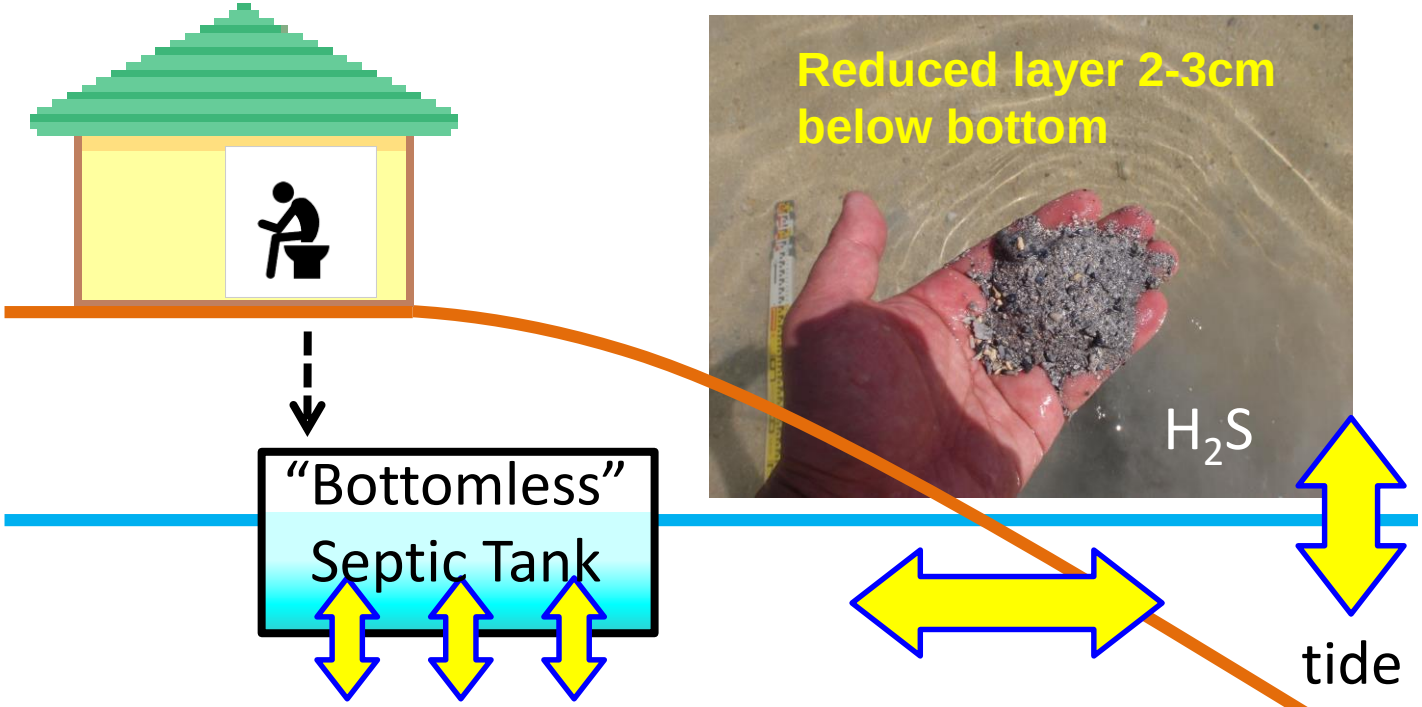
coral reef

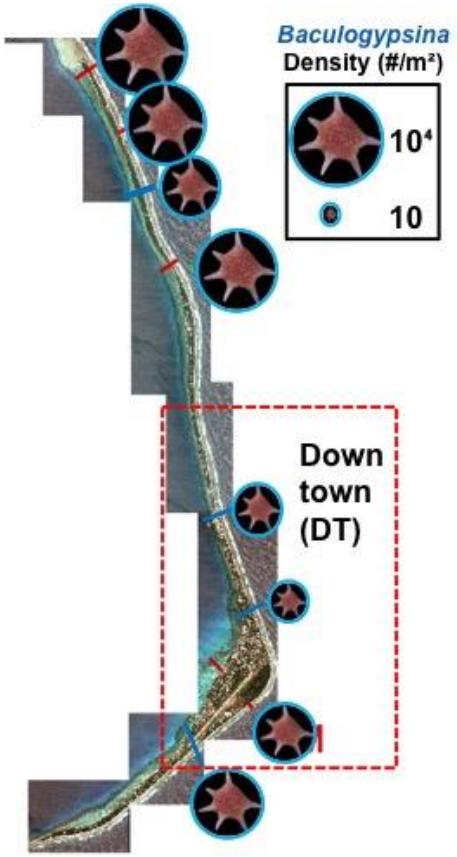
coral gravels

foraminifer sand

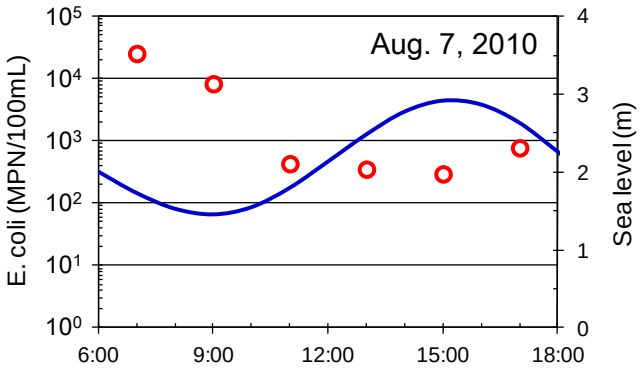
Halimeda

Water pollution by sewage effluent



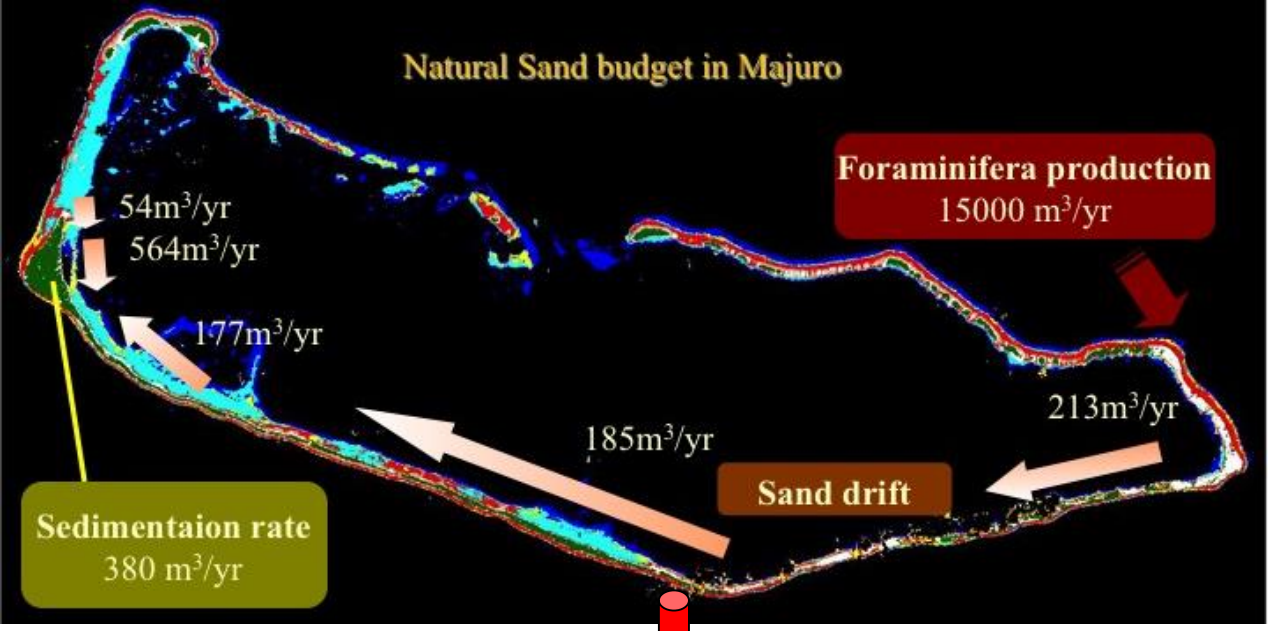


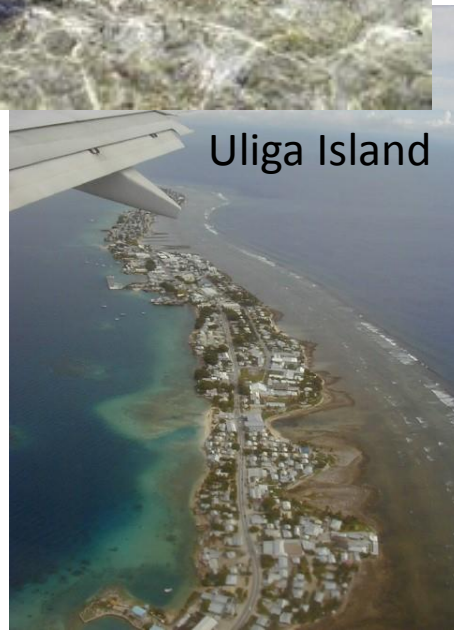
e-coli concentration 25 times higher than Japanese environmental criteria.

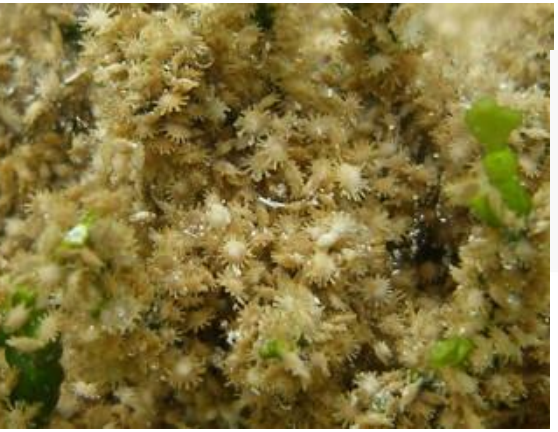


Ecosystem deterioration

Fongafale Is, Funafuti, Tuvalu



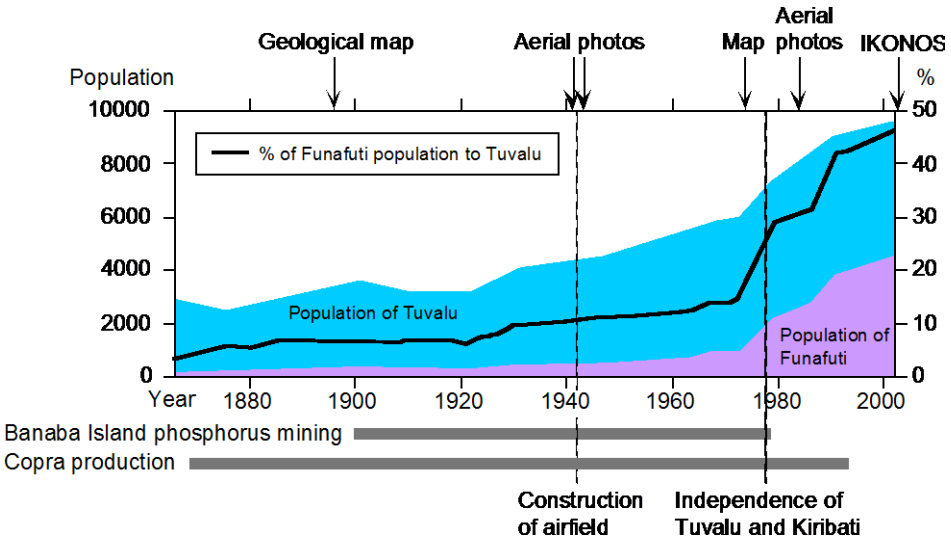




Almost one million forams in one squre meters.

Majuro Atoll, Marshall Is.

Land use: expansion of residential area to vulnerable low land



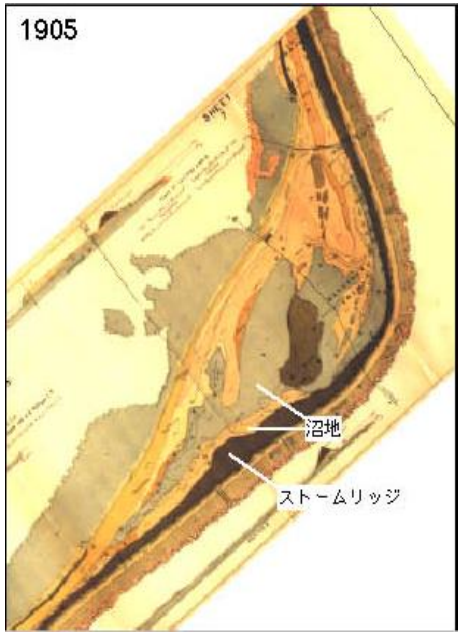
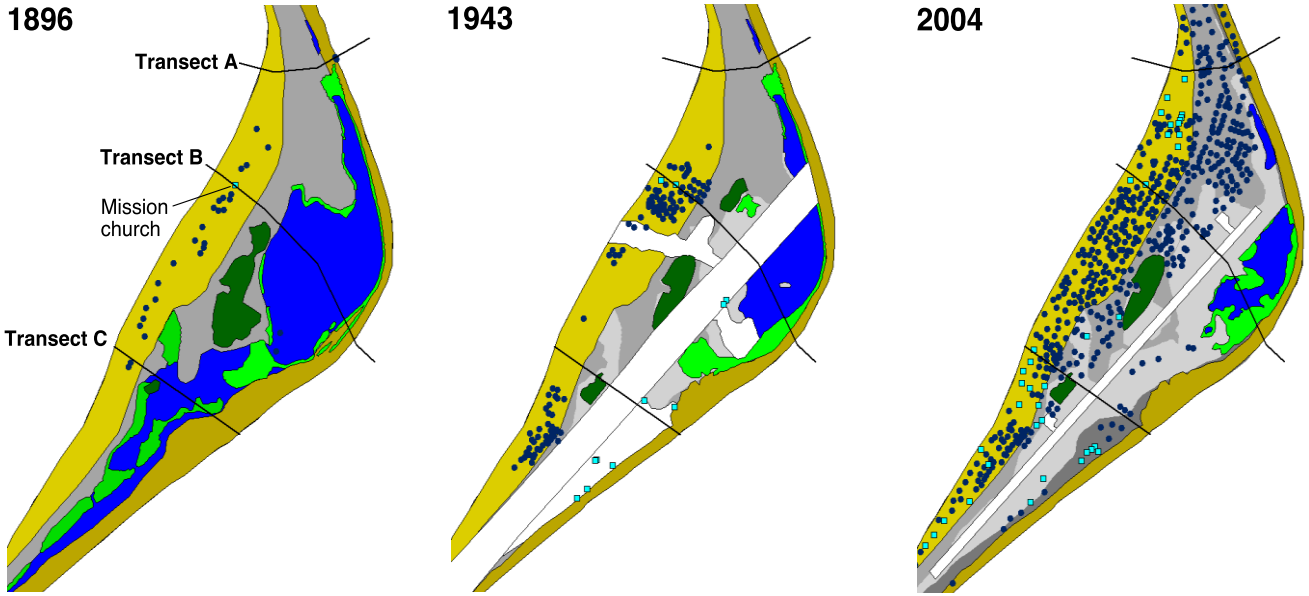


Figure 3



Fongafale Is, Funafuti, Tuvalu

Yamano et al. (2007)

Constructions against natural process

Vertical sea walls prevent sand sedimentation at their foots.

Causeways prevent sand transportation

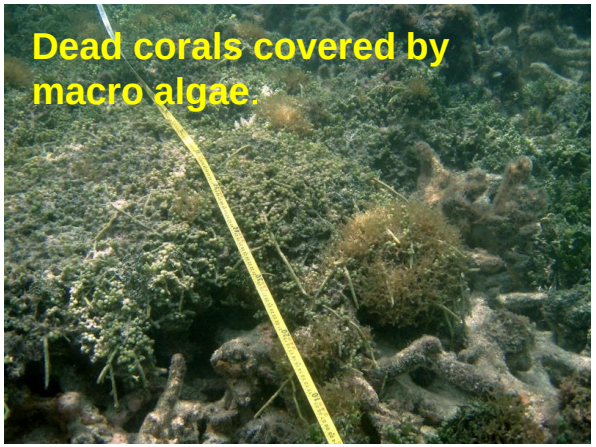
from ocean to lagoon

or release to deep ocean through boat channel.

Geo-Ecological process is degraded by local human activities

production

Ecosystem degradation by seawater pollution



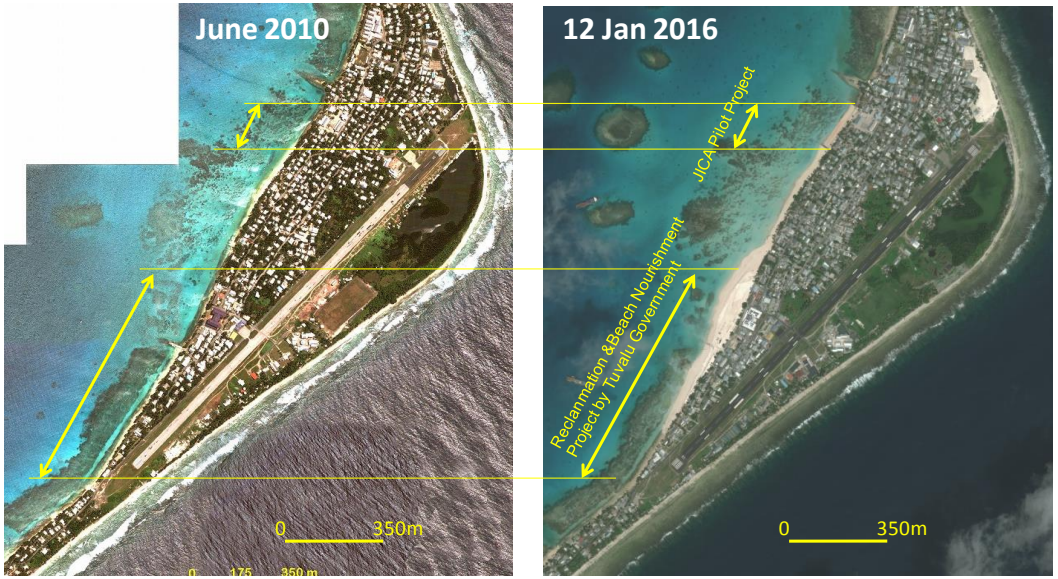
transportation

Sand drift interrupted by jetties and dredges

seimentation

Beach erosion by vertical seawalls

Ecosystem-based coastal protection



Beach nourishments

(not vertical seawalls)

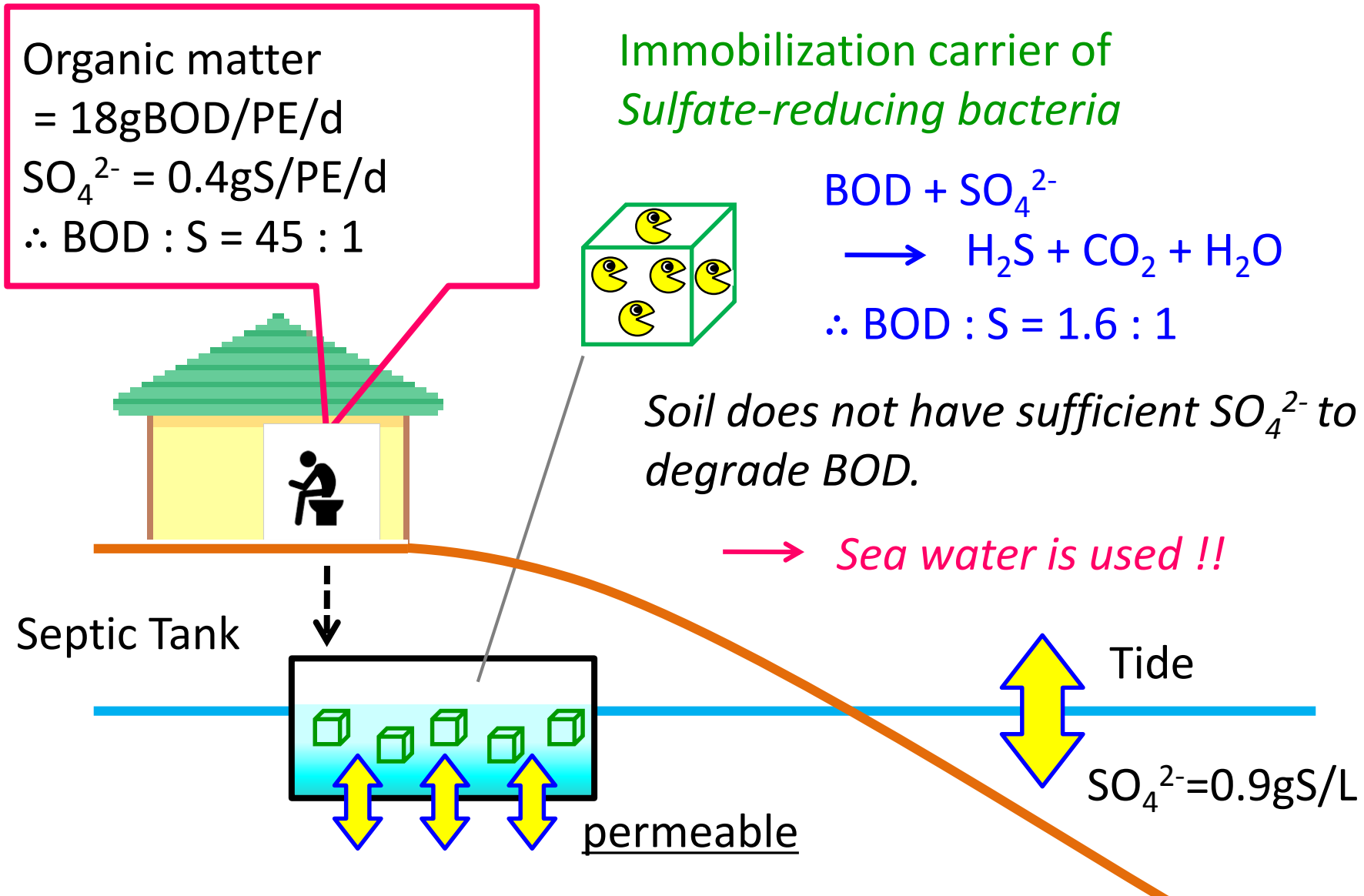
Fongafale Is, Funafuti, Tuvalu

JICA technical cooperation project
(photos by Nippon Koei)

Ideal design of the causeway.
Open-cut to the level of reef flat.

Sewage treatment by bacteria and seawater

(Fujita 2016)



Production

Improvement of coastal eivironment is required bofore or in parallel with any ecosystem rehabilitation challenges.

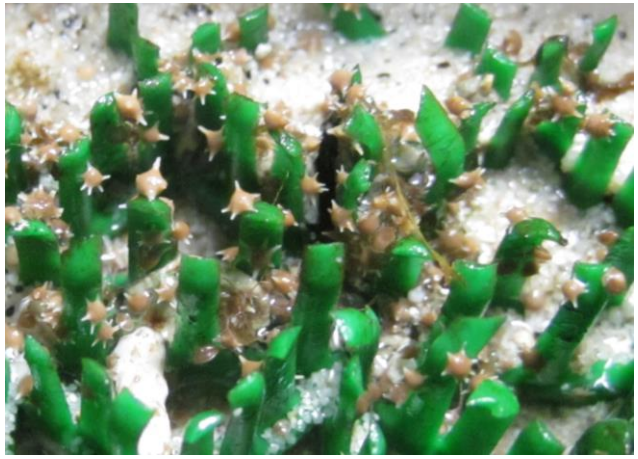
Then we can adopt ecotechnology.

Coral culture and transplantation

Okinotorishima

Foram culture

Tuvalu



Sustainable ecosystem management equals sustainable land management against sea level rise in small island countries.

Scientific and technological challenge level

High

Low

Ultimate goal

Regeneration of sandy beach

Open-cut causeway

Culturing foraminifera and corals

Recovery of coastal ecosystem

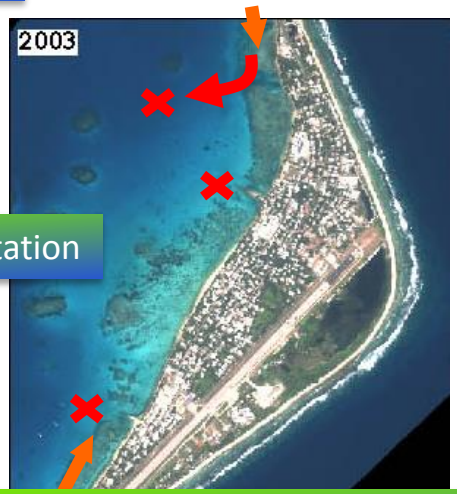
Waste treatment

Sewage treatment

Replanting coastal vegetation

Sand bypass

Beach nourishment



Removal of jetties
Backfill dredges

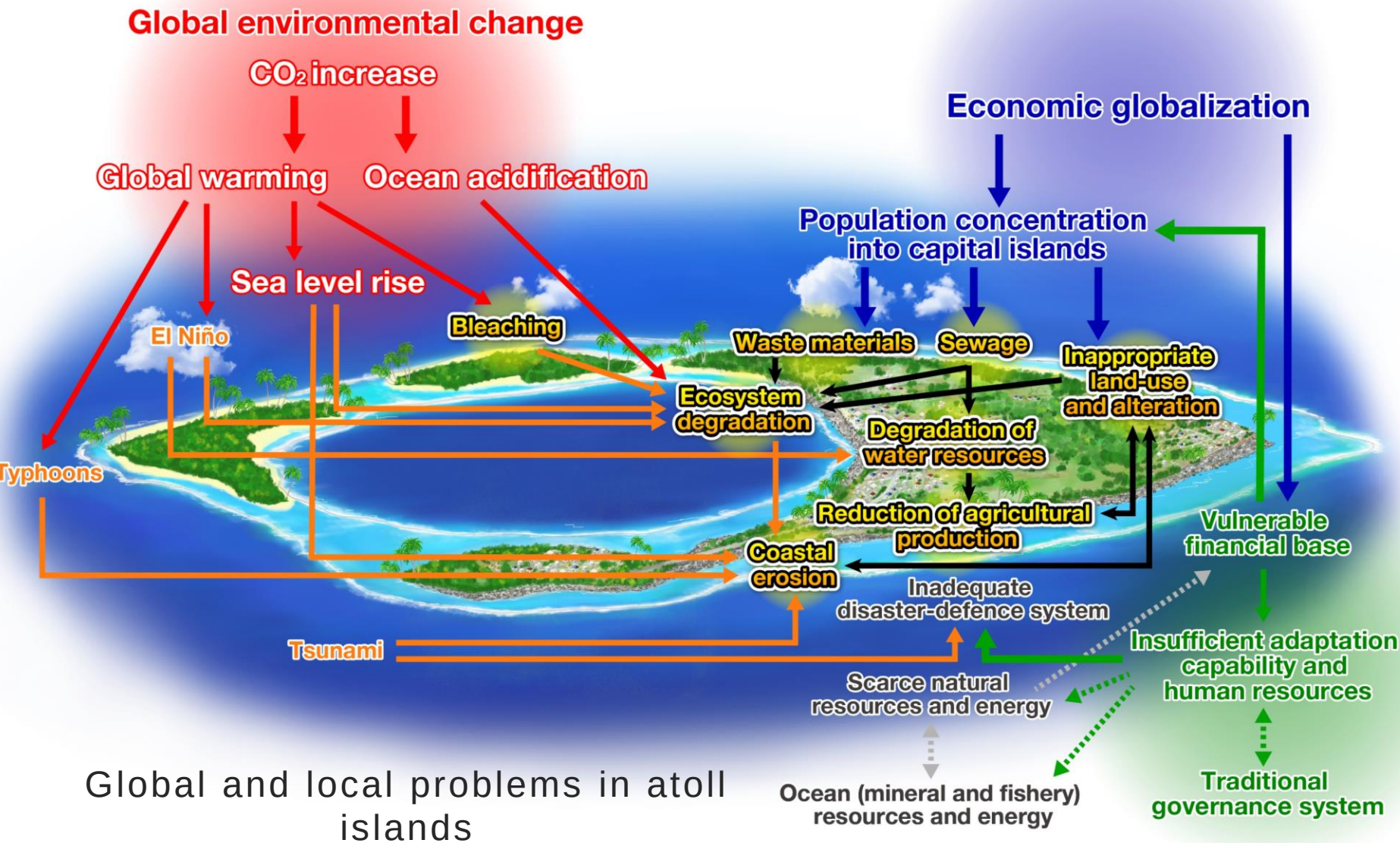
Present state

Decadal（10 yr）

Time scale

Centennial（100 yr）

- Only ecosystem-based management cannot save small islands from rising sea level.
- However, any grey coountermeasure works must NOT coflict with, and should enhance natural ecological process which forms the island and coast.
- Combined grey and green technologies are necessary.
- Ecosystem-based management needs understanding by local people and governments, and socio-economical aspects of small island countries.

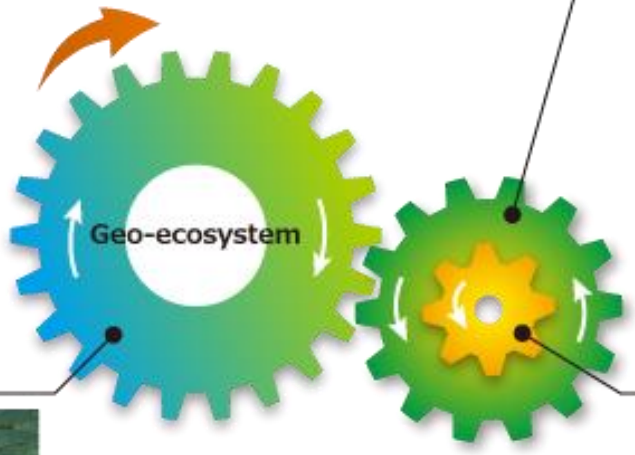


Global and local problems in atoll islands

1 Adaptive geo-ecosystem

Geo-ecosystem provides many benefits to local social system

= Smooth



Traditional island community

Sound geo-ecosystem

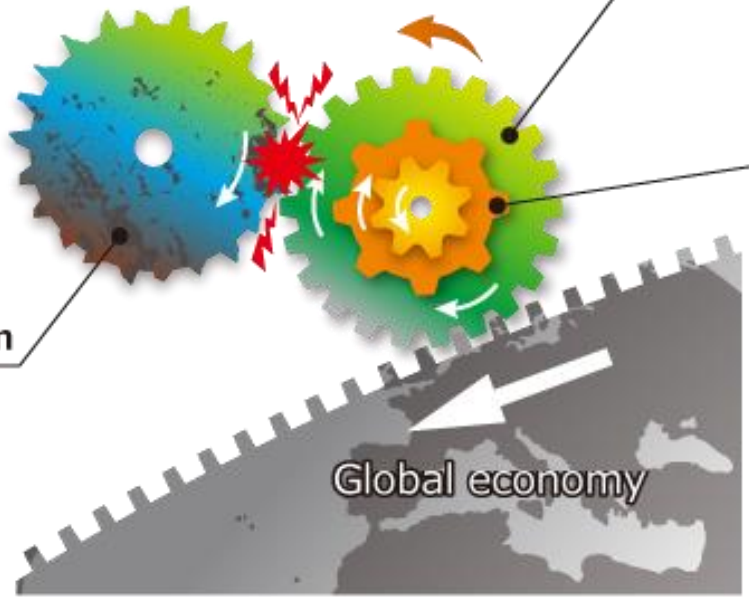
Traditional governance

High geo-ecological resilience

2 Current social system in Island community

High energy inflow from global economy and international society

= **Crushing**



Bloated island community

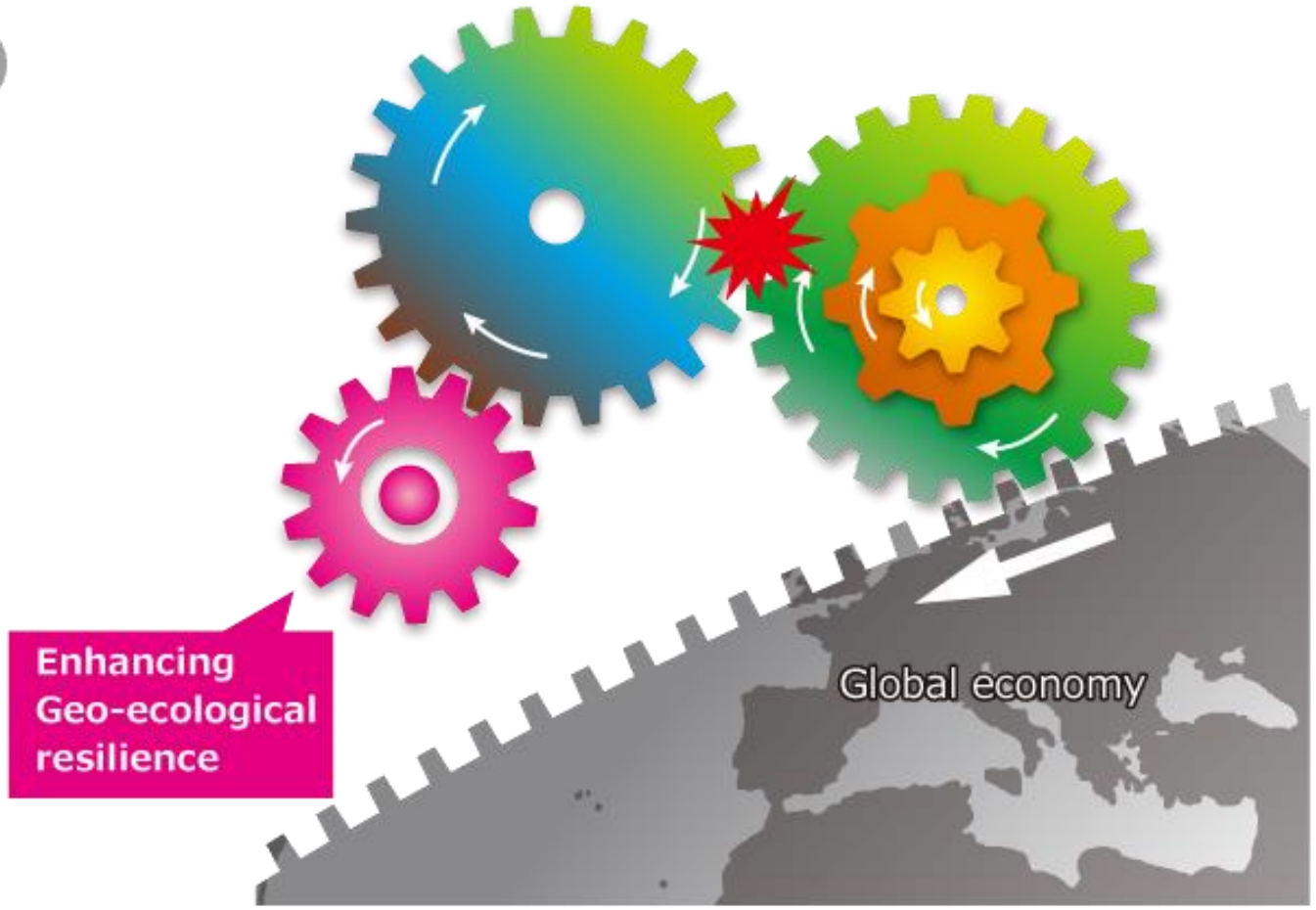
Introduced governance

Non-adaptive measures
Seawall/Wastwater treatment/
Human resource management

Badly-degraded geo-ecosystem

Low geo-ecological resilience

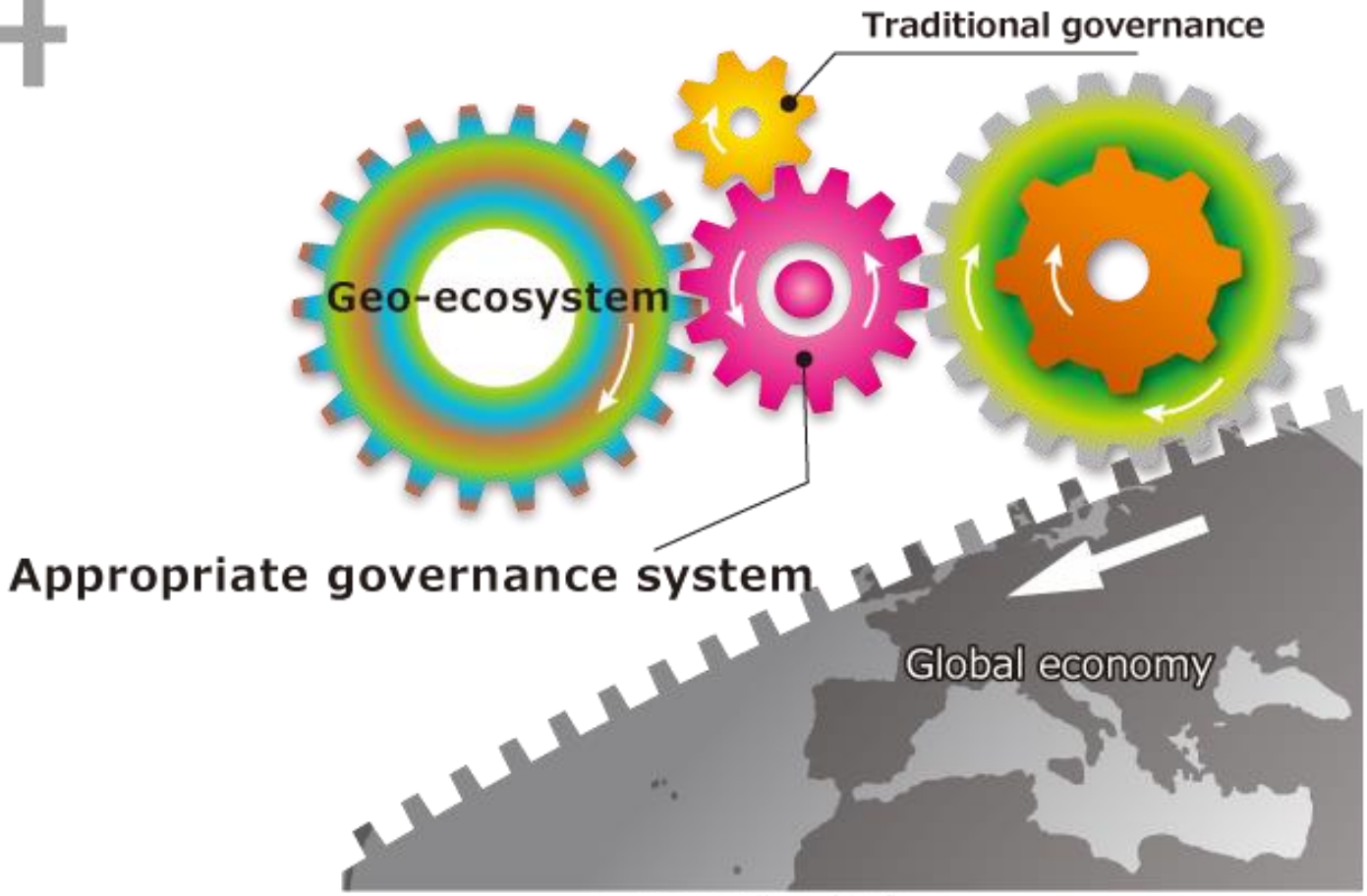
3



Current social system

In island community, low geo-ecological resilience directly links to the collapse of national land
We proposed several eco-technological measures...BUT

4



Adaptive social system with high resilience

Enhancing geo-ecological resilience beased on traditional governance
Creating new governance system to harmonize all gears (global economy, island community, geo-ecosystem)