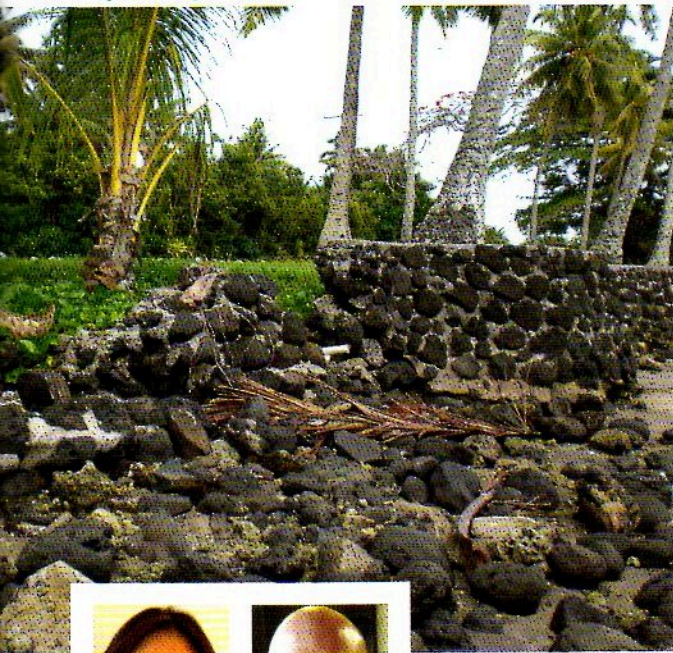


Figure 1: Independent Samoa: coastal defences are vulnerable to damage.



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Disappearing island states: ecosystem adaptation or relocation?

Climate change could have devastating effects on low-lying island states, which could disappear altogether in the course of this century with disastrous consequences for their inhabitants and their legal status. At present, the survival of these islands hinges on the ability of the local ecosystem of coral reefs to adapt to the consequences of a warmer planet. However, these vulnerable ecosystems are already under great stress. Coral reef conservation measures are required if these nations are to survive.

Small island states are extremely vulnerable to sea-level rise and climate change, and it is feared that some of them could disappear altogether in this century. Many of the islands that make up these countries are atolls with their highest points only a few metres above sea level. Even a small rise in sea level would profoundly affect the ecosystems of these vulnerable islands, severely diminishing their ability to provide food for their inhabitants.

There is little option to move to higher ground which means climate-induced migration could be the only option. Other consequences of climate change such as coral bleaching are also placing stress on the local environment. Coral reefs are vital to the existence of atolls, sustaining local fishing, supporting the tourist industry and acting as barriers against wave action and coastal erosion. Most important of all, they provide the sand that makes up the very islands themselves.

In order to address the vulnerability of small island states to climate change, adaptive measures are already being implemented. These measures require technological and institutional adjustments at all levels of society, though their success is by no means guaranteed.

Vulnerable atoll island states

The beautiful islands of Tuvalu, Kiribati, the Marshall Islands, Tokelau and the Maldives (See Figure 4), are some of the most famous atoll island states that are facing problems because of climate change. According to the Fourth Report of the Intergovernmental Panel on Climate Change (IPCC), there is "strong evidence that under most climate change scenarios, water resources in small islands are likely to be seriously compromised", as they tend to be especially vulnerable to change.

“Coral reefs are vital to the existence of atolls, sustaining local fishing, supporting the tourist industry and acting as barriers against wave action and coastal erosion.”

Most of these islands are also comparatively underdeveloped and so lack the financial, technological and material resources to implement adaptation measures. Increases in tropical cyclone intensity as a consequence of warming surface sea temperatures could potentially also increase the damage caused by these events and further limit the islands' already low adaptive capability. Communities are left particularly exposed as

Figure 2: Cross-section through a typical coral island.

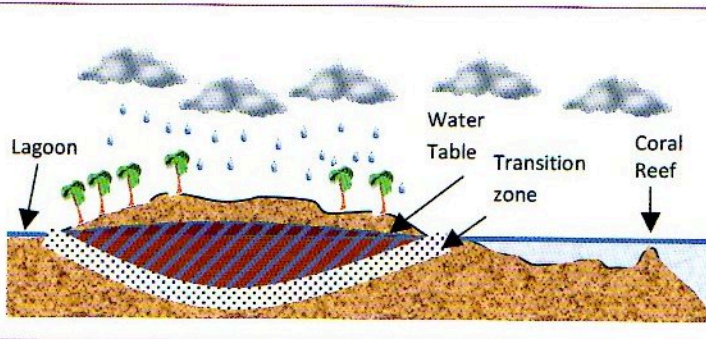


Figure 3: Houses in atoll islands are often located close to the sea (photo from Tuvalu).

most houses are built right on the coastal margins (See Figure 3).

Coral reefs form the key ecosystem on which atolls depend, normally surrounding the entire circumference of the island, as shown in Figure 2. They form one of the most productive ecosystems on Earth and they support a rich marine biodiversity which, in turn, provides various environmental services to nearby human populations, such as fishing, tourism, shoreline protection and medicines.

Loss of coral reefs

Although freshwater resources are fundamental to the long-term ability of the islands to support vegetation and crops, the main threat to the survival of the islands themselves is related to the wellbeing of their coral reefs. Currently, a great number of coral reefs are affected by the phenomenon of bleaching, the frequency of which has increased markedly in the past decades. While corals might recover from bleaching, many die off completely.

Coral bleaching results from a variety of stresses which can include high sea temperatures, high levels of ultraviolet light, low light conditions, high turbidity, pollution and abnormal salinity. Nevertheless, the majority of large-scale coral bleaching has been linked to the presence of increased sea surface temperatures. It is currently believed that coral growth around the atoll islands will not be able to overcome the stressors to which they are currently subjected and that places like Kiribati, Tuvalu, the Marshall Islands and the Maldives could become submerged within this century.

Funding needed for research and adaptation

Adaptive measures have been discussed through the National Communications to the UN Framework Convention on Climate Change (UNFCCC) from small island states, who have assessed their own vulnerability to climate change. The most common theme stated was the immediate need for sufficient financial resources to fund urgent action. Freshwater was seen as a serious issue and many island states recognised the need for more integrated planning and management concerning coastal zones, human health and tourism, as highlighted in the Fourth Report of the IPCC.

There is a growing realisation that the future supply of freshwater might be threatened due to increasingly variable rainfall, more intense drought events and increased salinity of the soils on coastal margins. Often, the freshwater table in these islands is already contaminated due to the increased frequency of 'king' tides, which results in sand being deposited over agricultural lands and a general increase in the salinity of the islands.

In order to protect the shorelines of these islands, technical and policy measures have been used. Some relate to the preservation of coral reefs, mangrove areas and sandy beaches, with numerous studies recognising that the preservation of these coastal barrier systems is essential to the survival of atolls. However, at present not enough is known about how coral reefs could adapt to the multiple stressors that are being placed on them.

Coral replanting has been shown to be successful in many areas around the world.

It is imperative not only that more research is carried out on how these ecosystems may behave in the future, but also to ascertain which species of corals will prove more resilient to climate change, in order that they could be replanted in areas where they have disappeared. Coral replanting has been shown to be successful in many areas around the world, though the long-term success of these schemes would depend on the general ability of the planted species to cope with the changes in their environment. This is poorly understood at present, and should become an area of priority research in the future.

Coastal protection: nature knows best

Vulnerability has two factors: the susceptibility of communities or natural systems to environmental changes, and their resilience. It is possible to increase the resilience of coastal communities through infrastructure and hence another possible adaptive measure is the construction of sea dykes and defences. However, this solution would be costly: the Japanese government constructed several concrete barriers to protect the tiny

Figure 4: Many atoll islands are important tourist destinations and places of great natural beauty (Maldives).



Japanese island of Okinotorishima at a cost of 29.3 billion yen (approximately US\$360 million).

For small island states, the problem is securing the financial resources necessary to implement such costly schemes. As the IPCC identifies, "the costs of overall infrastructure and settlement protection are a significant proportion of GDP and well beyond the financial means of most small island states". Even in the hypothetical situation where enough financial resources were available, defence work could create a situation where islands end up being lower than the surrounding sea, similar to the low-lying polders surrounded by dykes in the Netherlands.

However, the hypothetical 'polder-like' atoll island would end up, even in a best-case scenario, a barren piece of land due to the high salinity of the water beneath it. More likely, water would seep under the defence works due to the pressure differential and inundate the area behind it, requiring expensive ground improvement works and constant pumping. Coastal defences are also vulnerable to damage. Figure 1 illustrates the case of Samoa, a string of tiny islands in the Pacific Ocean. Although not atolls, the islands also suffer from the problem of coastal erosion. Generally this is a problem that affects all tropical islands, and the economic benefits of having a resilient, 'living' coast are clear. An artificial barrier will require constant reconstruction and maintenance, whereas a healthy coral reef will rebuild itself and greatly reduce the maintenance effort required by coastal communities. Ecosystem adaptation measures are therefore likely to be superior to human engineering solutions, particularly in cost, and should be prioritised.

Ecosystem destruction and community relocation

Ultimately, if the adaptation measures described above fail, it will be necessary to relocate island communities. However, if all the islands that presently form one of these archipelagic atoll countries are completely submerged, their citizens would lose their nationality as, under conventional international law, a state is required to possess a defined territory. In addition, refugee law would not apply to these people since they do not fulfil the conditions to become refugees. The Refugee Convention defines refugees as people who are outside their country of origin with a well-founded fear of persecution on account of their race, religion, nationality, political opinion or membership of

a particular social group. Nevertheless, certain protective measures could be applied, such as the principle that no one should be sent back to their home countries to suffer persecution.

Thinking about all of these consequences can be considered alarmist. However, it is clear that there is the potential for them to happen and that there is a moral imperative for those who are most responsible for the causes of climate change to address the consequences. In this case, ensuring the survival of local ecosystems is probably the best way to prevent the disappearance of these islands and their populations. However, this will no doubt require much research, ingenuity and local action to preserve and help the coral reefs adapt to the new environmental conditions forced upon them. The alternative would be not only for whole cultures to be lost, but also for countries to have to start dealing with influxes of climate-change induced migrants from all over the planet.

The photographs used in this report were originally taken by Sergio Fernandez, Gloria Caramanzana, Tomoya Shibayama and Hiroshi Takagi. Their permission to use them is kindly acknowledged.

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