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Atoll Island States and Climate Change: Sovereignty Implications

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Contents

List of abbreviations

Art. Article

CO_2 carbon dioxide

EEZ Exclusive Economic Zone

IPCC Intergovernmental Panel on Climate Change

SMOM Sovereign Military Order of St John of Jerusalem, of Rhodes and of Malta

ppm particles per million (related to concentration of CO2 gasses in the atmosphere)

UNCLOS United Nation Convention on the Law of the Sea

UNFCCC United Nations Framework Convention on Climate Change

1. Introduction

Climate change has been recognized as one of the main challenges of the twenty-first century, and the threat that it poses to our civilization has only recently started to be understood. In particular, climate change will probably have a disproportionate effect on coastal regions, as due to the acceleration in sea level rise caused by increasing of CO_2 levels in the atmosphere some low-lying areas could be submerged in the course of the next century. Also, potentially increased levels of tropical cyclone activity could devastate coastal areas due to the combined effect of storm surges and high waves. A number of these threats have already been recognized by the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).[1]

The present paper focuses on the threat that climate change poses to the long-term survival of Atoll Island States, which could become submerged in the course of the next century by a combination of sea level rise and coastal erosion resulting from higher levels of tropical cyclone activity. This would be a significant development in human history, as although in the course of time many countries have come and gone, in the modern era no state has ever ceased to exist due to submergence by the sea. The concept of disappearing islands and lands, though present in the human mind due to mythological tales such as that of Atlantis, is not often given the full consideration it probably deserves. In fact, while the possibility of "disappearing" states has been recognized since the late 1980s, the issue has so far been addressed mainly as involving "climate" or "environmental refugees". This concept, however, is not an accurate one, as people displaced as a consequence of climate change cannot be considered as refugees under the 1951 Refugee Convention Art. 1.[2] The present paper, however, will attempt not to enter this argument, which has been significantly explored in literature elsewhere.[3] Instead, the paper will focus on the issue of sovereignty over the lands currently claimed by Island States, and whether this sovereignty can be maintained if the islands become submerged. Nevertheless, this issue of sovereignty is also of vital importance to try to establish what would be the status of the citizens of these countries if their islands cease to exist.

[1] Contribution of Working Group II to the 4th Assessment Report of the IPCC, Cambridge University Press, 2007.

[2] According to this Article a refugee is a person who must be outside their country of nationality or former residence; he or she has to have a fear of persecution; and this fear of persecution must be on grounds of race, nationality, religion, membership of a particular social group or political opinion; and the fear must be well-founded. Therefore, in international refugee law, environmental conditions might not be recognized as basis for refugee protection.

[3] See Renaud, Fabrice, Bogardi Janos J., Dun, Olivia, Warner, Koko. Control, adapt or flee- how to face environmental migration, Intersections, United Nations University, Institute for Environment and Human Security, No.5/2007; Conisbee, Molly and Simms, Andrew. Environmental refugees- the case for recognition, New economics foundation, 2003.

To understand the threat that climate change poses to low-lying islands this paper will first analyse what is likely to happen to sea levels during the course of the twenty-first century and why it is believed that tropical cyclones will increase in intensity in the future. However, to understand the context first a brief introduction to atolls will be given, followed by an analysis of why sea level rise is important to low-lying Atoll Island States. These small islands typically have a poorly developed infrastructure and limited natural, human and economic resources, and often their small populations are highly dependent on fishing to meet their protein needs.[4] Economically, they are generally reliant on a limited resource base, and their adaptive capacity to climate change is generally considered to be low.[5]

Other possible consequences of climate change on the local ecosystems and how this can influence the inhabitability of the islands will then be discussed, along with the potential higher rates of erosion that could result from stronger future tropical cyclones. This working paper concerns itself with the legal consequences that these effects would have on the sovereignty of Atoll Island States, where the entire country is formed only of low-lying atolls that could either become uninhabitable or disappear during the course of this or the next century. Prominent in this group of countries are Kiribati, Tuvalu, the Marshall Islands and the Maldives.[6] However, climate change is a serious issue that will have important consequences for the coastal areas of many countries, and much of what is in this working paper can be applied to other tropical coastal areas, independent of whether they are islands or not.

The working paper will examine some of the possible legal effects of the re-location of the citizens of these countries. It will discuss the issue of sovereignty, which would determine the ability of the people of the islands to keep long-term control over their current natural resources. Key to this would be the status of a submerged Atoll Island State, and if sovereignty could be preserved through civil engineering defence works.

Finally, the possibility of having a government-in-exile will be discussed, which would centre upon the idea that these islands could re-emerge one day in the distant future, where the descendants of the current inhabitants could re-claim these lands. The scientific basis for this will also be discussed, highlighting the complex physical and socio-political problems and uncertainty associated to the status of these countries.

[4] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
[5] Ibid.
[6] R. Rayfuse, W(h)ither Tuvalu? International Law and Disappearing States, Uni. Of New South Wales Faculty of Law Research Series, Paper 9, Berkeley Electronic Press (2009).

2. Atoll Islands

Atolls are islands made from dead corals, enclosing a central lagoon and surrounded by an annular coral reef ecosystem. Most of them are located in the Pacific Ocean, although they exist also in the Indian and Atlantic Oceans. Reef-building corals only thrive in warm tropical and subtropical waters, and hence they are not generally found in the colder seas north and south of 30° latitude.

Charles Darwin originally explained the creation of coral atolls in the South Pacific, which originated as high volcanic islands and gradually transformed into atolls. His original explanation is still accepted as basically correct (with some minor refinements), and is illustrated in Figure 1. The origins of atoll islands can thus be traced back to an original volcano that emerged from the sea. Corals start to colonize the area around the volcano and slowly grow with time. Once the volcano dies the island starts to subside, and the fringing coral reef surrounding the island start to grow upwards. Eventually the fringing reef becomes a barrier reef as the outer part of the reef can maintain itself very near sea level through natural growth in the coral reef. The inner part of the reef falls behind in this growth and becomes a lagoon, as the conditions for coral growth are less favourable in this area (see Figure 2). Eventually the original volcanic part of the island falls below the ocean surface, though the barrier reef continues to thrive, with the island becoming an atoll.

Figure 1: Darwin's process of atoll formation

a) In the beginning the island is formed by a volcano that emerges from the sea

b) After the volcano dies, corals start to build a fringing reed, which typically has a shallow lagoon between the land and the reef

c) Finally the island sinks below the sea level, and the barrier reef becomes an atoll surrounding a central lagoon

Fresh water originates from rainfall, and although due to their sandy/coral nature atolls are highly permeable, the fresh water table is only slightly above sea water, which allows vegetation to flourish. The location of this water table, however, is critical for the survival of vegetation and can be easily contaminated by salt water or by human and industrial waste (see Figure 3).[7]

Figure 2: Cross Section through an atoll

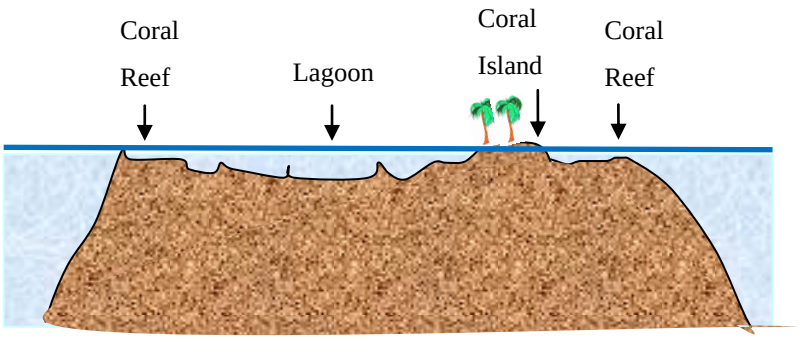
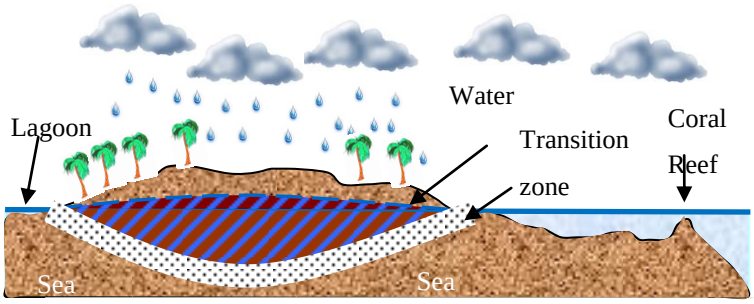


Figure 3: Cross Section through a typical Coral Island



2.1 Coral Reef Communities

Coral reefs are built by small colonial, anemone-like animals that house microscopic algae and secrete skeletal structures made up of calcium carbonate. Symbiotic algae provide energy

[7] UNEP (United Nations Environment Programme), Pacific Islands Environment Outlook, UNEP, Apia, 1999.

to the coral animals through photosynthesis. Together, they are the main contributors to reef accumulation, as the coral animals secrete the calcareous structures of the reef.[8] Coral reefs are characterized by a high level of biodiversity and elaborate specialization of resident species, and provide many ecosystem services that economically support nearby human populations. They also offer some level of protection from natural disasters such as high waves or tsunamis.

Based on analysis undertaken by the Economics of Ecosystems and Biodiversity (TEEB) project, the value that coral reefs offer to human societies has been estimated at between USD 130,000 and USD 1.2 million per hectare per year.[9] These calculations take into account the services provided by coral reefs in relation to food, raw materials, ornamental resources, climate regulation, moderation of extreme events, waste treatment, water purification, biological control, cultural services (including tourism), and maintenance of genetic diversity. Despite their benefits, many of them have been seriously degraded by human activities such as over-fishing, coastal development, pollution or destructive fishing practices (such as fishing using explosives). The reefs are also sensitive to elevated sea temperatures, which causes the corals to expel their symbiotic algae, resulting in what is known as coral bleaching. These coral bleaching episodes have increased markedly in the past decades, and while corals might recover from these events, high mortality is often reported as a result.[10] Also, the corals are vulnerable to ocean acidification, which has been shown to decrease the rate at which the corals can form their calcium carbonate skeletons.[11]

2.2 Atoll Island States

The current working paper will deal with the consequences of climate change on Atoll Island States. These will be defined as countries that have formed uniquely of one or more atoll islands (i.e. an atoll archipelago). They are considered to be highly vulnerable to climate change, as the highest point in these islands is often only a few metres above sea level, and hence the population cannot move to higher ground within the islands and would probably have to emigrate to foreign countries as a consequence of sea level rise and other climate

[8] Joanie Kleypas (Lead Author); Jean-Pierre Gattuso (Topic Editor);. 2010. "Coral reef." In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth October 18, 2006; Last revised March 28, 2010; Retrieved May 27, 2010]<http://eoearth.org/article/Coral_reef>.
[9] TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.
[10] Reaser, J.K., Pomerance, R., and Thomas, P.O. Coral Bleaching and Global Climate Change: Scientific Findings and Policy Recommendations. Conservation Biology 14, 1500-1511 (2000).
[11] Joanie Kleypas (Lead Author); Jean-Pierre Gattuso (Topic Editor);. 2010. "Coral reef." In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth October 18, 2006; Last revised March 28, 2010; Retrieved May 27, 2010]<http://eoearth.org/article/Coral_reef>.

change effects. They typically have a high ratio of coastline to land area, relatively high population densities and low level of available resources for adaptive measures.[12] This in turn makes their economies highly vulnerable, and on average they are also more food insecure than other small island states.[13] Generally, many of the settlements are in coastal locations, with the main city typically hosting the main port, airport and government institutions.[14]

Prominent in this group of countries are Tuvalu, the Maldives, Kiribati, the Marshall Islands and Tokelau. Some basic statistics for these countries are given in Table 1, and Figure 4 shows their location together with that of other atolls mentioned later in this paper. However, many other countries have atolls in their territory, and although the sovereignty consequences described later in this paper might be less severe than those for Atoll Island States (formed uniquely of atolls), the physical dangers described in Section 3 will still severely affect these islands. In fact, many other archipelagic Island States are usually composed of more than one type of island.[15] Although the sovereignty discussion in this paper will be centred on atolls, the arguments are also valid for other types of low-lying island environments, such as sand cays or low-lying volcanic islands with fringe reefs (such as Fiji or Samoa, for example).

Table 1 : Atoll Island States Statistics

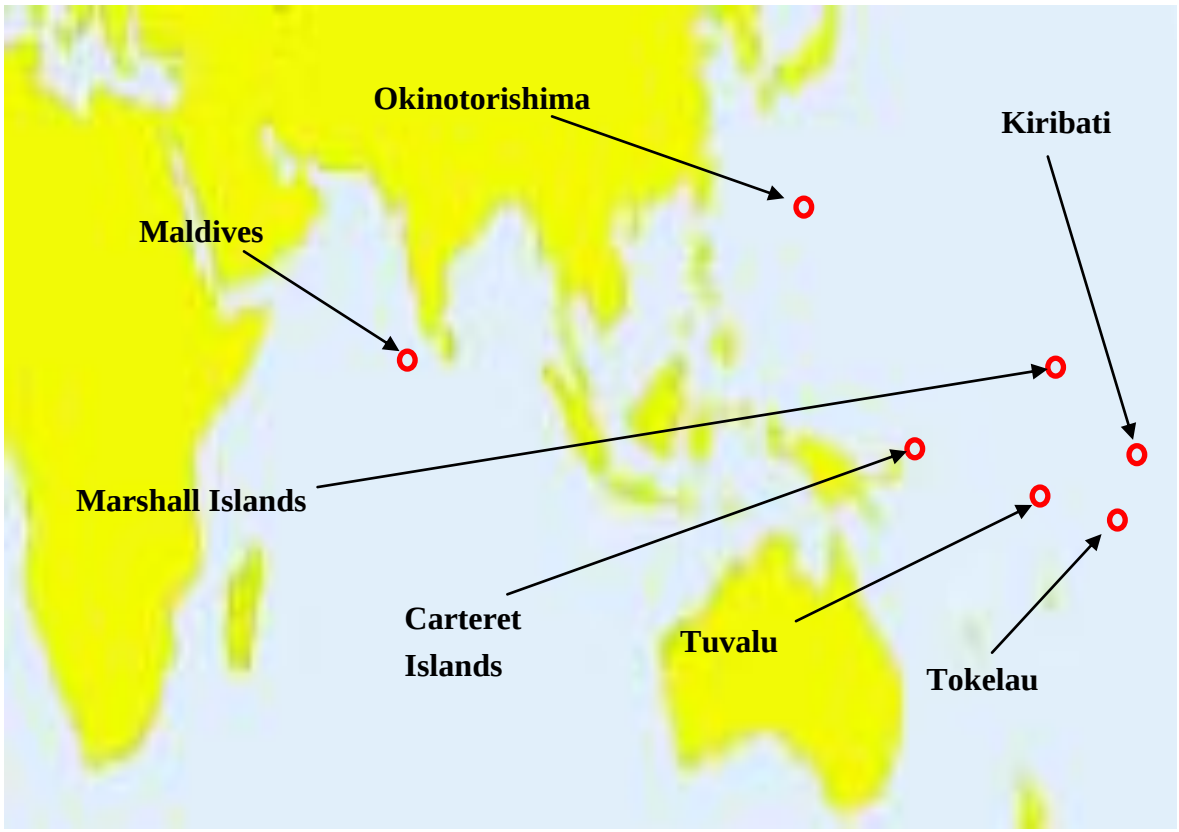
Country Statistics	**Tuvalu**	**Kiribati**	**Maldives**	**Tokelau[1]**	**Marshall Islands**
Population	10,472	99,482	395,650	1,400	65,859
GDP (US$)	$14.94m	$596.5m	$1,673m	N/A	$161.7m
GDP per capita(US$)	$1,600	$6,100	$4,200	$1,000[2]	$2,500
Land area (km2)	26	811	298	12	181
Highest Elevation (m)	5	81	2.4	5	10

Notes:
[1] Territory of New Zealand
[2] 1993 estimate

Source: CIA - The World Factbook

[12] Barnett, J. and Adger, W.N. Climate Dangers and Atoll Countries. Climatic Change 61:321-227 (2003)
[13] Ibid.
[14] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
[15] Barnett, J, and Campbell, J. "Climate Change and Small Island States: Power, Knowledge and the South Pacific", Published by Eartscan Ltd., ISBN 978-1-84407-494-5

Figure 4: Location of some atoll islands



3. Climate Change and Its Implications for Atoll Island States

Climate change poses a severe challenge to the long-term survival of Atoll Island States. It is feared that in the coming years the increasing levels of CO_2 concentrations in the atmosphere will accelerate the pace of global warming and gradually increase the rate of sea level rise. The 4th IPCC discusses different global warming scenarios for various parts of the world and states how "the probability of extreme warm seasons is 100% in all cases for the small islands and the scenarios of warming are all very significant by the end of the century".[16] The IPCC also states with very high confidence that "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 future changes and distribution of rainfall.[17] For the case of Tarawa Atoll in Kiribati it has been estimated that a 10 per cent reduction in average rainfall could lead to a 20 per cent decrease in the size of the freshwater lens, and this problem could be further compounded by sea level rise.[18] Surface sea temperatures are

[16] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
[17] Ibid
[18] Ibid

expected to rise as a result of this global warming, and it is believed that this could lead to stronger tropical cyclones, resulting in increased damage and coastal erosion. Crucially also for small atoll countries, warming of the sea may lead to increased coral mortality, which together with greater ocean acidification might decrease the ability of these creatures to keep pace with sea level rise. The combination of all these factors could render many atoll islands uninhabitable during the course of the next century, and will be discussed in more detail in this section.

3.1 Sea Level Rise

Increasing global temperature causes sea water to also increase its temperature, which makes it expand, and increases the volume of oceans globally. Increasing temperature also leads to the melting of the polar ice and glaciers, which further contributes to sea level rise. The IPCC noted that there is strong evidence that global sea level has gradually risen in the twentieth century.[19] In itself, this is nothing that the planet has not experienced before, as sea levels have naturally increased and decreased in the past following ice age cycles. However, what is different this time is that, according to the IPCC, "it is *very likely* that the response to anthropogenic forcing contributed to sea level rise during the latter half of the 20th century".[20] It appears that prior to the nineteenth century, sea levels had not significantly changed for a few thousand years, whereas it is estimated that during the twentieth century, global average sea level rose at a rate of approximately 1.7mm per year. Better information is available since the early 1990s as satellites have been able to provide more accurate data. Since this time, sea level rise is estimated to have increased by around 3 mm per year, which is significantly higher than during the previous half a century.

This increase in sea level rise is believed to be the consequence of a general rise in global temperatures, which are believed to be at least partly caused by anthropogenic increases in greenhouse gases in the atmosphere. As at present CO_2 emissions continue to increase, it appears that a significant level of sea rise is inevitable unless drastic action is taken to reduce emissions. Furthermore, the IPCC notes that "atmospheric CO_2 will continue to increase in the long term even if it's emission is substantially reduced from present levels" as these particles are not so easily eliminated once they are in the atmosphere.[21] Hence, as a consequence of this, the IPCC has forecasted that a sea level rise of between 0.19 to 0.58m is

[19] N. L. Bindoff, et. al., Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2007.
[20] S. Solomon, et al., Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the 4th Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, 2007.
[21] Ibid.

likely during the course of the twenty-first century.[22] Due to ocean density and circulation changes the distribution of sea level rise is unlikely to be uniform. For the Maldives it has been suggested, for example, that a rise in sea level of approximately 50cm by the end of the twenty-first century is the most reliable scenario.[23] More extreme recent scenarios even argue that global sea level rise could be in the range of 0.81 to 1.79m by 2100.[24]

The impact of the sea level rise could have serious consequences in certain areas of the world, flooding millions of people living in the low-lying areas of South, South-East and East Asia.[25] Even under a conservative scenario of only 40cm increase in sea level by the end of the twenty-first century this would increase the projected number of people flooded in coastal areas from 13 to 94 million.[26] Bangladesh would lose a great amount of coastal areas,[27] and it is estimated that by 2050 more than 1 million people will be affected by sea level rise in each of the Ganges-Brahmaputra-Meghna, Mekong and Nile deltas.[28] For the case of many small islands it could lead to a massive loss of coastal mangroves, which in turn would result in increased rates of coastal erosion and flooding.[29] Not only would certain coastal areas be permanently flooded, but areas further inland would also become less productive due to the increased salinity levels brought about by inundation during tropical cyclone storm surges.

The consequences of sea level rise would thus be felt by most nations on earth. However, it is possible for the inhabitants of most countries to move inland to areas of higher ground or to attempt costly sea defences, which would not only result in significant economic losses but also threaten the existence of the countries themselves. Where no coastal defences are attempted, either because of their unfeasibility or cost, massive displacement of people from low-lying areas to higher grounds will occur. For the case of Atoll Island States, where the entire islands are only a few metres above sea level, neither of these strategies are certain to guarantee the long-term survival of the countries, as will be discussed later. The international

[22] Meehl et al., Global Climate Projections. Climate Chnage 2007: The Physical Science Basis. Contribution of Working Group 1 to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2007.
[23] Woodworth, P.L. Have there been large recent sea level changes in the Maldive Islands?. Global Planet Change, 49, 1-19 (2005).
[24] Vermeer M and Rahmstorf S PNAS 2009;106:21527-21532.
[25] Stern, N. Stern Review on the Economics of Climate Change. Cambridge University Press. Cambridge, 992 pp. 2007.
[26] Wassmann, R., Hien, N.X., Hoanh, C.T. and Tuong, T.P., Sea leverl rise affecting the Vietnamese Mekong Delta: water elevation in the flood season and implications for rice production. Climatic Change 66, 89-107 (2004).
[27] D. Caron, When law makes climate change worse: Rethinking the law of baselines in light of a rising sea level, in Ecology Law Quarterly, vol.17:621 (1990).
[28] Ericson, J.P, Vorosmarty, C.J., Dingman, S.L., Ward, L.G. and Meybeck, M. Effective sea-level rise and deltas: causes of change and human dimension implications. Global Planet. Change, 50, 63-82.
[29] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

community will have to cope somehow with this, though currently it is not prepared to grant the necessary protection to the victims of this human created phenomenon. The legal questions regarding the status of what has been termed "environmental" or "climate refugees" has been widely discussed in recent times, and will not be the subject of this paper.[30] However, for the case of Atoll Island States this is linked to the issue of sovereignty and what will happen to their inhabitants once their lands become uninhabitable. Possible outcomes include the formation of a "government-in-exile", the complete loss of sovereignty, or some sort of compromise solution, as will be discussed later.

3.2 Loss of Coral Reefs

It is not the sea level rise in itself that poses the greatest long-term risk to the existence atolls, but the inability of coral reefs to keep up with this sea level rise.[31] Although sea level has gradually risen in the past, coral reefs have been able to keep pace with it, and atolls have been able to survive through the supply of sand created by the corals. The "Reefs at Risk Revisited" paper estimates that more than 60 per cent of the world's reefs are under immediate and direct threat from one or more local sources (such as coastal development, marine or watershed based pollution and destructive fishing practices).[32] When these are combined with the effects of climate change, it is believed that 75 per cent of the reefs are considered to be threatened.[33] Generally, reefs in the Pacific region (where many Atoll Island States are located) are less threatened due to lower pressures on coastal resources, with almost 50 per cent of the reefs currently considered threatened, out of which around 20 per cent are rated as having a high or very high threat level.[34]

Coral reefs are vulnerable to changes in their environment, particularly the quality (quantity of nutrients, salinity, etc.) and temperature of the water around them. Global warming is projected to cause a constant increase in sea surface temperatures, and recently episodes of mass coral reef mortality through "coral bleaching" are being experienced around the world, characterized by the corals losing their colourful appearance and turning white.[35] This whitening of the corals is the visible sign of a loss of cells containing zooxanthellae, which

[30] See, for example, A. Okamatsu, Problems and prospects of international legal disputes on climate change. (2005) available at http://web.fu-berlin.de/ffu/akumwelt/bc2005/papers/okamatsu_bc2005.pdf, access on 5th Feb, 2009, or M. Conisbee and A. Simms, Environmental Refugees-The case for recognition, Nef, 2003.
[31] Reaser, J.K., Pomerance, R., and Thomas, P.O. Coral Bleaching and Global Climate Change: Scientific Findings and Policy Recommendations. Conservation Biology 14, 1500-1511 (2000).
[32] Burke, L, Reytar, K., Spalding, M. and Perry., A. (2011) Reefs at Risk Revisited. World Resources Institute. http://www.wri.org/.
[33] Ibid.
[34] Ibid.
[35] Reaser, J.K., Pomerance, R., and Thomas, P.O. Coral Bleaching and Global Climate Change: Scientific Findings and Policy Recommendations. Conservation Biology 14, 1500-1511 (2000).

plays a vital role in coral metabolism.[36] Coral bleaching is associated with events where the water temperature is above normal, and temperature variations of over +3 or 4ºC can result in "mass bleaching" events such as those that took place in 1982–3, 1987–8, 1994–5 and 1998.[37] It is important to note, however, that different species of corals respond in different ways to increased temperatures and how there are other factors at play, such as how the local geography impacts the flows of cold and warm water (such as, for example, upwelling from cold deep waters and the effects of tides) and variations in water turbidity and the resilience of each reef.[38] Also, corals in each area show different tolerances to water temperatures, suggesting how a number of adaptation and evolutionary mechanisms might be at play.[39] It is not difficult to imagine that given time and assuming no other stressors the corals would be able to successfully adapt to a changing environment. However, anthropogenic climate change could limit the time available for corals to evolve and adapt to the new conditions, and hence preventing the eventual disappearance of Atoll Island States appears difficult.

Coral mortality can lead to shift in reef ecological status, such as what happened in Uva Island off the Pacific coast of Panama in 1982–1983.[40] Here warm surface temperatures associated with an El Niño event and associated coral bleaching led to a reduction in approximately 50 per cent of coral cover. This resulted in a shift in the reef ecological state, which was made worse by low tide exposure, cold water stress after the El Niño had passed and increases in corallivore erosion (due to increases in echinoid densities). It is of course important to note how coral reefs can recover from many of these events and that natural cycles might be the norm in these kinds of environment. There is considerable evidence that this concept of phase shift indeed takes place (Jamaica coral cover declined from around 55 per cent in the 1950s to around 3 per cent, while macroalgal cover increased from 4 to 92 per cent).[41] Indeed, Kench et al. note how natural cycles of geomorphic change might be the norm, with periods of higher sea temperatures resulting in greater coral mortality then being followed by periods of recovery.[42] However it remains unclear what would happen if the frequency of periods of higher sea temperatures was to increase, as predicted under current climate change models.

[36] Kench, P.S., Perry, C.T. and Spencer, T., (2009). Coral Reefs. Chapter 7. In: Slaymaker, O.,Spencer, T., Embleton-Hamann, C. (Eds.), Geomorphology and Global Environmental Change. Cambridge University Press, Cambridge, pp. 180–213.
[37] Ibid.
[38] Ibid.
[39] Ibid.
[40] Ibid.
[41] Ibid.
[42] Ibid.

Corals are also vulnerable to ocean acidification, which can decrease the rate at which the corals form their calcium carbonate skeletons,[43] and hence increased concentrations of CO_2 in the oceans could also retard the capacity of coral reefs to keep up with sea level rise.[44] Ocean acidification occurs as a consequence of the enhanced uptake of CO_2 by the oceans, with the pH of tropical surface water declining from 8.2 in the pre-industrial period to 8.1 nowadays.[45] Calcification rates are predicted to decrease by between 12 and 48 per cent by the time that CO_2 concentrations reach twice the preindustrial era in the next 30 to 50 years, leading to slower skeletal growth.[46] Also, increased acidification will lead to higher dissolution rates of carbonate in the water, which will compound the effect of slower coral growth and negatively affect reef building.[47] These effects can be observed already in naturally occurring areas with high CO_2 concentrations, such as in areas that have naturally occurring vents that release CO_2 into the water. These areas effectively serve as "natural labs" that allow scientists to observe the effects that CO_2 has on coral populations. In one such area in Papua New Guinea, the water progressively increases in acidity in the proximity of the vents, and these areas are characterized as having fewer species of corals, and particularly none of the structurally complex ones that can provide cover for fish.[48] At pH levels of 7.8 (in line with what could be expected if CO_2 concentrations increased from the present levels of around 390 to 750 ppm, as per some of the scenarios found in the 4th IPCC), coral reef cover is typically maintained, though coral diversity is severely reduced and *Porite* corals establish a dominance over the coral reefs, though at low rates of calcification. At pH levels of 7.7, reef development ceases, and the environment becomes dominated by seagrasses, but devoid of the hard-shelled snails that normally live there.[49] The precise levels of CO_2 reached in the atmosphere are thus a crucial matter to ensure the survival of coral reefs as we presently know them. Veron et al. predict that

[43] Joanie Kleypas (Lead Author); Jean-Pierre Gattuso (Topic Editor), (2010). "Coral reef." In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth October 18, 2006; Last revised March 28, 2010; Retrieved May 27, 2010]<http://eoearth.org/article/Coral_reef>.

[44] Kleypas, J., Buddemeier, R., Archer, D., Gattuso, J., Landon, C., and Opdyke, B. Geochemical Consequences of Increased Carbon Dioxide in Coral Reefs, Science 284, 118-120 (1999).

[45] Kench, P.S., Perry, C.T. and Spencer, T., (2009). Coral Reefs. Chapter 7. In: Slaymaker, O.,Spencer, T., Embleton-Hamann, C. (Eds.), Geomorphology and Global Environmental Change. Cambridge University Press, Cambridge, pp. 180–213.

[46] International Society for Reef Studies (2008). Coral reefs andocean acidification, Briefing Paper 5, (http://www.fit.edu/isrs/documents/ISRS_BP_ocean_acid_final28jan2008.pdf). Retrieved 05 April 2011.

[47] Kench, P.S., Perry, C.T. and Spencer, T., (2009). Coral Reefs. Chapter 7. In: Slaymaker, O.,Spencer, T., Embleton-Hamann, C. (Eds.), Geomorphology and Global Environmental Change. Cambridge University Press, Cambridge, pp. 180–213.

[48] Fabricius, K. E, Langdon, C., Uthicke, S., Humphrey, C., Noonan, S., De'ath, G., Okazaki, R., Muehllehner., N., Glas, M. S. and Lough, J. M. (2011), Losers and winners in coral reefs acclimatized to elevated carbon dioxide concentrations Nature Climate Change, 1, 165-169.

[49] Ibid.

> at today's atmospheric CO_2 levels (~387 ppm), coral reefs are committed to an irreversible decline. Mass bleaching will in future become annual, departing from the 4 to 7 years return-time of El Niño events. Bleaching will be exacerbated by the effects of degraded water-quality and increased severe weather events. In addition, the progressive onset of ocean acidification will cause reduction of coral growth and retardation of the growth of high magnesium calcite-secreting coralline algae. If CO_2 levels are allowed to reach 450 ppm (due to occur by 2030–2040 at the current rates), reefs will be in rapid and terminal decline world-wide from multiple synergies arising from mass bleaching, ocean acidification, and other environmental impacts. Should CO_2 levels reach 600 ppm reefs will be eroding geological structures with populations of surviving biota restricted to refuges. [50]

Coral reefs, if they were not subjected to the detrimental effect of human activities and anthropogenic climate change, have the potential to keep pace with sea level rise (4th IPCC). However, the combination of an increase in sea temperatures, acidification, land-based sources of pollution (see Figure 5) and other anthropogenic stressors (destructive fishing, coastal development, etc.) make it unlikely that the coral reefs will be able to keep up with the pace of sea level rise.[51] By 2030 the combined impact of ocean warming and acidification could mean that 90 per cent of the reefs will move to threatened status, and by 2050 nearly all of them could be classified as such, assuming there is no change in local pressure on reefs.[52] This would lead to increases in flooding, a decreasing ability of the islands to sustain human populations [53] and eventually places like Kiribati, Tuvalu, the Marshall Islands and the Maldives could potentially become entirely submerged.[54] It is important to remember, though, that the timescales involved in this are likely to be greater than sometimes claimed. Reef structures have considerable resilience, and even if the ecosystem that supports them degrades considerably there is a delayed response for that to propagate through the geomorphic system. [55] Paradoxically, episodes of bleaching and other natural or human impacts might have a short-term positive impact on the supply of sediments, and hence the

[50] Veron, J. E. N., Hoegh-Guldberg, O., Lenton, T. M., Lough, J. M.,, Obura, D. O., Pearce-Kelly, P., Sheppard, C. R. C., Spalding, M., Stafford-Smit, M. G. and Rogers, A. D. (2009) The coral reef crisis: The critical importance of <350 ppm CO2. Marine Pollution Bulletin 58: 1428–1436.

[51] Westmacott, S., Teleki, K., Wells, S. and West, J.M., Management of Bleached and Severely Damaged Coral Reefs, International Union for the Conservation of Nature, Gland, Switzerland. (2000).

[52] Burke, L, Reytar, K., Spalding, M. and Perry., A. (2011) Reefs at Risk Revisited. World Resources Institute. http://www.wri.org/.

[53] Barnett, J. and Adger, W.N. Climate Dangers and Atoll Countries. Climatic Change 61:321-227 (2003).

[54] D. Caron, When law makes climate change worse: Rethinking the law of baselines in light of a rising sea level, in Ecology Law Quarterly, vol.17:621 (1990).

[55] Kench, P.S., Perry, C.T. and Spencer, T., (2009). Coral Reefs. Chapter 7. In: Slaymaker, O.,Spencer, T., Embleton-Hamann, C. (Eds.), Geomorphology and Global Environmental Change. Cambridge University Press, Cambridge, pp. 180–213.

reality of how these changes might come about is far more complex than what is often thought.

Figure 5: Land-based pollution can affect coral reef growth (photo from Tuvalu)

3.3 Increase in Tropical Cyclone Intensity

One of the fears of global warming is that it might result in an increase in the frequency and intensity of tropical cyclones due to the increases in surface sea temperatures.[56] Tropical cyclones can have devastating effects on low-lying coastal areas, due to a combination of several factors:

- High winds
- High precipitation
- High waves that are generated as a consequence of the high winds
- Storm surges, which are increases in the mean sea level that originate as a consequence of the low atmospheric pressure associated with these systems and the wind and wave forcing of the sea water.

[56] Knutson, T. R., J. L. McBride, J. Chan, K. Emanuel, G. Holland C., Landsea, I. Held, J. P. Kossin, A. K. Srivastava,and M. Sugi, (2010): Tropical Cyclones and Climate Change. Nature Geoscience, Review Article, 21 February 2010, DOI: 10.1038/NGEO779.

The damage due to these events varies greatly depending on factors such as the local coastal geometry, the atmospheric storm intensity or the location of human settlements. They can have potentially devastating consequences for low-lying coastal areas, especially in poor countries, such as in the case of the 1970 Bangladesh cyclone where between 300,000 and 500,000 people were killed.[57] In the Caribbean, Hurricane Ivan devastated Grenada in 2004, damaging or destroying over 90 per cent of hotel guest rooms, 80 per cent of the island's nutmeg trees (both the island's main foreign exchange earners) and causing massive damage to the country's socio-economic infrastructure.[58] However, tropical cyclones occur most frequently in the western north Pacific area, which accounts for approximately one-third of all typhoons in the world.[59] In 2006, typhoon Durian left 800 people dead in the Philippines alone.[60] Cyclone Val hit Samoa in December 1991, the worst storm to hit the islands in over 100 years, and destroyed over half the coconut palms. The country was devastated by a tropical cyclone again in 1998. However, serious damage from typhoons is not limited to less developed countries. In August 2009, Typhoon Morakot struck Taiwan, leaving hundreds dead, and many were buried alive or trapped by mudslides and floods.[61]

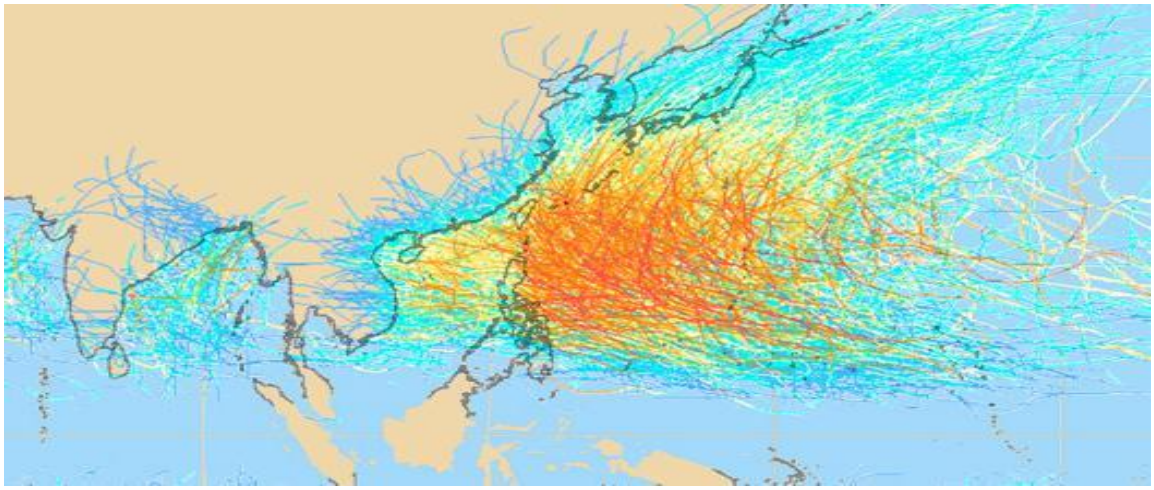
3.3.1 What are Tropical Cyclones?

A tropical cyclone is a storm system characterized by a large low-pressure centre surrounded by numerous thunderstorms, which result in strong winds and heavy rain. The driving mechanism behind them is the heat released when moist air rises, resulting in condensation of the water vapour contained in this moist air. The heat mechanism that drives them differentiates these storms from other types of cyclonic windstorms, such as European windstorms, as they originate in the vicinity of the equator, though not too close to it (from around 10° north or south of it). The reason for this is that they require a certain amount of Coriolis force (which is an acceleration given by the Earth's rotation), which does not exist at the equator. Equally, as they feed on warm moist air, they cannot form in the colder northern latitudes, as shown in Figure 6.

[57] Landsea, C. W., B. A. Harper, et al. (2006) Can We Detect Trends in Extreme Tropical Cyclones? Science 313(5786): 452 – 454.
[58] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
[59] Imamura, F. And Van To, D. (1997) Flood and Typhoon Disasters in Viet Nam in the Half Century Since 1950. Journal of Natural Hazards 15: 71-87.
[60] See Munich Re (2009) Natural disasters 1980-2008, 10 costliest typhoons ordered by insured losses. http://www.munichre.com/ Retrieved 28th April 2009.
[61] BBC News. Taiwan leader in typhoon apology. 15 August 2009. http://news.bbc.co.uk/2/hi/asia-pacific/8202821.stm.

Tropical cyclones, as their name implies, are cyclonic in nature, with counter clockwise rotation in the Northern Hemisphere and clockwise rotation in the Southern Hemisphere. Depending on its location, a tropical cyclone is referred to by a variety of names such as hurricane (America), typhoon (Asia Pacific) or cyclone (Indian Ocean).

Figure 6: Typhoon tracks in the Asia Pacific Region[62]



3.3.2 Influence of Climate Change of Tropical Cyclones

Over recent years a number of scholars have voiced concerns about the possibility that global warming could be causing an increase in tropical cyclone intensity, and it is claimed that a thirty-year analysis of satellite record of tropical cyclones confirms this.[63] An analysis of the trends in the upper quintiles of cyclone maximum wind speeds also found a significant upward trend for wind speed quintiles above the 70th percentile.[64] However, some authors have disputed the accuracy of satellite-based pattern recognition.[65]

To try to understand how tropical cyclones are likely to be affected by an increase in global temperatures, a number of climate models using powerful supercomputers have been carried out, as highlighted in the IPCC.[66] One example of a simulation of the increase in tropical

[62] The image was produced by Wikipedia users and released into the public domain. http://en.wikipedia.org/wiki/File:Tropical_cyclones_1945_2006_wikicolor.png.
[63] Webster, P. J., G. J. Holland, et al. (2005) Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science 309(5742): 1844-1846.
[64] Elsner, J. B., Kossin, J.P. and Jagger, T.H. (2008) The increasing intensity of the strongest tropical cyclones. Nature 455, 92-94.
[65] See of example Landsea, C. W., B. A. Harper, et al. (2006) Can We Detect Trends in Extreme Tropical Cyclones? Science 313(5786): 452 – 454.
[66] Giorgi, F. and Co-authors (2001) Regional climate information-Evaluation and projections. Climate Change: The Scientific Basis. J.T. Houghton et al.: 583-638.

cyclone intensity is the work of Knutson and Tuleya, who carried out simulations for a Surface Sea Temperature (SST) change of between +0.8° to +2.4°C (assuming a linear +1% compounded yearly increase in CO_2 over a period of eighty years up to the year 2085).[67] This +1% yearly increase means that CO_2 levels would reach 2.2 times the control value (that of 2004) by the year 2085. Knutson and Tuleya computed and presented histograms for the maximum surface wind speed for four different types of hurricane simulation, as shown in Figure 7. The histograms depict an increase in both storm intensity and near-storm precipitation rates related to the increase in Surface Sea Temperature. These authors acknowledge how other radiative forcing agents besides greenhouse gases may have important effects on the global climate, but quantification of their past and possible future forcing remains even more unclear than for greenhouse gases. However Surface Sea Temperature is not the only factor that affects the intensity of tropical cyclones. Other factors such as vertical wind shear can also play a crucial role, although how to correctly apply this is at present still under discussion. For this reason, Knutson and Tuleya chose not to include this effect, as they take the view that it is possible to obtain useful information on the relative distribution of intensities from the knowledge of the potential intensity alone.[68]

The IPCC reports that although there is general agreement that tropical cyclones are likely to increase in intensity, there is no consensus yet on the future frequency of these events. Pielke also highlights the uncertainties regarding future changes in tropical cyclone intensity, and reports how nine of the leading scholars on tropical cyclones and climate change give estimates ranging from a zero to 36 per cent increase in tropical cyclone intensity by the year 2100.[69] Regarding frequency, however, recent research suggests that the number of the most intense cyclones might increase in the future, as current higher resolution modelling gives a more precise picture than the modelling carried out in previous years.[70]

Higher tropical cyclone intensity correlates also with higher waves. However, changes in wave patterns do not result only from changes in tropical cyclone intensity. It has been

[67] Knutson, T. R. and R. E. Tuleya. (2004) Impact of CO2 –Induced Warming on Simulated Hurricane Intensity and Precipitation Sensitivity to the Choice of Climate Model and Convective Parameterization. *Journal of Climate* **17**(18): 3477-3495.

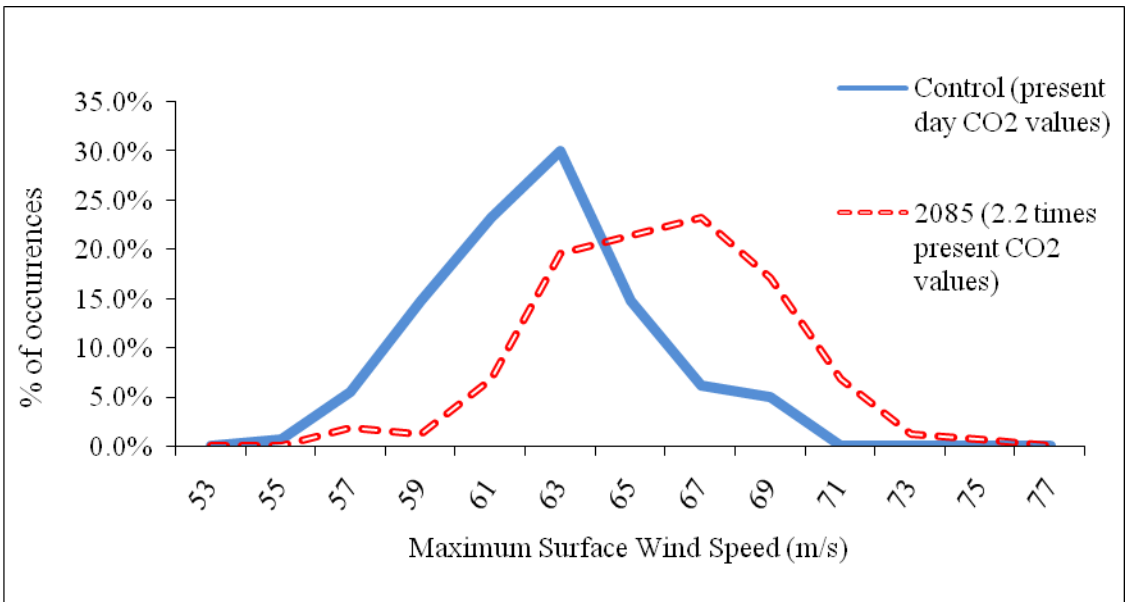
[68] See: Emanuel, K., Sundararajan, R., Williams, J. (2008) Hurricanes and Global Warming. Results from Downscaling IPCC AR4 Simulations. Bulletin of American Meteorological Society, 89, 3, 347-367, DOI:10.1175/BAMS-89-3-347; Chan, J. C. L. (2006) Comment on Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science, 311, 1713; Vecchi, G. A., Swanson K. L., Soden, B. J. (2008): Whither Hurricane Activity? Science, 322, DOI:10.1126/science.1164396.

[69] Pielke Jr., R. A. (2007) Future Economic Damage from Tropical Cyclones. Sensitivities to Societal and Climate Changes, Philosophical Transactions of the Royal Society, DOI:10.1098/rsta.2007.2086.Pielke., R. A. and Landsea C. W., (1998) Normalized Hurricane Damages in the United States: 1925-95. Weather and Forecasting, 13, 621-631.

[70] Knutson, T., McBride, J., Chan, J., Emanuel, K., Holland, G., Landsea, C., Held, I., Kossin, J., Srivastava, A., & Sugi, M. (2010). Tropical cyclones and climate change Nature Geoscience, 3 (3), 157-163 DOI: 10.1038/ngeo779.

estimated that as a consequence of climate change future daily wave climate will have a lower mean wave height in middle latitudes, and a higher mean wave height in the high latitudes and equatorial areas.[71] Future extreme wave conditions in the Northern Pacific Ocean are estimated to become more severe than they are in the present climate due to the increase in the strength of tropical cyclones.[72]

Figure 7: Typical Resolved inner-grid convection hurricane intensity simulation, from Knutson and Tuleya (2004)



3.3.3 Tropical Cyclone Damage

Tropical cyclones present a number of problems and challenges for human settlements. They can cause not only direct damage to human habitation and infrastructure, what could be described as the direct economic damage, but also damage to the surrounding environment and ecosystems. The economic damage caused by these events is generally believed to be exponential,[73] where for example in the East Coast of the USA a 10 per cent increase in intensity can cause a 54 per cent increase in the mean normalized economic losses.[74] For the case of the Asia Pacific region it has been estimated that the shift in tropical cyclone

[71] Nobuhito, M,, Yasuda, T., Mase, H., Tom, T., and Oku, Y. (2010) "Projection of Extreme Wave Climate Change under Global Warming", Hydrological Research Letters, Vol. 4, pp 15-19.
[72] Ibid.
[73] Pielke Jr., R. A. (2007) Future Economic Damage from Tropical Cyclones. Sensitivities to Societal and Climate Changes, Philosophical Transactions of the Royal Society, DOI:10.1098/rsta.2007.2086.Pielke., R. A. and Landsea C. W., (1998) Normalized Hurricane Damages in the United States: 1925-95. Weather and Forecasting, 13, 621-631.
[74] Hallegatte, S. (2007) The use of synthetic hurricane tracks in risk analysis and climate change damage assessment, Journal of Applied Meteorology and Climatology, 46, 11, 1956-1966.

distribution shown in Figure 7 could cause a significant increase in housing damage in the Philippines.[75]

For the case of atoll islands most of the infrastructure and houses tend to be located close to the sea, making these types of islands extremely vulnerable to tropical cyclone damage (see Figure 8). Furthermore, the tourist installations from which many of these islands extract a large part of their revenues are often also located near the coastline and hence are vulnerable to coastal erosion. The IPCC notes how tourism is a major contributor to GDP and employment in many small islands (for example, tourism provides more than one-fifth of the GDP of Kiribati and 28 per cent of that of the Maldives[76]), and that the effects of climate change are likely to be direct and indirect, and largely negative, especially for those in low latitudes (such as atolls).[77]

The damage that tropical cyclones can cause to ecosystems and land is more difficult to quantify, as the erosion of coastal areas sometimes appears to have no direct economic consequence but over a long period of time it can affect the inhabitability of the island. These events have also been known to damage coral reefs, which are also vital to the long term sustainable development of atoll islands. For the case of low-lying atoll islands, the damage caused by storm surges can also be substantial, as the inundation of the island can increase the salinity of soils, gradually decreasing their productivity till they are eventually unable to sustain any vegetation or crops.

An increase in tropical cyclone intensity would thus exacerbate all of these effects in the future, resulting in increased erosion of coastal areas and an additional loss in soil productivity due to higher frequencies of coastal flooding (due to storm-surges). The combined effect of both sea level rise and the potential increase in tropical cyclone intensity would thus place great stress on atoll islands that could eventually destroy the ecosystem of the island, rendering it uninhabitable or completely submerging it.

[75] Esteban, M., Stromberg, P. Gasparatos, A. and Thomsom-Pomeroy, D. (2010?) "Global Warming and Tropical Cyclone Damage in the Philippines", Journal of Climatic Research (under review).
[76] CIA Factbook, www.cia.gov, Retrieved 19th July 2010.
[77] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

Figure 8: Houses in Tuvalu are often located next to the shore

4. Future Scenarios for Atolls and Sovereignty Implications

The 4th IPCC highlights how "climate change puts the long-term sustainability of societies in atoll nations at risk", and how some Island States are facing the threat of completely disappearing from the map due to rising sea levels.[78] The potential abandonment of sovereign Atoll Island States can be used as the benchmark of the 'dangerous' change that the UNFCCC seeks to avoid.[79]

Climatologists admit that the meteorological effects of climate change cannot be adequately predicted for many areas. However, there is a general consensus that any further global warming will bring with it further sea level rise. "Sea-level rise seems the most probable and perhaps the most globally uniform consequence of warming projected into the next century".[80] As a result some of these Island States might lose one of the basic requirements to be a state: their own territory.[81] This potential problem raises a number of questions regarding the sovereignty of these islands and the status of their current inhabitants.

[78] N. Minura, et al., Small Islands. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the IPCC, Cambridge University Press, 2007.
[79] J. Barnett and N. Adger Climate dangers and atoll countries. Climatic Change, 61, 321-337 (2003).
[80] D. Caron, When law makes climate change worse: Rethinking the law of baselines in light of a rising sea level, in Ecology Law Quarterly, vol.17:621 (1990).
[81] The two main theories behind the concept of Sovereignty are discussed in J. Crawford. The creation of states in international law, Oxford University Press, 2006. These are the constitutive theory and declaratory theory.

It is worth noting that very little of the coastal erosion that has so far occurred around atoll islands can be attributed to climate change. Most of the causes behind the erosion so far observed are anthropogenic, where interference with the delicate long-term sediment transport balance of the islands can dramatically alter the shoreline. The disappearance of some atoll islands in Tuvalu is often cited as a climate change problem, though there is some evidence that shows that many changes in the coastline are due to dredging and other alterations during the Second World War by the American Military.[82] However, a rise in sea level due to climate change, combined with a potential increase in tropical cyclone intensity, could alter the long-term equilibrium of these islands and eventually render them uninhabitable. Flooding due to storm surges and the rising saltwater table resulting from sea level rise could destroy deep rooted food crops and coastal erosion could undermine and topple even coconut trees, a tree which is otherwise highly salt tolerant and able to grow in the sand.[83] Normally this rise in sea level would be counteracted by the natural growth in coral reefs, though as explained previously in this paper and in the 4th IPCC, there is the fear that in the future corals will either not be able to grow quickly enough to follow the pace of sea level rise, or that many of these coral reefs will disappear altogether.

Most of the Atoll Islands States threatened by sea level rise are part of an archipelagic grouping rather than a single island, and these groups have a different legal status under the United Nation Convention on the Law of the Sea (UNCLOS). The smaller atolls would probably be the first to disappear,[84] and the larger, more populated islands are likely to survive for longer through a variety of adaptation measures.[85] The disappearance of each

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The former states that to be a state under international law, it is necessary to be recognized by other states. The latter states that recognition of a new State is a political act, which is, in principle, independent of the existence of the new State as a subject of international law.
The formulation of the basic criteria for statehood can be found in article I of the Montevideo Convention on the Rights and Duties of States, 1933. This states that a State as a person of international law should possess the following qualifications:
(a) a permanent population; although no minimum limit is apparently prescribed. Currently the smallest States by population are the Vatican City with 768 inhabitants and Tuvalu with just under 10,000.
(b) a defined territory; although a State must possess some territory, there appears to be no rule prescribing the minimum area of that territory. The smallest State by territory is Vatican City with 0.4 km^2, the second smallest is Monaco with 1.5 km^2 followed by Nauru, 21km^2 and Tuvalu 26km^2.
(c) a government; it is the governing power with respect to a certain territory.
(d) the capacity to enter into relations with other states; this is more a consequence for statehood than a criterion for it, being a conflation of the requirements of government and independence.

[82] Webb, A (2005) Tuvalu Technical Report - Coastal Change Analysis Using Multi-Temporal Image Comparisons – Funafuti Atoll, EU EDF 8/9 –SOPAC Project Report 54, Reducing Vulnerability of Pacific ACP States.

[83] Rakova, U. How-to guide for environmental refugees. Ourworld 2.0. http://ourworld.unu.edu/en/how-to-guide-for-environmental-refugees/. Retrieved 23rd August 2009.

[84] J. Vidal, Pacific "Atlantis: First Climate Change Refugees", The Guardian Newspaper, 25th November 2005. http://www.guardian.co.uk/environment/2005/nov/25/science.climatechange.

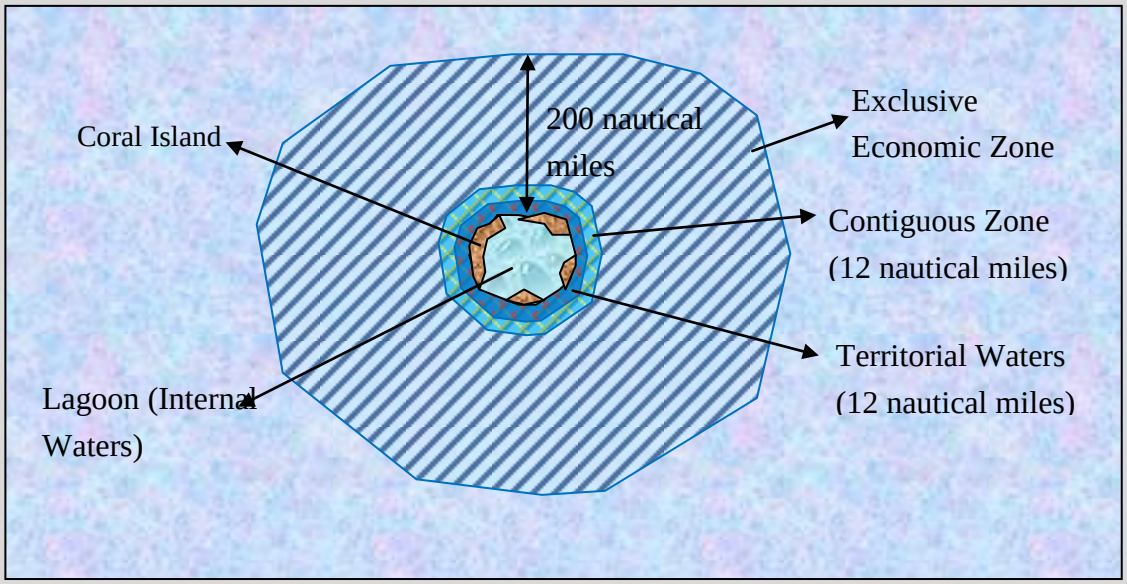
[85] See for example Rakova, U. "How-to guide for environmental refugees". Ourworld 2.0. http://ourworld.unu.edu/en/how-to-guide-for-environmental-refugees/. Retrieved 23rd August 2009

individual island would have consequences for the ability of an archipelagic state to continue to claim an Exclusive Economic Zone (or EEZ, see Box 1) around a section of its previous territory, as this is measured from the coastline of each island. More crucially, however, the submersion of the last island in the archipelago would raise important questions on the sovereign status of the country, as will be discussed in later sections of this paper.

It is not easy to imagine what will actually happen to these islands in the future, but a number of scenarios could be envisaged, as detailed in the following subsections.[86]

Box 1. Key Legal Concept: The Exclusive Economic Zone (EEZ)

Figure 9: Classification of coastal waters



The International law regarding entitlement to maritime zones is set out in the 1982 United Nations Convention on the Law of the Sea (UNCLOS).[87] This Convention establishes a number of different rights for the coastal State over a number of regions adjacent to a certain baseline. According to Art. 5 of this Convention, the baseline is normally taken as "the low-water line along the coast as marked on large-scale charts officially recognized by the coastal state", although a number of exceptions exist. The determination of these baselines is of

and Minivan News "Seawall built around Dhuvaafaru" http://www.minivannews.com/news_brief.php?id=6878, Retrieved 23rd August 2009.

[86] According to Yamamoto, L. and Esteban, M. (2009), "Sovereignty issues of the disappearance of Island States", Ocean & Coastal Management Journal. Doi:10.1016.

[87] United Nations Convention on the Law of the Sea (UNCLOS), 1982 http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm. Retrieved 24th August 2009.

crucial importance for the determination of the rights of States in the territories adjacent to them. The zones outlined in this Law of the Sea Convention include the territorial sea, the contiguous zone, the Exclusive Economic Zone (EEZ) and the continental shelf.

The territorial sea, according to Art. 3 of UNCLOS, is the area of the sea over which a coastal state can extend its sovereignty beyond its land territory and internal waters, which is limited to 12 nautical miles from the coastal baseline from which it is measured. The sovereignty of this area is extended to the airspace over the territorial sea and to its bed and subsoil (Art. 5 UNCLOS).

This EEZ is regulated by UNCLOS as an area beyond and adjacent to the territorial sea in which the coastal state possesses certain rights and jurisdiction and all other states possess certain rights and freedoms (Art. 55 UNCLOS III).[88] The coastal state possesses sovereign rights over the natural resources, whether living or nonliving, of the waters and seabed in the zone (Art. 56(1) UNCLOS III), while other states possess the freedoms of navigation and overflight (Art. 58 UNCLOS III). The breadth of the exclusive economic zone cannot exceed 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

For the case of Island States, the crucial point is what is considered as the baseline of an island, as the EEZ would be measured from the baseline of each of the island that constitutes the State. The regime of islands can be found in the United Nations Convention on the Law of the Sea (UNCLOS), Art. 121.[89] According to the present article, an island must meet a certain number of requirements:

1. An island is a naturally formed area of land, surrounded by water, which is above water at high tide

2. Except as provided for in paragraph 3, the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf of an island are determined in accordance with the provisions of this Convention applicable to other land territory

3. Rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf

[88] Ibid.
[89] Ibid.

4.1 Scenario I: No Change

Although the scientific consensus is that sea levels are rising (the IPCC estimates that for the twentieth century the global average sea level rose at a rate of about 1.7mm per year, and that sea level is projected to rise during the twenty-first century at a greater rate than during the twentieth century), it is possible that coral reefs could keep up with the rise in sea level.[90] The IPCC notes how corals might be able to grow upwards with sea level, or adapt to higher sea temperatures by hosting more temperature-tolerant symbiotic algae.[91] This "no change" scenario is however rather unlikely, as the current climate drivers are such that they are almost certain to cause wide-spread mortality and change in the coral reefs, as described earlier in this paper.

4.2 Scenario II: Barren Rock

A raise in water level has already led to large scale damage to the vegetation in several atolls, such as the Carteret Islands in Papua New Guinea.[92] Many small islands are already experiencing water stress even at present, as pollution and high levels of extraction are already depleting this resource.[93] The impact of extreme weather events (such as the "king tides" in the Carteret Islands) can also contribute to reducing the availability of fresh water[94] and push sand onto the islands, dramatically decreasing their fertility.[95] Coral bleaching also leads to the disappearance of the fish stocks that depend on the corals for survival,[96] and coral reefs are not expected to be able to sustain themselves against the multiple stresses currently affecting them.[97]

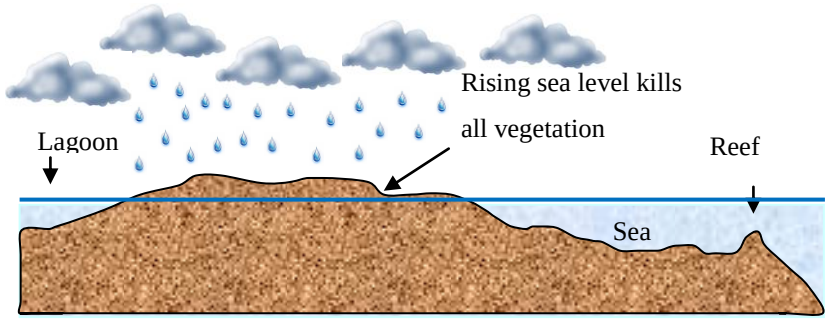
It is important to remember that from the point of view of marine life a "barren" situation is quite unlikely, as even if corals die it is likely that something (likely macroalgae) would take their place (as described earlier in this paper). One possibility is that corals that are faster growing and can tolerate higher temperatures will become dominant, while the slower

[90] N. L. Bindoff, et. al., Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2007.
[91] Ibid.
[92] J. Vidal, Pacific Atlantis: First Climate Change Refugees, The Guardian Newspaper, 25th November 2005. http://www.guardian.co.uk/environment/2005/nov/25/science.climatechange.
[93] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
[94] Barnett, J. and Adger, W.N. Climate Dangers and Atoll Countries. Climatic Change 61:321-227 (2003).
[95] Rakova, U. How-to guide for environmental refugees. Ourworld 2.0. http://ourworld.unu.edu/en/how-to-guide-for-environmental-refugees/. Retrieved 23rd August 2009.
[96] Barnett, J. and Adger, W.N. Climate Dangers and Atoll Countries. Climatic Change 61:321-227 (2003).
[97] Westmacott, S., Teleki, K., Wells, S. and West, J.M., Management of Bleached and Severely Damaged Coral Reefs, International Union for the Conservation of Nature, Gland, Switzerland. (2000).

growers (often the massive reef building corals, like brain and star corals) would be unable to keep up with sea level rise and die out. Thus, there would be a change to the species composition of reef communities. A more serious possibility is that the coral reef ecosystem would reach an environmental tipping point, and rapidly shift into an alternative state.[98] This alternative state would likely be an algal-dominated community, which has much less biodiversity and fisheries benefits. Although such an algal-dominated community is not a barren environment, the number of people who would be able to live from it would be severely reduced. If the cultivation of food on the land itself was rendered impossible due to higher salinity levels this would compound the problem and dramatically reduce food security, though for a period of time people could still live on the atoll by obtaining food from outside. This is indeed what appears to be the case for the Carteret Islands.[99] It would also be possible to invest in desalinization plants, and places such as the Bahamas, Antigua and Barbuda, Barbados, the Maldives, Seychelles and Tuvalu (amongst others) have invested in them, though in the Pacific some of the systems are only used in the dry season due to operational and cost problems.[100]

It is likely that such an algal-dominated environment would be more vulnerable to coastal erosion due to sea level rise, and this could eventually lead to the disappearance of the island (Scenario III).

Figure 10: Scenario II



[98] Kench, P.S., Perry, C.T. and Spencer, T., (2009). Coral Reefs. Chapter 7. In: Slaymaker, O.,Spencer, T., Embleton-Hamann, C. (Eds.), Geomorphology and Global Environmental Change. Cambridge University Press, Cambridge, pp. 180–213.
[99] J. Vidal, Pacific Atlantis: First Climate Change Refugees, The Guardian Newspaper, 25th November 2005. http://www.guardian.co.uk/environment/2005/nov/25/science.climatechange.
[100] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

From the legal point of view what would happen in the case where the islands could no longer sustain a human population is a complex issue, and the state would probably lose the right to claim the Exclusive Economic Zone (EEZ) since "barren rocks" cannot be a basis for claiming it (UNCLOS Art.121(3)). However, the Island State could continue to claim a territorial sea and a contiguous zone since these elements are not regulated by the article regarding island statute, but on provisions of UNCLOS applicable to "other land territory" (Art. 212(2)). In addition, it would also lose sovereign rights over the continental shelf if it did not establish its outer limits according to UNCLOS.[101] It may be possible to claim that the interpretation of an island should rely on Art. 121(1) of UNCLOS and not Art. 121(3), and thus maintain a claim to the EEZ, though the legal case for this is quite complicated. This would in effect be similar to what the Japanese government is doing for the case of Okinotorishima (see Box 2).

In this case, the key concept is whether the islands have an "economic life of their own", which is an expression that is not completely clear, as it could refer to activities on the island or the sea area that surrounds it. If it refers to the sea area, there is no doubt that the sea-related economic activities (such as fishing) could sustain an economic life. A crucial argument in the context of climate change is that presented by Kuribayashi for the case of Okinotorishima (see Box 2).[102] This author argues that "a priori, it is not possible for it to be determined that Okinotorishima corresponds to a 'rock' which cannot sustain human habitation and economic life on its own. For instance, it could be claimed that there is a possibility that hereafter, with the development of science and technology, a situation where economic life is possible could be created. In addition, 'human habitation' and 'economic life' are terms which have not yet been internationally agreed.[103] Following this interpretation, it would be possible for Atoll Island States that have a non submerged "rock" to claim their EEZ even after suffering from the effects of sea level rise. According to this an island that was previously able to support life (Scenario I) but where the vegetation is killed due to rising sea water (Scenario II) would still be able to claim an EEZ. On the other hand, Jon Van Dyke claims that Okinotorishima is the description of an uninhabitable rock that cannot sustain economic life of its own.[104] According to this interpretation, therefore, it would not be possible to claim an EEZ for Scenario II. However, the Japanese case is different from that of Atoll Island States in the sense that the survival of Japan as a country is not in question. Also, the protective infrastructure that the Japanese government has put in place to preserve the

[101] Hayashi, M. "The Adverse Impacts of Sea Level Rise on the Rights of Islands and Island States over their Surrounding Sea Areas: Procedural Options of International Legal Measures for Mitigating Impacts", Proocedings of International Seminar on Islands and Oceans 2010, January 20-22,2010,p.106.
[102] T. Kuribayashi, The position of Okinotorishima in the international law, Nippon Foundation's The Report on Promoting economic activities in Okinotorishima, http://nippon.zaidan.info/seikabutsu/2004/00009/contents/0001.htm access on 4th February, 2009.
[103] Ibid.
[104] J. Van Dyke, Speck in the Ocean Meets Law of the Sea. Letter to the New York Times, Jan. 21 (1988).

rocks is not meant to mitigate the effects of the sea level rise, but to prevent erosion by wave action. At present there is no doubt of the Japanese sovereignty over the rocks since the Chinese government has not put that into question.[105]

Box 2. Case Study: Okinotorishima

The discussion of whether a rock could guarantee an EEZ can be seen in the case of Okinotorishima Island. The island is located in the south part of the province of Tokyo in Japan. It is constituted of two barren rocks located 1,400 yards apart and no more than two feet out of the water at high tide.

The island is the subject of controversy between the Chinese and Japanese governments. The Chinese government recognizes Japanese sovereignty over Okinotorishima, but they claim that it is a rock (not an island) which cannot sustain human and economic life, and hence that this does not grant Japan an EEZ around it.[106] They also do not accept the fact that the island is natural, considering the protection structures and enlargements that have been built around it by Japan.

On the other hand, the Japanese government claims that it has been making efforts to save the island by constructing circular blocks of steel and concrete around it. The Japanese government regards Okinotorishima as an island, as it considers that Art. 121(1) provides the requirements of an island and Art. 121 (3) states the requirements of a rock. In this way as Okinotorishima fulfils the requirement of Art. 121 (1) of UNCLOS it is not bound by Art. 121 (3).[107] The Japanese claim that the "island" itself (the two barren rocks) were not touched, and that the breakwaters were constructed around these rocks as a protection against natural disasters. That is to say the construction was not executed in order for the island to fulfil the requirements of Art.121 (1), but only to preserve the integrity of the islands which already met the criteria of this article.[108]

[105] D. Caron. Climate change, sea level rise and the coming uncertainty in oceanic boundaries: A proposal to avoid conflict. Maritime Boundary Disputes, Settlement Processes and the Law of the Sea. Seoung-Yong Hong and Jon Van Dyke eds. 2008.
[106] Y. Yoshikawa. . The US-Japan-China mistrust spiral and Okinotorishima, The Asia-Pacific Journal: Japan Focus (2007). www.japanfocus.org/products/details/2541. Retrieved on 29th January, 2009,
[107] Y. Kagami, Sustainable development as catalytic agent- Art. 121(3): the attempt of Okinotorishima's recovery. Relatory on the revitalization of Okinotorishima, Ocean policy research foundation,2005. Original in Japanese 「持続可能な開発のための触媒としての国連海洋法条約第 121 条 3 項：沖ノ鳥島再生への一試論」『沖ノ鳥島再生に関する調査研究』(海洋政策研究財団、平成 18 年).
[108] Ibid.

Some authors argue that on the preparatory works of the United Nations Convention on the Law of the Sea III, countries presented two types of "island" conceptions.[109] The first one relied on certain criteria to classify different types of islands and give them different status. The second one was of not distinguishing between different types of islands. The former was made to distinguish between those which would have an EEZ around them and those which would not have it. The latter would grant EEZ to all islands, without any distinction.[110] As Art. 121(3) was approved, it is clear that the intention of the drafters was to make a distinction between different types of islands. However, the concept of rock still remains unclear, which further complicates the legal interpretation of this treaty for the case of Atoll Island States.[111]

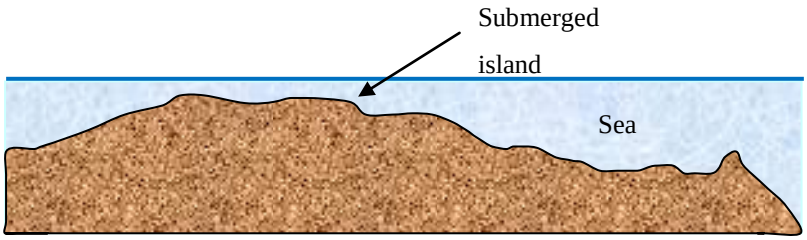
4.3 Scenario III: Submergence

The stress placed on coral reefs combined with sea level rise and a potential increase in tropical cyclone intensity could increase the rates of coastal erosion and eventually lead to the complete disappearance of low-lying islands, forcing their inhabitants to migrate.[112] In fact, it has already been reported that two small uninhabited Kiribati islands have disappeared under the waves.[113]

Point 3 of Art. 121 of UNCLOS is clear in that an island which is entirely submerged (Scenario III) would have difficulty claiming that it existed as a State and would probably lose the EEZ around the islands.[114] Further implications of this will be discussed in later sections of this paper.

[109] T. Kuribayashi, The position of Okinotorishima in the international law, Nippon Foundation's The Report on Promoting economic activities in Okinotorishima, http://nippon.zaidan.info/seikabutsu/2004/00009/contents/0001.htm access on 4th February, 2009.
[110] Ibid.
[111] Ibid.
[112] Westmacott, S., Teleki, K., Wells, S. and West, J.M., Management of Bleached and Severely Damaged Coral Reefs, International Union for the Conservation of Nature, Gland, Switzerland. (2000).
[113] J. Vidal, Pacific Atlantis: First Climate Change Refugees, The Guardian Newspaper, 25th November 2005. http://www.guardian.co.uk/environment/2005/nov/25/science.climatechange.
[114] United Nations Convention on the Law of the Sea (UNCLOS), 1982 http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm. Retrieved 24th August 2009.

Figure 11: Scenario III



4.4 Scenario IV: Protection by Coastal Structures

Entire sections of low-lying islands could be protected from the effects of tropical cyclones and rising waters by the usage of sea dykes, in a similar way to what happens in the Netherlands. This would be costly, as in the case of Okinotorishima where the Japanese government has already spent 29.3 billion yen protecting two rocks (see Box 2).[115] However, it is not clear whether small islands have the financial resources necessary to implement such costly schemes, and the IPCC notes "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".[116] It has been estimated that a temporary sea wall for one Marshall Island atoll would cost USD 100 million, more than twice the wealth the country produces annually.[117] Table 1 shows how the GDP of Atoll Island States is small, and most of the islands are only a few metres above sea level at most (for the case of the Maldives 80 per cent of the land area is 1m or less above sea level).[118] In places like the Carteret islands[119] or the Maldives[120] some limited schemes have been implemented in the past, though these works themselves are vulnerable to erosion and their overall effectiveness is not very clear, as shown in Figure 12 for the case of Independent Samoa. As tropical cyclones are expected to increase in strength in the future, sea defences would need to become even bigger than what would be required nowadays,[121] further undermining the economic case for these structures.

[115] Y. Kagami, Sustainable development as catalytic agent- Art. 121(3): the attempt of Okinotorishima's recovery. Relatory on the revitalization of Okinotorishima, Ocean policy research foundation,2005. Original in Japanese 「持続可能な開発のための触媒としての国連海洋法条約第 121 条 3 項：沖ノ鳥島再生への一試論」『沖ノ鳥島再生に関する調査研究』(海洋政策研究財団、平成 18 年).

[116] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

[117] BBC (British Broadcasting Corporation) Island Disappears Under the Seas, http://news.bbc.co.uk/2/hi/science/nature/368892.stm, Retrieved 23rd August 2009.

[118] CIA Website, www.cia.gov website, retrieved on 19 Feb 2009.

[119] Rakova, U. How-to guide for environmental refugees. Ourworld 2.0. http://ourworld.unu.edu/en/how-to-guide-for-environmental-refugees/. Retrieved 23rd August 2009

[120] Minivan News Seawall built around Dhuvaafaru http://www.minivannews.com/news_brief.php?id=6878, Retrieved 23rd August 2009.

[121] Takagi, H., Kashihara, H., Esteban, M. and Shibayama, T. (2010) "Assessment of Future Stability of Breakwaters under Climate Change", Coastal Engineering Journal, (under review)

Also, the loss in natural beauty resulting from these protection works could be detrimental to the local economy, as many of these islands depend on tourism for much of their revenues (90 per cent of government tax revenue in the Maldives originates from tourism).[122] Generally, the creation of these protection works could ultimately prove to be unsustainable. Other Island States, such as Tuvalu or Kiribati, are poorer than the Maldives, and would find it even more difficult to attempt such a scheme (see Table 1). Strictly speaking, the construction of coastal defences could result in a (very modest) landward movement of the baseline from which the EEZ is measured. In this case the high-water mark will not move (as it would be protected by the structure), but the low-water line (which determines the baseline) could move towards the land if the beach in front of the coastal structure were eroded.[123] While morphological processes will determine whether the beach will be eroded or not, the construction of coastal defences and sea walls does often lead to erosion. This would hence displace the baseline, though this would probably only be by a few dozen metres rather than kilometres.

Figure 12: Damaged Coastal Defences in Independent Samoa

Also, it is not clear whether it would be possible to preserve the vegetation behind the defensive works from dying, as a rise in the saltwater level and high tides could effectively

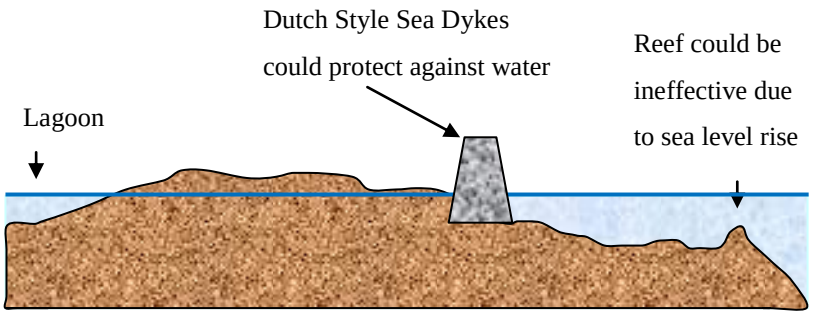
[122] CIA Website, www.cia.gov website, retrieved on 19 Feb 2009.
[123] Bird and Prescott cited by Stoutenburg, J.Grote, "Implementing a New Regine of Stable Maritime Zones to Ensire the (Economic) Survival of Small Island States Threatened by Sea-Level Rise"(2011) 26 pp.263-311, The International Journal of Marine and Coastal Law,p.277.

kill the trees and crops.[124] This would raise the question once more of what is an inhabitable island, as discussed in previous sections.

Eventually, as the sea level continues to increase, the defence works could create a situation where the islands would be at a lower level than the surrounding sea, similar to that of the polders in the Netherlands. Although the sovereignty of the Netherlands over these areas is not questioned (and indeed during the centuries over 3,000 polders have been created), the polders in the Netherlands contain farmable lands that rely on a complicated system of waterworks.[125] The hypothetical "polder-like" atoll island would in the best of cases be a barren piece of land due to the high salinity of the water under 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. This is probably far from economical, and the consequences to the sovereignty of the island would be similar to those of Scenario II, as discussed previously.

In summary, it appears that although the construction of coastal dykes could extend the time that humans could continue inhabiting the islands, progressively more and more food would have to be imported.[126] Essentially, this scenario would become increasingly similar to that outlined in Scenario II (that of a barren rock).

Figure 13: Scenario IV

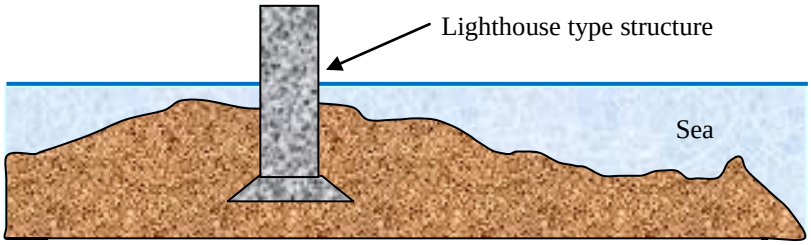


[124] Rakova, U. How-to guide for environmental refugees. Ourworld 2.0. http://ourworld.unu.edu/en/how-to-guide-for-environmental-refugees/. Retrieved 23rd August 2009
[125] Wikipedia, http://en.wikipedia.org/wiki/Polder, Retrieved on 19th Feb 2009.
[126] Rakova, U. How-to guide for environmental refugees. Ourworld 2.0. http://ourworld.unu.edu/en/how-to-guide-for-environmental-refugees/. Retrieved 23rd August 2009

4.5 Scenario V: Lighthouse

With the islands completely submerged, a tall structure, such as a lighthouse could be built to keep a claim on the adjacent waters (this corresponds to the "sovereignty marker" Scenario proposed by Yamamoto and Esteban, though it is unlikely that such a structure can really assert sovereignty over an area, as discussed below).[127] This structure would be populated by a few people, such as maintenance personnel or weather observers.

Figure 14: Scenario V



This would inevitably be a very costly structure and could prevent the island from being classified as a barren rock under Art. 121 (3) of UNCLOS, though its effectiveness to claim ownership on the surrounding seas would probably be limited. It is unclear whether these people could be considered as a population, as it would also be necessary for the islands to have an "economic life of their own".[128] However, it is unlikely that a small Island State would be able to fund a sufficiently large structure to house over 50 individuals.[129] Moreover, in the preliminary work on the Convention on the Law of the Sea III, military and governmental facilities do not fulfil the requirement of economic life, and hence it is unlikely they would prevent the island from being re-classified as a rock.[130]

[127] Yamamoto, L. and Esteban, M. (2009), "Sovereignty issues of the disappearance of Island States", Ocean & Coastal Management Journal. Doi:10.1016.

[128] The number of people to inhabit an island was already discussed by J. Van Dyke and J. Gurish, The Exclusive Economic Zone of the Northwestern Hawaian Islands: When Do Uninhabited Islands Generate an EEZ?. 25 San Diego Law Review, 425-494 (1988). In their definition, human inhabitation would be the capacity of living on the island on the basis of the natural resources of the island, in a stable community which is an institutionalized human group without external assistance. In this "stable" community 5 people would be considered few, but if there were 50 people it would be enough for it to be classified as inhabited.

[129]Yamamoto, L. and Esteban, M. (2009), "Sovereignty issues of the disappearance of Island States", Ocean & Coastal Management Journal. Doi:10.1016.

[130] Y. Kagami, Sustainable development as catalytic agent- Art. 121(3): the attempt of Okinotorishima's recovery. Relatory on the revitalization of Okinotorishima, Ocean policy research foundation,2005. Original in Japanese 「持続可能な開発のための触媒としての国連海洋法条約第 121 条 3 項：沖ノ鳥島再生への一試論」『沖ノ鳥島再生に関する調査研究』(海洋政策研究財団、平成 18 年).

In a solution that is not exclusively related to the protection of sovereignty, but of baselines, Hayashi suggests the construction of lighthouses on low-tide elevations in order to use them as basepoints, or by interpreting the provision on unstable coasts to draw straight baselines between them.[131] These baselines would not change after being drawn and publicized, independent of whether the low water lines moved or not.

4.6 Scenario VI: Houses on Piles or Stilts

Another possibility for the case of an island where the coral reefs fail to keep up with sea level rise is for the inhabitants to start building houses on piles or stilts. In this case the houses would still be above sea level, in a way not too dissimilar to the houses in Venice or to popular tourist resorts in the Maldives (see Figure 15). The Motuans of Papua New Guinea also live on houses built on stilts over the sea, which are made from wood and typically last for 20 to 30 years. These houses are typically 3.5 to 4m above sea level, and hence the houses are not flooded even during high tides. From an engineering point of view this kind of technology is not too expensive, and creating higher piles to cope with increases in sea level would not present an excessive challenge, especially if modern building materials were to be employed (see Figure 16). Progressive increases in water depth will, however, result in higher waves in the area behind the fringing reef, though this is also unlikely to pose a serious engineering problem. The issue of securing adequate food supplies is far more important, as a species shift from corals to macroalgae could severely reduce fish stocks, and the lack of land would require most other food to be imported. Nevertheless, the inhabitants could theoretically live off a combination of fishing and tourism.

In this case, where the island is totally submerged and only houses on stilts remain above the sea level, it would be difficult to claim sovereignty over the former territory, since the only element left above the sea level would be an artificial structure. This scenario, however, differs from scenario V in that it would be able to sustain a higher number of people in these elevated housing structures, which could be considered a population. Nevertheless this fact would not be able to support the claim that the area continues to be an island. One of the fundamental principles of the Law of the Sea is that "the land dominates the sea", that is, it is the possession of coastal land which gives the coastal state rights over waters off its coast.[132] For the case of Venice and the Maldives, the water area on which the houses are located is

[131] Hayashi, M. "The Adverse Impacts of Sea Level Rise on the Rights of Islands and Island States over their Surrounding Sea Areas: Procedural Options of International Legal Measures for Mitigating Impacts", Proocedings of International Seminar on Islands and Oceans 2010, January 20-22,2010,p.106.

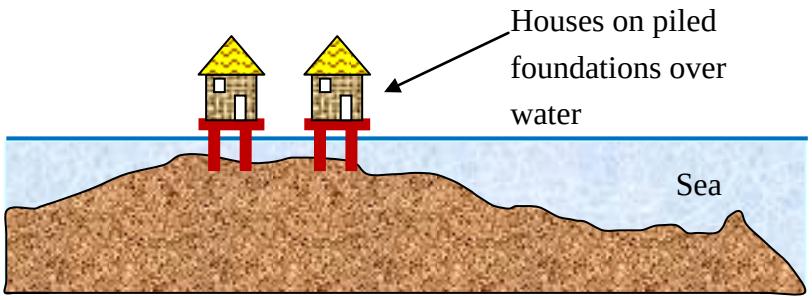
[132] ICJ, North Sea Continental Shelf Cases (Federal Republic of Germany v. Denmark; Federal Republic of Germany v. Netherlands), Judgement of 2 February 1969, at para.96."…since the land is the legal source of the power which a State may exercise over territorial extensions to seaward, it must first be clearly established what features do in fact constitute such extensions."

close to the islands (in the case of Venice it is a coastal lagoon surrounded by land or small islands such as Lido).

This scenario would thus have similar consequences as to that of the lighthouse scenario, essentially not allowing for the preservation of the sovereignty of the Island State.

Figure 15: Many popular tourist resorts in the Maldives are on top of the water, in the proximity of existing islands

Figure 16: Scenario VI



5. The Disappearance of Islands and Sovereignty

The question of what would be the status of an Island State whose entire territory had been submerged (Scenario III) is unclear. This question is essential as it would not only determine

the Island State's ability to continue utilizing the resources which had previously been within its EEZ (such as fisheries) but also from the point of view of preserving the cultural identity of its citizens. Island States are often seen as being all essentially alike, as are their human populations, when they are recognized at all.[133] However, inhabitants of Island States have a strong connection to their islands, and even as some appear resigned to the need to leave their islands, they are hoping to periodically return to them in order to have a connection to their heritage.[134] Their right to dispose of their own wealth would also be violated. Art. 1(2) of the International Covenant on Civil and Political Rights sets forth that "All peoples may, for their own ends, freely dispose of their natural wealth and resources without prejudice to any obligations arising out of international economic co-operation, based upon the principle of mutual benefit, and international law. In no case may a people be deprived of its own means of subsistence." The loss of all the territory would result in the deprivation of a means of subsistence for the population. In addition, the citizens of these countries could also lose their nationality, becoming stateless. The right to nationality is established in Art. 15(1) of the Universal Declaration of Human Rights.[135]

Indeed, it could be argued that Atoll Island States and cultures can never be satisfactorily compensated for the loss of their physical bases.[136] The IPCC notes how the populations on many small islands have "long developed and maintained unique lifestyles, adapted to their natural environment".[137] In fact, the loss of such cultures could not only have consequences for the islanders but would also constitute a loss for the heritage of humanity as a whole.

5.1 Alternative Statehood Solutions

If an island became an uninhabited rock (Scenario II) that is still above sea level, it falls within Art. 121 (3) of UNCLOS and the State which previously laid claim to it would not be entitled to an EEZ, but it would still keep the sovereignty over the rock, as explained in the previous section. Eventually, if the Island State was to physically lose all the islands that make its territory (through a combination of coastal erosion and sea level rise), it would find itself in a situation that has certainly not occurred in modern history.[138] The Island State[139]

[133] Barnett, J, and Campbell, J. "Climate Change and Small Island States: Power, Knowledge and the South Pacific", Published by Eartscan Ltd., ISBN 978-1-84407-494-5.
[134] Rakova, U. How-to guide for environmental refugees. Ourworld 2.0. http://ourworld.unu.edu/en/how-to-guide-for-environmental-refugees/. Retrieved 23rd August 2009.
[135] Barnett, Jon and Adger, W.Neil. Climate dangers and atoll countries in Climate Change 61:321-337. 2003, p. 332.
[136] Barnett, J. and Adger, W.N. Climate Dangers and Atoll Countries. Climatic Change 61:321-227 (2003).
[137] Mimura et al. Small Islands. Climate Change 2007, Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
[138] R. Rayfuse, W(h)ither Tuvalu? International Law and Disappearing States, Uni. Of New South Wales Faculty of Law Research Series, Paper 9, Berkeley Electronic Press (2009).

would probably lose its sovereignty, as normally under international law a State requires a defined territory, as stipulated by the Montevideo Convention.[140] It is interesting to note, however, how Art. 6 of the UN Charter provides that States can only be expelled for persistently breaking the principles of the Charter and after recommendations from the UN Security Council.[141] Thus, it would be up to some countries to stop recognizing these States and breaking-off diplomatic relations, though non-recognition by other UN Member States does not necessarily lead to the expulsion from the UN (such as Turkey not recognizing Cyprus or North Korea and South Korea).[142] Even if most countries decided to break-off diplomatic relations, the government of these Island States could preserve an international status even if no longer classed as a normal State. In fact, the concept of sovereign entities without a territory is already perceived and recognized by some States, such as for example the Sovereign Military Order of St. John of Jerusalem, of Rhodes and of Malta (SMOM), as highlighted in Box 3.

Box 3. The Sovereign Military Order of St. John of Jerusalem, of Rhodes and of Malta (SMOM)

The Sovereign Military Order of St. John of Jerusalem, of Rhodes and of Malta (SMOM) is an ancient religious order currently dedicated to the provision of medical services. Throughout its history it was sovereign over the islands of Rhodes (1310–1528) and then Malta (1530–1798), from which it was ejected by Napoleon in 1798. Up to that date the SMOM was a State, though from then on they still have retained sovereignty under international law, despite not being a State any more.[143] The Papal tribunal added that "the status of the sovereign Order is functional, that is to say, intended to assure the fulfilment of the scope of activities of the Order and its development throughout the world".[144] Also, they still have their own government and issue passports, but detain a personality recognized by particular States only. In a similar way the Papal See was recognized as a State after it was annexed by Italy in 1870, despite possessing no territory, until it was granted sovereignty over the Vatican City by the Lateran Treaties of 1929.[145]

[139] The concept of Island State being referred to here is that of a State formed by one or more small islands, and the problems discussed in this section would be triggered once the last of the islands was submerged.
[140] J. Crawford. The creation of states in international law, Oxford University Press, 2006.
[141] A. Maas and A. Carius. Territorial Integrity and Sovereignty: Climate Change and Security in the Pacific and Beyond. Climate Change and Security Conference, Trondheim, Norway, 21-24th June 2010. http://climsec.prio.no/papers/Paper_Trondheim_PSIDS_CCIS_Maas_Carius_final.pdf.
[142] Ibid.
[143] T. Koivurova International legal avenues to address the plight of victims of climate change: problems and prospectsin J. Environmental Law and Litigation Vol. 22, 267 (2007).
[144] J. Crawford. The creation of states in international law, Oxford University Press, 2006.
[145] R. Rayfuse, W(h)ither Tuvalu? International Law and Disappearing States, Uni. Of New South Wales Faculty of Law Research Series, Paper 9, Berkeley Electronic Press (2009).

The organs of the SMOM are hosted by Italy, and are not subject to taxation, and the Order enjoys sovereign immunity in countries that recognize it. Currently, the Order has formal diplomatic relations with 102 states and missions to some European countries, as well as to European and international organizations.[146]

It is possible that Island States, even after disappearing as countries, could retain some form of "deterritorialised" statehood, having their international personality recognized by other States.[147] They could also, for example, be granted a status of Permanent Observer to the United Nations, as is the case with the SMOM. However, Island States such as Tuvalu and the Maldives are facing the threat of losing their territories not because of a war or occupation, but as a result of rising sea levels caused by climate change, a situation that has never happened before. If they lose their territory they would depend on other States to recognize their international personality, but unlike the SMOM they might not have functions that could be of interest to the rest of the world (such as providing medical services for other countries, as in the case of SMOM). In order to keep an alternative to sovereignty they would also have to rely on other States to host part of their organs of government. It is more likely that States which are geographically closer to them would accept to do so, or it could be reasonable to have the States that were responsible for major emissions of greenhouse gas to share the burden of receiving not only part of the population of these countries, but to also assure the preservation of this special form of statehood. The question that remains is whether the international community would accept this form of statehood.[148]

Also, it is not clear to where the population of the country would emigrate. The question of people who are forced to leave their homes due to the sea level rise has been frequently discussed in literature, and these individuals could be defined as "people fleeing their place of residence because of an environmental stressor regardless of whether or not they cross an international border".[149] However, a detailed discussion as to which countries could share the burden of hosting the inhabitants and institutions of "de-territorialized states" is outside the scope of this paper. Soons suggests that another possibility would be for the State to take over, by treaty of cession, the territory belonging to a different State (for example, by purchasing a

[146] The Sovereign Military Hospitaller Order of Saint John of Jerusalem Official Website, http://www.orderofmalta.org/site/struttura.asp?idlingua=5, accessed on August 1, 2008.
[147] R. Rayfuse, W(h)ither Tuvalu? International Law and Disappearing States, Uni. Of New South Wales Faculty of Law Research Series, Paper 9, Berkeley Electronic Press (2009).
[148] Yamamoto, L. and Esteban, M. (2009), "Sovereignty issues of the disappearance of Island States", Ocean & Coastal Management Journal. Doi:10.1016.
[149] Renaud, F. Bogardi, J.J. Dun, O. Warner, K. "Control, adapt or flee- how to face environmental migration? " Intersections, 'Interdisciplinary Security Connections'Publication Series of UNU-EHS, No.5/2007, Bonn, Germany, p.14.

certain area of land, as in the case of Alaska).[150] Rayfuse cites the precedents for responding to environmental catastrophes. During the 1870s, Icelanders left their country after a volcanic eruption responsible for the destruction of half of the island. They were granted a large piece of land by the Canadian government and their rights as citizens of Canada and Iceland were guaranteed for them and their descendants. Afterwards, New Iceland joined the province of Manitoba and was completely integrated into Canada.[151]

However, currently a treaty of cession does not assure that the acquired territory will be considered to belong to the same State that is purchasing it, as the State that sells the territory may not recognize the portion of land as a territory of the purchasing state. Thus, it is more likely that the state that is ceding the territory will attempt to become a successor of the Island State that was submerged.

Another possibility would be a merger of the Island State with another state, as suggested by Soons and Caron.[152] The consequence of this suggestion, according to Rayfuse, is that pre-existing maritime zones would remain effective, but the zones would belong to the host state. The disappearing states would purchase the new land in the host state by ceding their maritime zones to these states. In addition, the host state would also represent the interests of the relocated population.[153]

Another important question would be which countries should share the burden of responsibility for climate change. The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol give only a partial answer to the issue of responsibility of states for climate damage to other states. In the process of the negotiation of the UNFCCC, industrialized nations emphasized that they would not recognize treaty provisions hinting at state responsibility. This led many of the States that signed the UNFCCC and the Kyoto Protocol to make a declaration that eventually was not in the final document: "(…) signature of the Convention shall in no way constitute a renunciation of any rights under international law concerning state responsibility for the adverse effects of climate change (…)."[154]

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[150] Soons, A.H.A. The effects of a rising sea level on maritime limits and boundaries, NILR 1990, pp.207-232, p.230.
[151] Rayfuse, Rosemary, Whither Tuvalu? International Law and Disappearing States. in University of New South Wales Faculty of Law Research Series, 2009, 8.
[152] Soons, Caron and Rayfuse, "International Law and Disappearing States: Utilising Maritime Entitlements to Overcome the Statehood Dilemma"(2010), University of New South Wales Faculty of Law Research Series, pp.9, at http://law.bepress.com/unswwps/flrps10/art52, access at 20 June 2011.
[153] Rayfuse, R. "International Law and Disappearing States: Utilising Maritime Entitlements to Overcome the Statehood Dilemma"(2010), University of New South Wales Faculty of Law Research Series, p.9, at http://law.bepress.com/unswwps/flrps10/art52, access at 20 June 2011.
[154] Tol, Richard S.J, Verheyen, Roda. State responsibility and compensation for climate change damages- a legal and economic assessment. In Energy Policy 32 (2004) 1109-1130, p.1114.

Despite the limitations that exist in the framework of climate change law, victims are seeking responses using existing international law instruments, such as the case of the Inuit people (see Box 4).

Box 4. The Inuit and the petition at the Inter-American Commission on Human Rights

The Inuit are a group of indigenous people inhabiting Arctic regions of Alaska, Canada and Greenland, who share a similar culture. In 2005, the Inuit of the Arctic regions of the United States and Canada filed a petition at the Inter-American Commission on Human Rights claiming that the United States was responsible for the changes to their environment, violating their fundamental rights.[155] In this case, the petitioners were trying to demonstrate the link between the environmental change and the responsibility of the United States. They claimed that this violated their rights protected in the American Declaration of the Rights and Duties of Man (American Declaration) and referred to the American Convention on Human Rights, International Covenant on Economic, Social, and Cultural Rights, other regional conventions on human rights, and ILO Convention n. 169 on Indigenous and Tribal Peoples. The petitioners claimed violations of the right to life, liberty and personal security (Art. I); the right to residence and movement (Art. VIII); the right to inviolability of the home (Art. IX); the right to the preservation of health and well being (Art. XI); the right to the benefits of culture (Art. XIII); the right to work and fair remuneration (Art. XIV); and the right to property (Art. XXIII) of the Inter-American Declaration of human rights.[156] The Commission is reported to have dismissed the petition technically in December 2006, but held a hearing in Washington DC at which the petitioners made their case on 1 March 2007.[157]

A way of solving the problems that would originate from the disappearance of islands would be to permanently fix ocean boundaries, as the current system of delimiting territorial sea (based on ambulant baselines) might cause conflicts among countries concerning the dispute of ocean resources.[158] Hayashi proposes an amendment to the existing law which would enable Island States to maintain the baseline points that were fixed originally on the island, as

[155] T. Koivurova International legal avenues to address the plight of victims of climate change: problems and prospectsin J. Environmental Law and Litigation Vol. 22, 267 (2007).
[156] Ibid.
[157] P. Rokerick, Climate change in the courts: summary of cases, Environmental Law & Management, 20 (2008)
[158] See D. Caron, When law makes climate change worse: Rethinking the law of baselines in light of a rising sea level, in Ecology Law Quarterly, vol.17:621 (1990) and A. H. A. Soons, The Effects of a Rising Sea Level on Maritime Limits and Boundaries. 37 (2), Netherlands Int. Law Review, 207-232 (1990).

well as the territorial sea, the contiguous zone, the EEZ and the continental shelf. His amendment states:

> a coastal State may declare the baselines established in accordance with the provisions of UNCLOS as permanent once it has shown them on charts of an adequate scale or described them by a list of geographical coordinates, and given due publicity thereto, notwithstanding subsequent changes in geographic features of coasts or islands caused by climate and other natural processes.[159]

In the case where either most of the territory or the whole territory of the island is submerged (with most of the population leaving the islands) but where the baselines are somehow frozen, the successor state would exercise the rights over the submerged islands.[160]

The problem in this case could be agreeing on a specific date on which to fix them, as increases in sea levels have been identified in past decades and it may be difficult to agree on a date when coastlines are sufficiently unaltered by climate change.[161] For example, an island "lost" by Mexico could "re-emerge" under such an agreement.[162]

5.2 Governments-in-Exile and Future Sovereignty Claims

Governments-in-exile have frequently been recognized by their allies as governments of an enemy-occupied State during the course of the conflict and pending its outcome.[163] The possibility exists that in the case of the disappearance of an Island State a government-in-exile could be created, as in the case of the Polish government during World War II. However, governments-in-exile normally exist on the assumption of restoring power in their own country, and until recently have been more connected to situations of international conflicts (Poland and the Baltic Countries during World War II) or national conflicts (Taiwan and China). In World War II, after Germany's invasion, Poland's government-in-exile was constitutionally continuous with the pre-1939 government.[164] After the Yalta and Potsdam Agreements, Poland's population and territory were redistributed and a different

[159] Hayashi, M. The Adverse Impacts of Sea Level Rise on the right of Islands and Island States over their surrounding Sea Areas: Procedural Options of International Legal Measures for Mitigating Impacts. "Proceedings of International Seminar on Island and Oceans 2010, November 29,30, December 1, 2010, pp.103-111, p. 106.
[160] Ibid., 103-111, 107.
[161] A. Maas and A. Carius. Territorial Integrity and Sovereignty: Climate Change and Security in the Pacific and Beyond. Climate Change and Security Conference, Trondheim, Norway, 21-24th June 2010. http://climsec.prio.no/papers/Paper_Trondheim_PSIDS_CCIS_Maas_Carius_final.pdf.
[162] Ibid.
[163] J. Crawford. The creation of states in international law, Oxford University Press, 2006.
[164] J. Crawford. The creation of states in international law, Oxford University Press, 2006.

constitutional system was imposed, though in practice the State remained the same as before 1939.[165]

The difference between an Island State which is about to disappear and a government-in-exile is that while the latter would have the possibility of restoring its power over a determined territory, the former cannot expect to recover its sovereignty over the islands, unless they were to re-emerge again at a later date. This idea of the possible future re-emergence of an island should be viewed in the long-term framework of how climate has changed throughout the life of the planet. The IPCC notes how surface temperature has oscillated for the past few million years following glacial cycles, where mean global temperatures changed by between 4 and 7 degrees Celsius.[166] This in turn has influenced sea level, which rises and lowers according to these variations in temperature. The IPCC adds that "most of the observed increase in global average temperatures since the mid-twentieth century is *very likely* due to the observed increase in anthropogenic greenhouse concentrations".[167]

Current world efforts, centred on the United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol, have not yet managed to halt the global increase in the quantities of greenhouse gases released into the atmosphere. However, possible future treaties, regulations and technological advances to curtail greenhouse gas emissions could result in a stabilization and eventual reduction in greenhouse gas concentrations in the atmosphere. However, even in the case where emissions were reduced, the IPCC points out that even "if actions are taken to reduce the emissions, the fate of the trace gas concentrations will depend on the relative changes not only of emissions but also of its removal processes".[168] This means that it could potentially take a very long time for the Earth to revert to its current condition.

Nevertheless, there is the potential possibility that even if Island States were to disappear, they could eventually re-emerge due to a lowering in future sea levels. Islands could disappear in the twenty-first century, and re-appear centuries later in a time when greenhouse concentrations in the atmosphere revert to current levels. This could actually take a long time, and the IPCC discusses long-term climate change and commitment to the years 2300 and 3000. [169] Though there is a great deal of uncertainty regarding these projections and the assumption on which they are based, they do provide a starting point for how the Earth's

[165] Ibid.
[166] N. L. Bindoff, et. al., Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2007.
[167] Ibid.
[168] Ibid.
[169] Meehl, G.A. et al. Global Climate Projections. In Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the 4th IPCC. Cambridge University Press.

environment could change and then eventually return to its present day conditions. Essentially, the whole Earth climate system exhibits a certain lag due to the thermal inertia of the oceans (meaning that the effect of current increases in CO_2 concentrations will manifest themselves in the future, in the way that the present climate change effects are due to past CO_2 emissions). Also, the process of CO_2 removal from the atmosphere is quite complex, and although more than half of CO_2 emitted is removed within a century, some fraction remains in the atmosphere for millennia.[170] In this sense any CO_2 released at present "commits" us to certain future effects, as yet unfelt. The IPCC discusses how Earth System Models on Intermediate Complexity can be used to extend the projections of their A1B scenario up to the year 3000, where atmospheric conditions would be stabilized by the year 2100.[171] Even though emissions would be reduced to zero at the year 2100 it would take 100 to 400 years (according to different models) for CO_2 concentrations to drop from their maximum range (650 to 700 ppm) to double their pre-industrial level (560 ppm, which is still much higher than the present of around 400 ppm). They report how by 3000 there is a range of warming of between 1.9 and 5.6°C, and how although surface temperatures approach equilibrium quickly the sea level would continue to rise for many centuries.

Although these possibilities and time-scales appear pointless in the mind of the lifetime of individual human beings, several nations on Earth (such as China and Egypt) have a history that spans millennia. Indeed, it could be argued that when Britain asked China for a 99-year lease on what is now called the New Territories, the British Government were not thinking that the lease would one day come up. Eventually, 99 years later the United Kingdom was forced to return Hong Kong to China, highlighting how what appears like a very long time in the mind of a human being is but a chapter in the long history of certain nations. Similarly, territories that are under threat of disappearing could one day re-emerge, and the legal implications of current treaties could be called into effect centuries or millennia later. It should also be emphasized that the scenario described is quite extreme, and although there is some degree of doubt whether CO_2 emissions can be stabilized around the 450 ppm value (a level that is claimed would avoid the worst of climate change), reaching a level of 700 ppm by 2100 appears dramatic considering current international efforts.

The question would be whether the island could be recovered by the old sovereign power or be considered as *terra nullius*. It appears right that if the islands were to emerge again due to a lowering of the sea level they should belong to the descendants of the people who once lived there.[172] This, however, could depend on the continuous existence of a sovereign entity that defends the interests of the people who once lived on the islands, highlighting the

[170] Ibid.
[171] Ibid.
[172] Yamamoto, L. and Esteban, M. (2009), "Sovereignty issues of the disappearance of Island States", Ocean & Coastal Management Journal. Doi:10.1016.

importance of such a hypothetical "government-in-exile", which could have similar functions to the "deterritorialised state" proposed by Rayfuse.[173] This "government" would be elected by registered voters of the "deterritorialised state", and would continue to represent the state at the international level and the rights and interests of its citizens with regards to their new "host" state or states. Upon the eventual re-emergence of the island, the "deterritorialised state" would once again regain its status as a conventional state. The question, however, would be trying to find a country willing to accept this type of "government" and its inhabitants in the meantime.

6. Concluding Remarks

Several Atoll Island States are currently at risk of disappearing due to the combined effects of sea level rise, an increase in ocean acidity and temperature (that could severely damage coral reefs) and the potential for stronger tropical cyclones in the future. The present paper proposes a number of different scenarios of what could happen in the future to these islands, and discusses each of these according to the current Law of the Sea. Different remediation strategies were proposed, in order for these States to attempt to continue claiming Exclusive Economic Zones around them, which could be lost if they became "barren rocks" or disappeared under the sea.

The concept of a "deterritorialised state" is also discussed, which could become a special type of international entity that would allow these States to survive, in some form, the disappearance of their territory. The accordance of such a status could be essential in order to preserve their inhabitants' identity and culture, and major emitters of greenhouse gas could face a moral obligation to protect those communities, as they are very likely to be the ones responsible for the increased pace in sea level rise. Nevertheless, it is more likely that the inhabitants of these islands will migrate to other states and lose their nationality, becoming stateless.

The fact that human habitation and "economic life of its own" are concepts that are not well defined at present is also highlighted. This should be the target of further discussion, as these concepts could become a key element to the preservation of the interests of Island States under the current United Nation Convention on the Law of the Sea (UNCLOS). In fact, it appears that to preserve those interests it would be better to interpret the term "economic life" regarding the activities surrounding the island and not only on it, or to fix the outer limits of maritime zones. This would ensure the ability of Island States to continue exploiting their EEZ for the benefit of their populations, even if these have to migrate to different lands.

[173] R. Rayfuse, W(h)ither Tuvalu? International Law and Disappearing States, Uni. Of New South Wales Faculty of Law Research Series, Paper 9, Berkeley Electronic Press (2009).

Finally, the concept of government-in-exile was also suggested as being complementary to that of the "de-territorialized state", as based on the long term history of the planet, sea levels could eventually go down. This would allow the descendants of the inhabitants of these islands to potentially re-claim the lands that once belonged to their ancestors. Several Island States are currently beginning to evaluate the possible relocation of their population. For example, the Maldives will begin to divert a portion of the country's billion-dollar annual tourist revenue into buying a new homeland.[174] In order to consolidate the voices of small island developing states to address global climate change, 43 States have formed the Alliance of Small Island States (AOSIS). This association is calling for drastic mitigation measures by developed and key developing states, with the aim of establishing short and medium-term targets to limit temperature increases to below 1.5°C.[175]

The present study thus raises a number of important questions regarding the interpretation of the Law of the Sea and the status of Island States in the future. It is important that these questions are inserted into the current talks on climate change and that they be given proper attention in the coming years, as they would have not only consequences for Atoll Island States but also for many other countries that will probably lose land to rising waters. Island States should press for recognition of the consequences that climate change will have on their population, and some of the solutions outlined in this paper could be proposed as remedies to the situation they are facing.

[174] Ramesh, R. Paradise almost lost: Maldives seek to buy a new homeland. The Guardian, 10 November 2008, http://www.guardian.co.uk/environment/2008/nov/10/maldives-climate-change, Retrieved 24th August 2009.
[175] United Nations Press Conference. Press Conference by Alliance of Small Island States on Climate Change. http://www.un.org/News/briefings/docs/2009/090710_AOSIS.doc.htm, Retrieved 24th August 2009.

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