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IAFS 4500

26 April 2022

Human Consequences of Climate Change: Sea-Level Rise and Small Islands

Introduction

According to the United Nations Intergovernmental Panel on Climate Change (IPCC), small island communities are already experiencing severe impacts of climate change and will continue to be among the most affected groups by tropical cyclones, flooding, altered precipitation patterns, biodiversity loss, and sea-level rise (IPCC, 2022). As some of the most vulnerable states to climate change in the world, small islands have already begun to face the realities of a warmer, more extreme climate, which illustrate the severity and gravity of climate change for the rest of the world in real time. Small islands will continue to experience climate change uniquely in some regards due to their notably low-lying and isolated locations, but many of the aforementioned climate impacts also have implications for the human consequences of climate change on coastal communities around the world. Therefore, the challenges encountered by small islands, especially those associated with sea-level rise, are significant in that they will reshape and redefine human migration patterns and laws, international relations, geography, and the survival of island cultures and communities.

This paper will focus on the impacts of sea-level rise on small island communities in the Southern Hemisphere, specifically in the Pacific Ocean, where many of the most vulnerable islands are located. Sea-level rise (SLR) poses a unique risk in that the relatively low elevation and small land areas of islands accelerate land, freshwater, and biodiversity loss as the sea level rises (Veron et al., 2019). This heightened risk is further compounded by flooding from tropical

cyclones, storm surges, and changes in precipitation, making sea-level rise a central factor to consider in the discussion of climate change and small islands. This paper will therefore discuss climate change with an emphasis on how SLR impacts human communities on small islands and their governments' approach to climate adaptation.

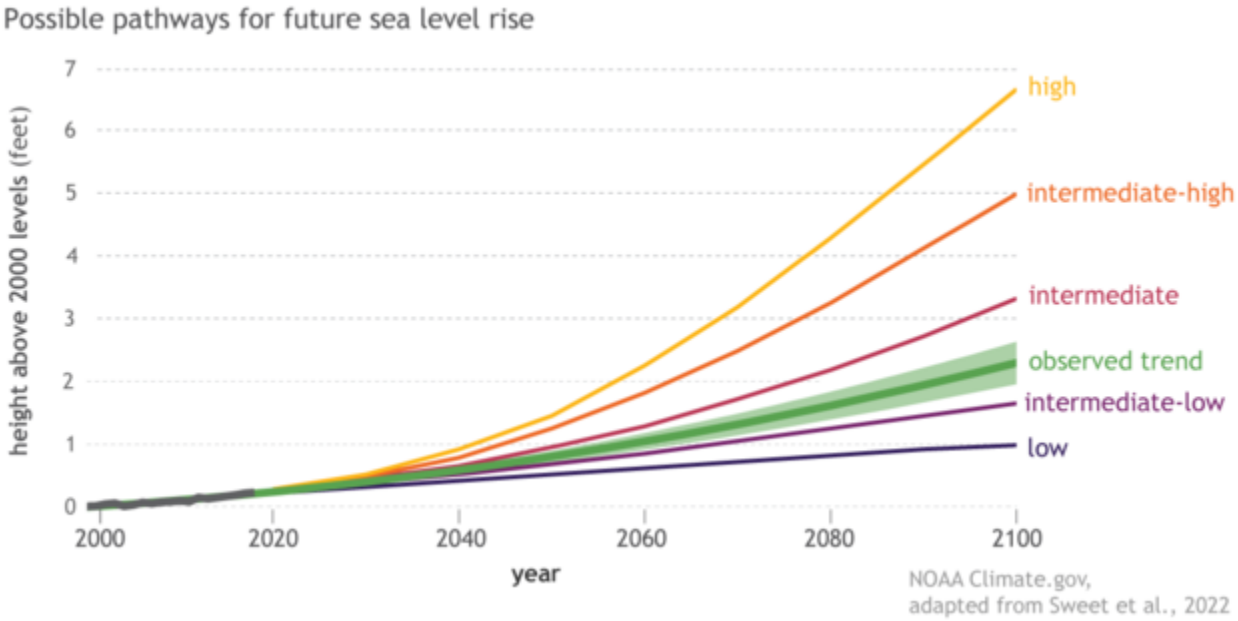
The first section will provide historical context for the trends in SLR caused by climate change, tracing the progression of these issues throughout the last century to the present day and into the future depending on projected emissions pathways. Next, "Human Consequences" will highlight evidence for the importance of small islands in the study of climate change and what exactly these communities stand to lose. This section will also evaluate the adaptation of small islands to climate change by discussing the redefinition of climate refugees and the impacts on the cultures and governments in these regions. Finally, the third major section will evaluate the policy choices and challenges faced by local island governments and communities in response to sea level rise, followed by a brief conclusion outlining the important points of this paper and a general policy suggestion.

Historical Context for Sea Level Rise and Climate Change Impacts on Small Islands

The IPCC Sixth Assessment reports high confidence in the severity of observed impacts of sea-level rise, tropical cyclones, declines in coral abundance, and decreased freshwater supply on small islands, which all describe impacts of climate change related to the inundation of small islands by the surrounding ocean (2021). The relationship between these factors and climate change rests on the confirmed finding that anthropogenic forcing, or the emission of greenhouse gasses by human activity, has been the primary determinant of the global mean sea level since 1970 (Oppenheimer et al., 2014). Global sea surface temperatures have risen 0.8℃ over the past century, melting ice sheets and increasing volume of the ocean due to thermal expansion, leading

to accelerated SLR (Church et al., 2013). As a result, the sea level has risen 21-24 cm since 1880 and will continue to increase due to the rise in global average temperatures. Based on IPCC emission scenarios predicting an increase in 1.1℃ or greater, a sea level rise of 61-132 cm relative to the sea level in 1990 can be reasonably expected by the end of this century following the current trend in emissions (Aral and Guan, 2016). *Graph 1* depicts potential pathways for future SLR based on each emission pathway, and in these projections, NOAA forecasts SLR on the lower end of Aral and Guan's predictions if the world continues to avert the now unlikely "high" emissions pathway (Lindsey, 2020). To conclude, the link between sea level rise over the last century and climate change has been well-established, and future sea level rise is dependent on which emission pathway the international community adheres to in the future.

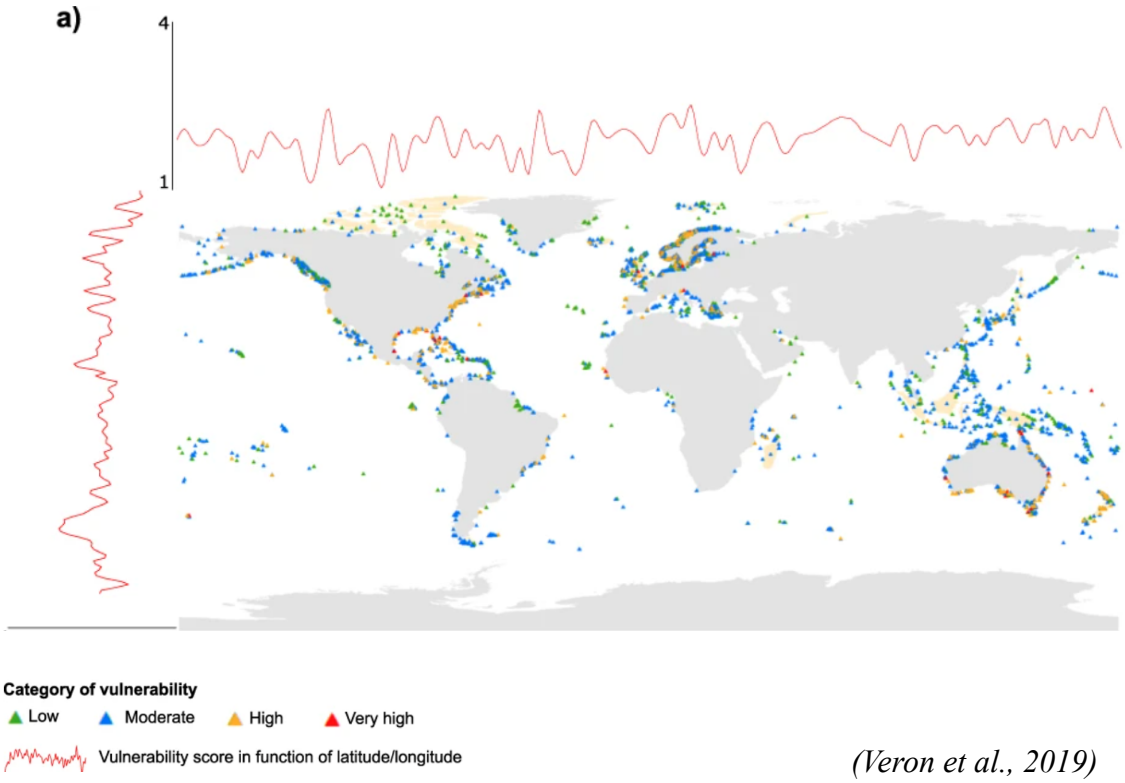
Graph 1: NOAA's Projections for Sea-Level Rise based on Global Warming Pathways



The observed rise in sea level from 2000-2018 is depicted alongside the "low" projection of SLR with a 1.5℃ increase in mean global temperature ranging up to more extreme and unlikely projections following increases of 2.5℃ or greater (Lindsey, 2020).

Both the rate of SLR and aggregate SLR have increased, signaling an increase in danger and urgency for small islands due to their high susceptibility to rising sea levels. Although 90% of coastlines are considered at risk, hot spots for rising sea levels will experience faster rates of SLR and greater negative impacts due to closer proximity of their population and economic assets to sea level, higher rates of land subsidence and/or erosion, and greater exposure to seasonal flooding, natural disasters, and/or El Nino (Becker et al., 2019). Becker et al. identify tropical Pacific islands, such as Tuvalu and the Solomon Islands, as well as the Maldives—with 80% of its land only 1 m above sea level—as hotspots for increased rates of SLR (2019). *Graph 2* depicts the same concept from a similar study evaluating the vulnerability of islands to SLR (Veron et al., 2019). SLR hotspots are also highlighted in the IPCC 6th Assessment, supporting the assertion that small islands suffer from an elevated risk from SLR (2022).

Graph 2: Worldwide Distribution of 5,565 Islands and Vulnerability to Sea Level Rise



(Veron et al., 2019)

Human Consequences of Sea Level Rise on Small Island Communities

Pacific Islander populations face some of the gravest consequences of SLR in the world, namely land loss and inundation of whole islands, which could potentially render many island nations uninhabitable. The projected rise of 2-3 feet (1 meter) as seen in *Graph 2* would likely have these consequences on many island nations by 2100, such as the Maldives and other low-lying atoll islands that rise only one to two meters above sea level (Rubenstein, 2011). Around 2.1 million people inhabit Pacific islands in Melanesia, Micronesia, and Polynesia, and for 3,500 years, these populations benefitted from their abundant access to trade routes and to marine life for food (Nunn, 2013). As a result of centuries of success on the coast, more than half of the population now live within 10 km of the coast with more than 50% of infrastructure supporting these communities located within 500 meters of the coast (IPCC, 2022, 15-24). This places a significant proportion of the population at risk of negative impacts of future sea level rise, especially in island nations with high ratios of coastline to land area.

Loss of Land and State Death

The projected SLR by 2100 would effectively inundate most or all of the Marshall Islands, the Maldives, Kiribati, Fiji, Tuvalu, and the Solomon Islands, to name some of most affected islands whose half million inhabitants occupy land only 1.5-2 meters above sea level (IPCC, 2022, 15-14). Loss of land has been accelerated by sea level rise already over the past century, and population growth among developing Pacific Islands has also increased coastal erosion from land development (Xue, 2005; Nunn, 2013). One of the most remarkable outcomes of such a high degree of land loss to the sea is the expected disappearance of entire countries from the international community. Prior to the study of climate change, the phenomenon of "state death" was previously understood as an old state being replaced by a new state through conquest,

the disintegration of an independent government, or by merging with another state. The loss of a state's entire territory into the ocean and the effects on geography that this entails are unprecedented in modern times. The loss of Pacific island nations would challenge the interpretation of state death under international law as previously defined by the fall of countries like the Soviet Union, forcing the international community to innovate new ways to continue to formally recognize Pacific Islander populations and governments (Ker-Lindsay, 2016). The formation of a new type of state death due to SLR is one example of how the experiences of small islands with climate change have far-reaching, global implications.

Threats to Food Security and Freshwater Abundance

While the death of Pacific island states would not likely occur until much later in the 21st century, rising sea levels throughout this century will have increasingly negative effects on freshwater access and food security among Pacific Islander populations. Freshwater is already considered a scarce resource on these islands due to a heavy reliance on rainwater and groundwater. Climate-driven drought and population growth also place island freshwater supplies at greater risk in the Pacific (de Freitas et al., 2013). However, SLR may trump these other factors by its capability of destroying wetlands and groundwater supplies by contaminating freshwater with saltwater (Terry et al., 2012). In the short term, a 0.4m SLR will have significant effects on freshwater resources in Pacific atolls, and in the long term, an increase in warming of only 1.5℃ would result in 25% less freshwater stress on small islands than warming by 2.0℃ (IPCC, 2022, 15-4). In other words, increases in SLR less than 1 meter will still decrease freshwater abundance on small islands, while larger increases in global warming will further reduce this abundance and threaten the survival of island populations.

SLR also threatens food security within small island communities because rising sea levels increase the salinity of soil and freshwater needed to support crops. Coastal erosion and inundation of land by the sea combine to destroy arable land through salinization or loss of territory (Nunn, 2013; IPCC, 2022). The Pacific region is dominated by subsistence agriculture, and inhabitants of these islands have weathered agricultural losses from droughts and tropical cyclones for decades, facing increased hardship during El Nino years. However, the depletion of fisheries, reliance on low-quality imported food, and an increased production of cash crops have increasingly strained food security on small Pacific islands (Barnett, 2010). Thus, SLR will likely continue to exacerbate existing food shortages in the region. Still, ocean acidification may have a much bigger impact on food insecurity with the destruction of virtually all coral reefs at 2.0℃ warming or greater in small rural Pacific communities where fish protein makes 50-90% of all animal protein (IPCC, 2022, 15-26).

Economic Costs to Small Islands

Many island nations will likely incur large economic costs with the destruction of infrastructure and resources by sea level rise. In 2007, the Maldives, a chain of islands located in the Indian Ocean, sustained damage that cost equivalent to 62% of their GDP from floods and a tsunami, moving the country into the category of least developed countries and displacing 30,000 people (IPCC, 2022, 15-32). While a tsunami differs in magnitude and frequency from SLR, this natural disaster in the Maldives represents a similar type of destruction, economic loss, and displacement to be expected on Pacific islands affected by SLR, but perpetual flooding would not allow these island nations to recover, likely leading to even higher economic costs. While the direct costs of SLR remain difficult to estimate, climate change could cost the Pacific region 2.9%-12.7% of their annual GDP by 2100, and it could continue to roll back economic gains in

the region after 2100 (ADB, 2013). Another loss that presents risks both to the economic productivity and to the unique, natural merits of Pacific islands is the loss of biodiversity with SLR. Small pacific islands have a high number of endemic species, and IPCC warns that SLR poses both direct risks to biodiversity through habitat loss and indirect risks through relocation of human populations into areas dominated by natural ecosystems (IPCC, 2022; Legra, 2008).

Options for Adaptation to Human Consequences of Sea Level Rise

The first option available to island nations in response to sea level rise is the construction of seawalls and other hard coastline structures designed to act as artificial barriers to flooding. Seawalls have proved to be the most popular solution to date, making up 28% of coast protection actions. This solution sidesteps the need to mitigate the root causes of sea level rise, but it poses other long term risks by disrupting natural sediment flows that replenish coastlines and by having catastrophic results on urban areas if these structures fail. Another technological solution is to elevate roads and buildings above the ground/sea level on stilts. However, this only acts as another band-aid solution to SLR and is a costly undertaking for governments of vast island chains (IPCC, 2022, 15-37).

In the event of the disappearance of island states due to SLR, migration may be the last resort for entire Pacific Islander populations. This undesirable outcome would either signal failure at a global scale to mitigate global warming, or it would become an accepted adaptation strategy to the negative impacts of climate change (IPCC, 2022, 15-39). In Kiribati, researchers found that many inhabitants would consider migrating to a new country if the challenges posed by climate change and sea level rise increase (Allgood & McNamara, 2017). Similarly, migrants from the Marshall Islands in the U.S. did not cite climate concerns as primary motivators in their decisions to leave the region, but 62% respondents in this study agreed that climate change

would impact their decision to return to their home country in the future (van der Geest et al., 2020). In general, climate change and sea level rise may increasingly affect migration patterns.

Challenges, Debates, and Choices Faced by Small Island Governments and Communities

The governments and local communities inhabiting small islands in the Pacific would first have to cope with the diversion of resources and revenue away from other needs and into the adaptation methods discussed in the previous section. As lower to middle income states, these economic costs may be more difficult to overcome in comparison to wealthier, larger countries such as the United States. Sea level rise will likely have major implications beyond the individual hardships for each island, challenging the international community to redefine norms and expectations regarding refugees and the permanence of state territories.

One of the major debates centered around sea level rise and its effects on the small Pacific islands is the international recognition of climate refugees. If accepted by the international community, a climate refugee would be identified as a migrant seeking asylum because their country of origin became uninhabitable due to the impacts of climate change (Munoz, 2021). Pacific Islanders could be among the earliest to be recognized as climate refugees by 2050, so those who support the concept of a direct relationship between climate change and migration often use the Pacific islands as evidence. New Zealand recently became the first country to propose creating a new visa for Pacific Islanders forced to migrate due to sea level rise, but the 1951 U.N. Refugee Convention would have to be revised in order to achieve international recognition of climate refugees (Taylor, 2017). However, the term still attracts controversy in its connotations of Western culpability for climate change. This concept would be difficult to institutionalize because refugees must prove that climate primarily motivated their migration as opposed to conflict or droughts only partially related to climate (Munoz, 2021).

Mass migration away from islands or major changes to Pacific Islanders' ways of life based in fishing and subsistence agriculture represent important losses of cultural diversity and indigenous knowledge (Nunn, 2013). Indigenous Micronesians, Melanesians, and Polynesians make up the vast majority of the permanent population in this region. The loss of homes, crops, and traditions to sea level rise will adversely affect these populations by negatively impacting mental health and contributing to identity loss. Pacific Islanders also center many of their traditions around collective ownership of the island and its biodiversity, rendering the loss of their land as particularly damaging in context of their culture and spirituality (McNamara, 2021). With rising sea level, the intangible, non-economic costs are expected to increase, and solutions to these losses are limited if the ocean floods these islands completely by 2100. The creation of artificial islands is one solution to state death, and other options include purchasing new territory to inhabit within another state, merging with other states, or establishing statehood without territory (Ker-Lindsay, 2016). The international community would face the unprecedented challenge of continuing to recognize states without territory in any scenario, and climate change would become central to the global discussion of sovereignty and statehood.

Conclusion

Small islands, especially low-lying island nations located in the Pacific Ocean, will soon begin to encounter direct impacts of climate change through sea level rise. The projected loss of land, freshwater, crops, culture, biodiversity, and even national sovereignty to sea level rise is largely dependent on the emissions pathways adhered to by much wealthier and larger countries. As discussed, the difference between 1.5℃ increase in global average temperature and 2.0℃ will greatly impact the degree of sea level rise throughout this century and beyond. Unfortunately, small island states, which are typically characterized as developing countries, have limited

control over efforts to mitigate climate change because they contribute less than 1% of global emissions (IPCC, 2022). As a result, these countries will likely continue to struggle to reconcile the devastating effects of climate change on their livelihoods with their lack of influence over the international community.

The increasing danger faced by small island states in the wake of global sea level rise, especially by those in hot spots of accelerated SLR, represents an issue of environmental justice in the international community. Pacific islands remain marginalized in the discussion of climate change due to their lack of economic influence and relatively small populations, but it is arguably unjust for these countries to tackle the first major impacts of climate change without support from the wealthier, larger countries responsible for most GHG emissions. Thus, the recommended course of action should extend beyond implementing small-scale adaptation strategies on each individual island, but rather, small islands may need to continue to work together to advocate for the mitigation of climate change through international cooperation. The human consequences of sea level rise fall disproportionately on small islands, and if the international community desires to uphold environmental justice, support for island communities should be central to the international response to climate change in the 21st century.

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