Ocean, climate change and migration

Guigone Camus,
Christine Causse,
Daria Mokhnacheva

Changes in the ocean and the cryosphere play a key role in the Earth's climate. Both the regulation role and services provided by these ecosystems are under threat. The impacts of these changes on ecosystems and human societies are now obvious. They jeopardize the safety of the most exposed populations, especially in coastal areas, on small islands, on mountains and in polar regions, and have economic, social and cultural impacts on all human communities, including those living away from these areas. For the most vulnerable populations, environmental migration can be an answer. Anticipating and adapting to these changes would help to reduce impacts on natural environments and on the communities that depend on them.

OCEAN, CRYOSPHERE AND CLIMATE

The ocean has absorbed 93% of the excess heat as well as nearly a quarter of the CO_2 emissions generated by human activities, thus regulating the climate system and limiting the extent of atmospheric warming. However, the ocean is severely disrupted by these major changes and is gradually getting warmer, more acidic and less oxygenated. These modifications also contribute to sea level rise and increase the frequency of destructive weather events, such as cyclones, spring tides, and ocean heat waves.

The cryosphere is also changing due to an overall reduction in ice cover: ice sheet retreat, sea ice melt and permafrost (permanently frozen land) thawing.

CHALLENGES

All the inhabitants of the planet depend on the ocean and the cryosphere. These natural environments, which are involved in the climate regulation and the water cycle, also support many human activities: food (fisheries and aquaculture), employment, tourism, health, leisure, etc. Fish products account for 20% of the protein intake in the human diet (excluding cereals) and provide a livelihood for tens of millions of people (in 2016, 60 million people worked in the primary sectors of capture fisheries and aquaculture, according to the FAO). Eighty percent of international freight transport is seaborne.

In 2010, 28% of the world's population (1.9 billion people) lived within 100 km of the coast and less than 100 m above sea level, and 11% (680 million people) lived less than 10 m above sea level (a number expected to grow to 1 billion by 2050). Approximately 10% of the world's population (4 million) live in the Arctic or in high mountain regions (670 million people). More than half of the world's population now lives in megacities, many of which are located near the coast.

Low-lying islands and coastal zones (including deltas, wetlands, etc.), from polar to tropical regions, are at the forefront of climate change due to their exposure to extreme events, the vulnerability of the ecosystems

on which they depend for their natural resources, and the increase in pressure from human activities. Lower coastal areas, such as great delta plains, are particularly attractive and the most densely populated areas in the world because of the resources they provide and their access to the sea.

Climate change-related modifications that affect the global ocean and the cryosphere have direct consequences on island and coastal populations, but their repercussions go beyond these regions: the environment, the economy and the social life of many communities can be jeopardized.

Sea level rise, extreme events and the water cycle

Rapid sea level rise and more frequent extreme events are threatening millions of human lives as well as their livelihoods, and they will require multi-billion dollar investments in coastal infrastructure.

Sea level rise accelerated between the mid-20th century and the past few decades.

The ocean is warming up and expanding, thereby increasing its volume. The water inflow resulting from continental ice melt is adding to the problem. From 1994 to 2018, the ocean level increased by 8.5 cm, *i.e.* an average rate of more than 3.5 mm/year. However, this rate varies widely from a region to another. In Southeast Asia, for example, the ocean is rising very rapidly, up to 15 mm/year in some areas. Conversely, it is falling on the Alaskan coasts. This can be explained by the fact that the ocean's heat is unevenly redistributed by ocean circulation. Average sea level rise strongly depends on atmospheric greenhouse gas emission rates. In 2100, this average is estimated to vary between +0.43 m and +0.84 m, depending on the IPCC scenario considered.

This increase in average sea level is causing coastal erosion, a phenomenon that will have significant impacts on all lowlands: in the Arctic (where it is combined with the permafrost thawing and the decline in seasonal sea ice extent), in densely populated coastal cities that concentrate many economic activities, in delta areas and on islands.

Coral atolls are not static lands. They will undergo both erosion and sediment accretion caused by stronger waves. For example, out of 33 coral islands studied in the Solomon Islands, 5 have disappeared and 6 are experiencing severe erosion. In Tuvalu, with an increase in average sea level of about 15 cm between 1971 and 2014, the small islands have decreased in size, while the larger populated islands have maintained or increased their land area, except for Nanumea Island. Out of the 709 islands studied, approximately 73.1% have a stable surface area, 15.5% have an area that has increased and 11.4% have an area that has decreased over the past 40 to 70 years. Nevertheless, the ability of coral islands to maintain their surface area by naturally adjusting to sea level rise could be reduced in the coming decades as a result of the combined effects of higher sea level rise, increased wave strength, and the impacts of ocean warming and acidification on reefs.

In the Arctic, the combined effects of changes in the ocean and the cryosphere will be intertwined. The decrease in seasonal ice cover reduces soil protection and the increase in ground temperature weakens the stability of frozen soils. Currently, 178 Alaskan communities are facing severe coastal erosion and 26 are in a critical situation.

Climate change will also be associated with a higher frequency of high-intensity cyclonic storms. Floods and stronger waves will exacerbate coastal erosion. IPCC projections show that for many coastal areas, extreme events related to rising waters levels (floods) that currently occur every 100 years could occur once a year by the end of the century.

The impacts can affect ecosystems as well as the services they provide to the economy but also the coastal infrastructure, the habitability of the region, the livelihoods of the communities and their cultural and aesthetic values. Coastal facilities (housing, infrastructure, industry, agricultural and aquaculture activities) are particularly vulnerable to these weather events, which can result in the loss of human lives as well as significant economic damage.

In 2015, Cyclone Pam devastated Vanuatu, causing US$449.4 million in damage to a country with a GDP

of US$758 million. In 2017, Cyclone Winston killed 43 people in Fiji and resulted in losses equivalent to one-third of the country's GDP. In 2017, Hurricanes Maria and Irma passed over 15 Caribbean islands and nations, and the cost of total repairs is estimated at US$5 billion. In 2018, Cyclone Gita affected 80% of Tonga's population.

Inland saltwater intrusions as a result of sea level rise and flooding will alter water groundwater (drinking water sources) and irrigation water, reducing arable land and water reserves. Thus, there is therefore growing concern that some Island States may become uninhabitable, with consequences in terms of population resettlement and state sovereignty. Many cases of saltwater intrusion affecting freshwater resources and crops have also been reported in delta areas. It is estimated that approximately 260,000 km² of land was temporarily submerged in the 1990s/2000s. Brackish water intrusions have been observed in the Delaware estuary in the USA, in the Ebro Delta in Spain and in the Mekong Delta in Vietnam. Agriculture, especially rice-growing, can be affected. In Bangladesh, the cultivation of oilseed, sugarcane and jute has ceased. Freshwater fish will lose some of their habitat, thus affecting fishing communities. Other consequences are the salinization of drinking water resources and the spread of cholera virus, as for example in the Ganges Delta.

In addition, changes in the water cycle – *e.g.*, the intensity and frequency of rainfall associated with seawater evaporation – increase the risk of flooding in some regions and drought in others. They affect water resources and promote epidemics. There are therefore increased threats to public health, food security and economic activities (fishing and tourism). Changes in the cryosphere will also have consequences for the safety of mountain communities that depend on glacial meltwater for their supply. Adapting to these phenomena will require the implementation of water regime regulation systems (*e.g.* rainwater and water from glacial melting ice management).

Affected marine biodiversity: what are the impacts on livelihood?

Physical and chemical changes affecting the ocean and the cryosphere will have significant impacts on marine and coastal organisms and ecosystems, which, in turn, will affect the livelihoods of millions of people who depend directly on these ecosystems and the many services they provide.

Ocean warming, acidification and deoxygenation affect benthic and pelagic marine species, large predators, and degrade ecosystems such as reefs, mangroves, coastal marshes, seagrass beds, and kelp forests.

The abundance and distribution area of many species are changing with environmental disruptions. Marine resource availability and abundance are therefore modified. Northward migration of some species, biological events (*e.g.*, breeding) that occur earlier in the season, and a global change in species distribution, are already being observed.

Coastal ecosystems protect coasts from erosion (coral reefs absorb 97% of wave energy) and provide populations with a variety of resources (food, mangrove wood, substances used in traditional medicine, etc.). These ecosystem services will be affected by climate change. The fishing and aquaculture sectors are impacted by marine wildlife migration and the changes in the marine environment. Ocean acidification, for instance, affects phytoplankton, fish larval growth, some mollusks' shell-building process or even the development of coral reefs, which support thousands of marine species.

Migration of vulnerable populations

These environmental phenomena and changes have a direct impact on various aspects of human safety and on the environmental, economic, political and social factors of human migration.

Small Island Developing States (SIDS), whose economies are closely linked to fisheries and tourism, are among the most vulnerable.

The impacts of climate change will exacerbate inequalities, cause population migration, and intensify competition for access to resources, which in turn will increase the risk of conflict, especially for the most vulnerable populations.

Coastal transformation has cultural impacts, particularly on low-lying islands. Studies led in Tuvalu show that, over the past 40 years, climate change has affected population mobility and places of residence and has grouped communities together in the least risky areas. Population relocation affects societal structures, lifestyles and livelihoods, and is accompanied by a loss of cultural heritage and identity.

It is estimated that the sea level rise caused by 2°C global warming by the end of the century would lead to flooding of lands where 280 million people live. While the risks are higher for low-income coastal areas and low-lying islands, this issue also concerns developed countries. In the USA, hurricanes have caused human migration and have had significant economic impacts. These movements of populations linked to extreme events interact with other migration pressures due to environmental and/or economic and political causes.

The combination of adaptation solutions will vary depending on the anticipated and observed impacts, the geographic location of populations, the adaptability of societies, and the establishment of new governance modes. The relocation of communities and economic activities is increasingly seen as an adaptation solution to climate change. However, it is accompanied by discussions on the costs and impacts on the well-being of relocated people. Population migration from coastal areas and lowlands is already underway in many regions: Alaska, Guatemala, Colombia, the Caribbean Islands and Vietnam. In Papua New Guinea, half of the inhabitants of the Carteret Islands are expected to be displaced on Bougainville Island by 2020. Relocations are also in progress on the Solomon Islands, in Alaska, and on the west coast of the USA.

As early as 2014, Fiji also successfully implemented programs to relocate people from some villages (such as Vunidogoloa in Vanua Levu, for example) in the wake of erosion problems. The relocation of populations will become an increasingly significant societal challenge for island and coastal communities.

In parallel, other migration strategies can be implemented. Thus, in many parts of the world, rural populations affected by recurrent hazards migrate on a temporary or seasonal basis. This allows them to make up for temporary income losses and provide for their families through urban or abroad employment.

Some Pacific countries, for example, participate in seasonal labor movement programs set up by New Zealand, Australia or Canada. Although these programs have not been developed directly in response to global warming issues, they could nevertheless benefit populations affected by the impacts of climate change who are seeking to diversify their sources of income through seasonal employment abroad. Other bilateral or regional agreements of this kind could be envisaged in the future to support the populations most affected by the impacts of climate change, particularly in Island States.

Ocean, climate change and human migration: Importance of the IPCC Special Report "Global Warming of 1.5°C"climatique de 1,5 °C »

In October 2018, the IPCC published a Special Report entitled "Global warming of 1.5°C". Echoing the requests already made in 2009 during COP15 in Copenhagen by a group of countries that are among the most vulnerable to climate change, this report owes its existence mainly to the representatives of Small Island Developing States (SIDS), members of the Alliance of Small Island States (AOSIS). In 2015, by the end of COP21, this group of countries had succeeded in having their vulnerability in the face of growing climate threats recognized through the inclusion, in the texts of the Paris Agreement, of three statements that are essential to their future: both SIDS and Least Developed Countries (LDCs) are vulnerable countries; this fact requires financial assistance from developed countries, specifically for adaptation measures; the insecurity they face could decrease if global warming were ? limited to +1.5°C. To endorse this last statement, the SIDS asked the IPCC to issue a Special Report to scientifically prove the relevance of this temperature requirement. It should be recalled that global warming impacts directly and dangerously

the ocean ecosystem surrounding small islands, exacerbating sea level rise, cyclones, storms, and ocean acidification and deoxygenation.

Emphasizing the urgency of a real awareness of the future of the planet in the event of 1.5°C global warming, the IPCC experts have analyzed with unprecedented accuracy the damage we would suffer by 2100 if we do not act to limit the rise in global temperature to 1.5°C compared with the years 1850-1900 (this reference period corresponding to industrial development in western countries, and therefore the beginning of greenhouse gas emissions). This figure, however, should not be seen as the solution to live in a better world, but rather as a remedy for the worst, which will not cure global harm.

Indeed, even if States agreed at the international level to making the necessary mitigation and adaptation efforts needed to achieve this target of 1.5°C, the fact remains that the many regions mentioned in the analysis of the challenges posed by ocean and cryosphere changes would continue to experience increased climate risks. And this even if they are already facing them and become more and more vulnerable.

Let us remember some of the major aspects of this 1.5°C Special Report with regard to migration. At present, and in view of published data, the IPCC is not in a position to accurately assess the level of correlation between increases of 1.5°C, 2°C, or 3°C on the one had, and increasing human mobility on the other hand. This difficulty also stems from the fact that migration depends on many and often interconnected economic, political and social factors that remain extremely complex and specific to each country or population. However, it is clear that migration is closely linked to multidimensional insecurity and poverty, which are strongly correlated with climate change.

It should be noted that, according to this Special Report, an increase in emigration could be statistically correlated with rising temperatures in communities directly dependent on agriculture. In addition, according to a study by the Organization for Economic Co-operation and Development (OECD), an average temperature rise of 1°C would be associated with a 1.9% increase in bilateral migration. In the event of 2°C global warming by the end of the century, significant population movements could occur in tropical regions, over distances exceeding 1,000 km. Among the countries likely to be forced into further climate migration are the SIDS, which actively promoted this report and are at the forefront of climatic threats because of their direct exposure to an increasingly changing and dangerous ocean environment.

This Special Report points out, above all, that compliance with the 1.5°C limit is crucial to a fundamental principle now enshrined in the Paris Agreement, namely the fairness between individuals, nations and generations. It should be recalled that climate change and its harmful consequences impact nations and peoples in very unequal ways. Industrialized countries are the least vulnerable and best equipped to face and adapt to climate change. Conversely, non-industrialized countries, which emit low levels of greenhouse gases, have a much more limited capacity to adapt. However, these economically vulnerable countries are the ones most severely and frequently affected by the most damaging climate disruptions. Inequality of responsibilities, wealth, impacts, and means of protection constitute the ethical backdrop against which IPCC experts call on rich countries to focus their discussions and actions beyond their geographical and political borders and economic concerns – and, indeed, beyond Nationally Determined Contributions (NDCs) alone.

The IPCC therefore claims two global imperatives that resonate with the principle of fairness between individuals, nations and generations: sustainable and global development is now urgently needed to fight not only climate change, but also poverty.