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Environmental Challenges In Low And Medium Islands

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Abstract
Effective management of these environmental issues is essential to ensure the sustainability of island ecosystems and the well-being of the communities that live there. For this, the development of innovative and adapted approaches for environmental management in order to meet the unique needs of these island ecosystems, the establishment of international and regional cooperation, strategic planning focused on climate resilience, initiatives such as the Strengthening infrastructure to better withstand storms, setting up early warning systems, and adopting climate-resilient agricultural practices are more than a necessity.
Nor does vulnerability depend solely on natural pressures, in this case occasional hazards and more gradual changes in environmental conditions. Anthropogenic factors will also play a determining role in the future of the islands and, more broadly, the coasts. Climate change and ocean acidification are real threats, it is irresponsible and dangerous to deny it, the problems of tomorrow are closely linked to current modes of occupying space and exploiting resources. resources that are not sustainable.
This study allowed us to understand the environmental vulnerabilities to which the islands are exposed, therefore, we have developed possible solutions for this purpose.
Keywords: *Environment, Island, Extent, vulnerability.*

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I. Introduction

The environment of small and medium-sized islands in the ocean is a complex subject that encompasses a variety of unique components. These islands, often isolated and far from continents, have unique environmental characteristics that distinguish them from other marine ecosystems. The main components of the environment of small and medium-sized islands in the ocean include geology, topography, climate, marine and terrestrial biodiversity, and human interactions (Spalding et al., 2001; Hopley, 2011).

The geology of small and medium-sized islands in the ocean is often marked by their volcanic or coral origin. These islands may be formed by underwater volcanoes or result from the accumulation of coral reefs. The topography varies greatly between islands, ranging from coastal plains to rugged mountains. Climate is also a distinctive feature, with variations ranging from humid tropical to more temperate climates (Rosemary and Clague, 2009; Sheppard et al., 2017). Marine and terrestrial biodiversity is a major characteristic of these islands. Island ecosystems often support a wide variety of endemic species, adapted to the specific conditions of each island. Human interactions, including tourism, fishing and other economic activities, also have a significant impact on the island environment (Connell and Hughes, 2013). Island environments are influenced by a multitude of geographic, climatic and ecological factors.

Small and medium-sized islands are found in different regions of the world, notably in the Pacific Ocean, the Indian Ocean, the Atlantic Ocean and the Mediterranean Sea. Each of these regions has unique environmental characteristics influenced by a multitude of geographic, climatic and ecological factors and often characterized by fragile and unique ecosystems, which are subject to increasing pressures from population growth, economic development and climate change. as well as similar challenges in terms of nature conservation and natural resource management (Spalding et al., 2007).

II. Environmental Problems And Natural Resource Management Policy In Small And Medium-Sized Islands

Small- and medium-sized islands often face unique environmental challenges due to their small size, geographic isolation, and dependence on natural resources. These islands are often vulnerable to climate change, sea level rise, biodiversity loss, pollution and other environmental problems. These challenges have significant

repercussions on fragile island ecosystems as well as the human communities that reside there. Among the environmental problems identified on small and small islands, we have:

Loss of biodiversity and degradation of the ecosystem

Loss of biodiversity is a major environmental problem for the islands. Due to their limited size, island ecosystems often support large numbers of endemic species that are particularly sensitive to environmental disturbances (MacArthur & Wilson, 2001). Deforestation, overexploitation of natural resources and the introduction of invasive species threaten the survival of many species unique to these islands.

According to the International Union for Conservation of Nature (IUCN) report in 2017, small and medium-sized islands have experienced a significant decline in their biodiversity in recent decades due to factors such as loss of habitat, invasive species and climate change. In its report, the United Nations Environment Program (UNEP) in 2010 highlights that island ecosystems face increasing pressures resulting from urbanization, unsustainable coastal development and overexploitation of natural resources.

Marine pollution

Pollution constitutes a major challenge for small and medium-sized islands. Plastic waste, untreated sewage and chemical pollutants have a detrimental impact on the health of marine and terrestrial ecosystems, as well as human health (Derraik, 2002). Inadequate waste management is a persistent problem in many island communities. According to studies by Weaver & Lawton, (2018) ; Scarsi et al. (2023) tourism can be an important source of income for island economies but they are vulnerable to marine pollution due to their small size, their proximity with coastal areas and their dependence on maritime activities such as fishing and tourism.

Sea level rise and extreme weather events

One of the major environmental problems facing small and medium-sized islands is the consequences of climate change. Scientists have observed increased average temperatures, extreme weather events such as tropical cyclones, and increased ocean acidification in these regions (Birkeland, 2004). These phenomena have devastating effects on marine and coastal ecosystems, as well as on infrastructure and the livelihoods of inhabitants.

Rising sea levels are a critical problem for many small and medium-sized islands. Scientists predict that this trend will accelerate during the 21st century due to the melting of ice caps and glaciers, which directly threatens low-lying lands and inhabited coastal areas (Church & White, 2011). The loss of arable land and the intrusion of salt water into fresh water reserves are direct consequences of this phenomenon. The Intergovernmental Panel on Climate Change (IPCC) in 2018 highlighted in its special report on the impacts of global warming of 1.5°C that small and medium-sized islands face increased risks. such as sea level rise, extreme weather events and ocean acidification.

Ocean acidification

Greenhouse gas pollution has begun to generate, alongside climate change, an increase in the dissolved CO2 content of ocean waters, better known as ocean acidification (Gattuso and Hansson, 2011). Ocean acidification is therefore "the other CO2 problem" (Turley, 2005 ; Doney et al., 2009). The oceans have in fact absorbed around a third of anthropogenic CO2 since the industrial revolution. However, the increase in CO2 in seawater reduces its pH, making it more acidic. Projections for the 21st century predict reductions in the global average pH, which could be 7.8 in 2100 Ciais et al. (2013) compared to 8.18 before the industrial era and 8.10 NOW.

This phenomenon has already, and will continue to have, serious repercussions on the basic chemistry of the ocean, then through a domino effect, on organisms (decrease in calcification in many organisms at skeleton or calcareous shell) and ecosystems (Pörtner et al., 2014, Gattuso et al, 2014a, Howes et al., 2021). Specialists therefore estimate that the consequences of acidification on corals become very significant above an atmospheric CO2 concentration of 500 ppm (Hoegh-Guldberg et Bruno, 2010).

The future vulnerability of small and medium-sized islands to climate and ocean changes will therefore largely depend on the evolution of these four pressure factors (sea level, extreme events, warming and acidification of the ocean).

Thus, the unsustainability of our current modes of development (degradation of marine and coastal ecosystems, disconnection of modern societies from environmental constraints, development of areas exposed to hazards, etc.) is at the heart of the threats. that climate change places on coastlines, particularly islands (Duvat and Magnan, 2014).

Ocean warming

A very large majority of the energy accumulated by the climate system is stored in the ocean, so much so that the first 75 m of water warmed by 0.11 °C per decade between 1971 and 2010 (Rhein et al., 2013). Substantial warming is now also clearly measurable down to at least 750 m depth (Arndt et al., 2010).

The gradual increase in ocean surface temperatures, combined with the occurrence of destructive thermal peaks occurring during El Niño episodes, raises fears of an increase in the frequency of bleaching phenomena, or even their persistence (Hoegh-Guldberg, 2011, Gattuso et al ., 2014b). This could lead to the extinction of many species.

Natural resource management policy in small and medium-sized islands

Natural resource management is a crucial aspect of ensuring environmental sustainability in islands. These islands often face limited resource constraints, such as fresh water availability, fragile soils, extreme weather conditions, and significant economic dependence on agriculture. However, despite these challenges, there are several successful initiatives aimed at promoting sustainable management of natural resources in these specific island contexts (FAO, 2018; UNEP, 2019). According to Altieri and Nicholls, (2020), the implementation of sustainable agricultural techniques such as agroforestry, permaculture, crop rotation, soil conservation and the use of seeds adapted to the local climate aim to improve productivity agricultural while preserving fragile island ecosystems. Initiatives such as establishing protected areas, regulating fishing and promoting eco-tourism can help preserve unique island ecosystems while supporting local livelihoods (Pomeroy and Douvere, 2008). Building local capacity, including agricultural training, access to appropriate technologies and support for smallholder farmers, is crucial to promoting sustainable agriculture in the island context. Likewise, community engagement and public awareness are essential to encourage active participation in the conservation of natural resources (Pretty and Bharucha, 2014).

III. Sources Of Environmental Problems And Their Impacts In Small And Medium-Sized Islands

Small and medium-sized islands, often referred to as small island developing states (SIDS), face unique environmental challenges due to their geography, economy and social structure. These problems are exacerbated by global climate change, local anthropogenic pressure, and the limitations inherent in the management of natural resources in restricted spaces. By analyzing the sources of environmental problems in these regions, several key factors can be identified (Church et al., 2013).

Climate Change

Islands are particularly vulnerable to the effects of climate change, including rising sea levels, increasing water temperatures, and intensifying extreme weather events. Rising sea levels directly threaten the very existence of certain low-lying islands, leading to the loss of habitable and cultivable land as well as the salinization of aquifers. More intense cyclones and hurricanes can cause considerable damage to infrastructure and fragile coastal ecosystems (Church et al., 2013). Small and medium-sized islands are particularly vulnerable to the impacts of climate change due to their geography, economy and ecosystems. The mechanisms by which climate change affects these islands include sea level rise, increased extreme weather events, ocean acidification, and changes in precipitation patterns. These phenomena have profound implications for island communities, their livelihoods, and biodiversity (Becker et al., 2012).

Sea level rise

The rise in sea level is undoubtedly the most publicized consequence of climate change, with catastrophist speeches which, poorly connected to prudent scientific conclusions, announce for some, the imminent disappearance of the most important islands. lowlands (particularly the Maldives, Kiribati and Tuvalu) and for the others, the submersion of the coastal plains which concentrate populations and economic activities.

While such assertions must be qualified, because the responses of island systems to climatic pressures will necessarily be diversified, one thing is certain: sea levels have been rising for more than a century due to original climate change. anthropogenic. For what? Because the increase in the temperature of the lower layers of the atmosphere causes, on the one hand, the warming of surface ocean waters, which has the effect of their expansion, and on the other hand, the melting of continental ice (mountain glaciers, Arctic and Antarctic ice caps). Combined, these two mechanisms result in an increase in the volume of water in the ocean, which tends to "overflow" in some way. The rate of sea level rise was 17 cm on average across the globe over the entire 20th century, or around 1.7 mm/year (Church et al., 2013).

Recent scientific work highlights two elements. First, the fact that the ocean does not rise everywhere at the same speed: the eastern Indian Ocean and the central Pacific, in particular, are experiencing particularly high rates of rise, with values reaching for example + 5 mm/year in Funafuti (Tuvalu) (Becker et al., 2012). Secondly, the scientific community recalls that sea level rise, which has accelerated since the early 1990s, will continue to do so over the coming century.

Intensification of extreme weather events

Although our understanding of the interactions between the ocean and the atmosphere is partial and limits our ability to model certain climatic phenomena, and therefore to make projections on the evolution of extreme phenomena (storms and El Niño phenomenon), we must expect the pressures they exert on small islands to increase. Tropical cyclones have greater power than temperate depressions, with wind speeds that can exceed 350 km/h.

Cyclonic waves, which frequently reach 4 to 6 m in height at the coast, can also be the cause of marked erosion peaks (retreat of the coastline by 10 to 15 m, lowering of the level of the fores). or, on the contrary, a strong enrichment of the coasts due to the accumulation of sand and blocks of coral torn from the coral reef (Étienne, 2012). If, given the complexity of the processes involved, it is difficult at this stage to say how cyclones, and therefore their impacts on small islands, will evolve under the effect of climate change, we can nevertheless remember, on the basis of the latest IPCC report, that: (i) their frequency will not necessarily increase in the future; (ii) the most intense cyclones are expected to intensify; (iii) the trajectories, therefore the impact areas of cyclones, have a high probability of changing in the future.

Par ailleurs, l'évolution des tempêtes des zones tempérées (nord et sud) et des hautes latitudes, qui reste difficile à prévoir, aura aussi des impacts sur l'évolution des risques liés à la mer en milieu insulaire. En effet, il est désormais clairement établi que les houles puissantes que produisent ces tempêtes se propagent sur de grandes distances à travers l'océan et causent des dégâts importants sur des territoires insulaires éloignés de plusieurs milliers de kilomètres de leur zone de formation (Nurse *et al.*, 2014). Celles de décembre 2008 en particulier ont engendré d'importants dégâts dans de nombreux États du Pacifique occidental, comme la république des Îles Marshall, les États Fédérés de Micronésie et la Papouasie-Nouvelle Guinée (Hoeke *et al.*, 2013).

Agricultural Runoff

Islands with intensive agricultural activities may experience significant pollution of their water resources due to runoff. Pesticides, herbicides, and chemical fertilizers can flow from agricultural land into waterways, leading to eutrophication and degradation of water quality (Étienne, 2012).

Plastic and Marine Waste

Islands are particularly vulnerable to plastic pollution due to their proximity to the ocean. Plastic waste can come from tourist activities, fishing, or be carried by sea currents. This waste harms marine life and can contaminate food chains (Hoeke *et al.*, 2013).

Untreated Wastewater

In many small and medium-sized islands, wastewater treatment may be insufficient or non-existent. Direct discharge of domestic or industrial wastewater into the environment can result in contamination with pathogens, excessive nutrients, and hazardous chemicals (Rankey, 2011).

Impacts of sources of environmental problems

Small and medium-sized islands are often faced with environmental problems which have significant consequences on their ecosystem, their economy and their population. These islands are often characterized by unique biodiversity and fragile ecosystems, making them particularly vulnerable to the effects of environmental change. The consequences of environmental problems on these islands can be devastating and have a long-term impact on the lives of residents and the health of the environment (Smith and Johnson, 2020).

The most common environmental problems facing small and medium-sized islands include rising sea levels due to climate change, loss of biodiversity, coral reef degradation, marine pollution, overexploitation of natural resources, and natural disasters such as hurricanes and tsunamis. These problems have a direct impact on the daily lives of the inhabitants of these islands, as well as their economy which often depends on tourism, fishing and agriculture (Smith and Johnson, 2020). Rising sea levels are one of the most pressing problems for many small and medium-sized islands. Rising sea levels directly threaten the long-term viability of many low-lying Pacific islands, jeopardizing not only coastal infrastructure but also freshwater supplies, according to a recent study published in the scientific journal Nature. for residents (Smith and Johnson, 2020).

IV. Impacts And Vulnerabilities Of Small And Medium-Sized Islands In The Future

Climate models do not yet provide precise evolution scenarios at the scale of the different oceanic sub-regions, the projections we have, supplemented by the understanding we have of the responses of island systems to different types of natural pressures and anthropogenic, making it possible to determine the main impacts.

Reduction in the surface area of the islands and the retreat of the coastline

The behavior of coral reefs will play a determining role in the response of many small and medium-sized islands to the effects of climate change. However, the future of reefs itself depends on the combination of various factors, the main ones being the rate of rise in sea level, the temperature of surface ocean waters, the rate of acidification of ocean waters. , the current vitality of corals and their ability to resist disturbance, and the degree to which their resilience is weakened by human activities (Gattuso et al., 2014b).

In the same way, on the coastal fringe of the high islands, the lowlands will gradually be taken over by the sea where no accretion phenomenon will cause their elevation or their extension towards the sea. Unless technical interventions, such as embankment works, prevent this and make it possible to maintain these spaces above sea level (Nurse *et al.*, 2014).

Récifs coralliens menacés

The behavior of coral reefs will play a determining role in the response of many small and medium-sized islands to the effects of climate change. However, the future of reefs itself depends on the combination of various factors, the main ones being the rate of rise in sea level, the temperature of surface ocean waters, the rate of acidification of ocean waters. , the current vitality of corals and their ability to resist disturbance, and the degree to which their resilience is weakened by human activities (Gattuso et al., 2014b).

The rates of sea level rise predicted for the coming decades theoretically allow corals to compensate for the rise in ocean level by their growth, because they can grow by 10 to 25 mm/year. During the last rise in sea level, the vast majority of reefs followed step by step (continuous growth) or after a delay (delayed growth) the rise in ocean level. But these various elements remain theoretical, because in reality, the behavior of corals will depend on the ecological conditions which reign in the different oceanic regions.

Future of mangroves

Mangroves play just as important a role as coral reefs in maintaining low-lying islands and sandy coasts, and in protecting human concerns from storms. Where mangroves have not been cleared and where the mudflats they colonize continue to be supplied with sediment, these coastal forests generally continue to expand. In many atolls, on the lagoon side, we observe, for example, an extension of the mangrove as a result of the colonization of sandy-muddy banks by young mangrove trees (Rankey, 2011).

What impacts will climate change have on mangroves? Theoretically, a rise in sea level causes their migration towards the shore, because the different ecological zones which constitute the mudflat themselves tend to migrate in this direction to adapt. But beyond just the rise in sea level, two factors will play a key role: the speed of sedimentation and the level of anthropogenic pressure exerted on this ecosystem. Where conditions are favorable (active sedimentation and reduced anthropogenic pressure), the rise in sea level can be offset by the rise of the shallow seabed. In this scenario, the mangroves are maintained or continue to extend offshore. The most sensitive sectors are therefore undoubtedly those which are already subject to strong erosion, which destroys the mangrove, and/or those in which it is degraded by humans (Wong et al., 2014).

It should be noted from the above that the responses of island systems to the effects of climate change and ocean acidification will not be unambiguous, because they depend on a combination of factors whose assembly and interactions vary in space, including over short distances. Furthermore, the knowledge we have of the capacity of corals and mangroves to adapt to natural pressures is still insufficient to establish a definitive diagnosis. While it is undeniable that reefs will be subject to increased pressures in the future, the results of recent work put the even more pessimistic results of the first studies into perspective.

Case of natural resources

To progress in the chain of impacts of climate change and ocean acidification on human societies, we will focus here on the consequences of physical disturbances on terrestrial resources (soils, water, fauna and flora) and marine (reef and fishery resources) of the low islands and the coastal plains of the high islands (Wong et al., 2014).

On land

Land resources will decrease under the effect of different processes (Nurse et al., 2014 ; Wong et al., 2014). First, the increase in atmospheric temperatures increases evapotranspiration10, which dries the soil and causes an increase in the withdrawals made by plants from the lenses of brackish water. These samples should

not be neglected. Indeed, measurements carried out in the Tarawa atoll (Kiribati) showed that the most widespread tree, the coconut palm, returned at least 150 liters of water per day to the atmosphere through transpiration.

Under these conditions, the foreseeable increase in water pumping by coconut trees and the rest of the vegetation will significantly reinforce the pressure already exerted on these lentils used by man to meet his food needs. The deterioration of soil quality and the reduction in water resources will further reduce the possibilities of cultivation, which will have the effect of a drop in production which will pose, particularly in island food-producing systems, a challenge of food security. This will lead to an increase in external dependence, particularly in the rural atolls of many coral archipelagos. The soils will also degrade under the effect of their salinization, due to the rise in sea level and the increase in marine submersion which will occur in the islands and coastal plains which will not rise.

However, with the exception of the coconut palm, few edible plant species tolerate salt. The coconut trees only tolerate it up to a certain threshold beyond which they die. The contraction of exploited areas, and in particular coconut groves, will also reduce the availability of construction materials. Furthermore, the gradual evolution of island farming practices towards species less resistant to the pressures of climate and marine agents than native species – the banana tree being, for example, less resistant than the pandanus or the coconut palm – risks increase the scale and frequency of food shortages (example of the Maldives following the damage caused by the 2004 tsunami) and trade deficits (case of the West Indies following the passage of Cyclone Dean in 2007) the future (Wong et al., 2014).

At sea

As highlighted in the latest IPCC report Pörtner et al. (2014) ; Hoegh-Guldberg et al. (2014) we currently have little information on the impacts that climate change will have on the distribution of resources. fisheries. The strong pressures already exerted on the coral reefs of the most populated regions will increase wherever population growth remains strong. As different factors contribute to the degradation of the reefs in these regions, the reef resources available per inhabitant will decrease. However, they play an important role in the daily diet of island communities, including on islands where consumption of imported products is high (Nurse *et al.*, 2014).

And this, especially since the possible modification of marine currents could reduce the presence of pelagic species in certain oceanic regions and, thereby, prevent the shift of consumption to these species. It is therefore the fishing sector as a whole which is being questioned, from the resource to the means of fishing (boats, ports, etc.), the latter being furthermore undermined by the rise in sea level, extreme events and other pressure factors (e.g. economic crisis). Of course, to this is added the decrease in fish stocks due to overfishing, which is already severely affecting near the coasts and in the lagoons as well as offshore (Pörtner et al., 2014).

V. Sustainable Agriculture And Natural Resource Management In Developing Small And Medium-Sized Islands

Promoting sustainable agriculture and effective management of natural resources in developing small and medium-sized islands is crucial to ensuring food security, protecting biodiversity and supporting local economies. Several successful initiatives have been implemented across the world, reflecting an adaptive and innovative approach to the unique challenges these islands face. By examining these initiatives, we can identify effective strategies and best practices (Duvat and Magnan, 2014).

Systèmes Agroforestiers à Samoa

Traditional agroforestry systems have been revitalized to promote sustainable agriculture. These systems combine the cultivation of food crops with the conservation of native forest trees, creating a diverse agricultural environment that improves soil fertility, conserves water and increases biodiversity. This approach not only strengthened the resilience of local agricultural systems in the face of climate change but also helped preserve traditional knowledge (Duvat and Magnan, 2014).

Gestion Intégrée des Ressources Naturelles aux Îles Galápagos

The Galapagos Islands are an iconic example of integrated natural resource management, where sustainable agriculture is encouraged among local communities to reduce pressure on sensitive ecosystems. Practices such as organic farming, composting and rainwater harvesting are promoted to minimize environmental impact. Additionally, the Ecuadorian government and various NGOs are working together to support farmers in transitioning to more sustainable methods (Duvat and Magnan, 2014).

Organic Certification Programs

Organic certification programs were established to encourage sustainable agricultural practices. These programs provide training to farmers in organic techniques and provide access to more lucrative markets for their products. By adopting organic methods, farmers can reduce their reliance on chemical fertilizers and pesticides, thereby improving soil health and conserving water resources (Duvat and Magnan, 2014).

Restoration of Mangroves

Mangrove restoration initiatives in the Philippines aim to protect coastal areas while supporting sustainable aquaculture. Mangroves serve as nurseries for many marine species and act as natural barriers against coastal erosion and storms. By replanting degraded mangroves and promoting integrated aquaculture (e.g. fish farming with plant cultivation), these initiatives contribute to both environmental conservation and local economic development (Duvat and Magnan, 2014).

Mitigation measures

The intrinsic characteristics, both physical and anthropogenic, place small and medium-sized islands on the front line of the threats associated with climate change and ocean acidification; their situation poses more universal questions in the sense that, ultimately, most of the world's coastlines are also threatened by extreme weather-marine events and by the progressive deterioration of the living conditions of ecosystems and societies. Small and medium-sized islands therefore do not present such marginal situations as one might think a priori. They are therefore sources of major lessons, three of which emerge from this text (Duvat and Magnan, 2014).

Finally, this means that starting now, on the islands and on the coasts in general, proactive policies for the redevelopment of territories, protection of the environment and modification of the relationship between societies and their economies to marine and coastal resources, constitutes a major step towards adaptation to climate change and ocean acidification. The identification of anthropogenic pressure factors, which are acting today, ultimately provides keys to thinking about and starting to implement adaptation to environmental changes (Magnan, 2013).

VI. Conclusion

Today, despite the existence of policies aimed at alleviating environmental problems on small and medium-sized islands, it must be recognized that profound consequences exist and persist on their natural environment, their economy and their population.

It emerges from this observation that small and medium-sized islands, due to their limited size, their geographical isolation and their limited resources, are faced with environmental problems of various nature and origin. Among these problems are: Biodiversity loss and ecosystem degradation, marine pollution, sea level rise and extreme weather events, ocean acidification, global warming ocean, deforestation and land degradation, coastal erosion. These problems are mainly caused by climate change, plastic and marine waste, tourism activities, overuse of water resources, unsustainable agricultural practices, open burning, transport, sewage and overfishing.

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VIII. Conflicts Of Interest

This article does not present any conflict of interest, to this end, the authors consent to it being published in this journal.

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