ACROSS
Journal of Interdisciplinary Cross-Border Studies
Vol 9, No.8, 2025
Sustaining Life: Contemporary Issues in Environmental Protection

THE IMPACT OF CLIMATE CHANGE ON AQUATIC ECOSYSTEMS

Aurelia NICA [1,2], Stefan PETREA[1,3], Isabelle METAXA[1,2], Alina ANTACHE[1,3], Ira SIMIONOV[1]

[1]Food Science, Food Engineering, Biotechnology and Aquaculture Department, Food Science and Engineering Faculty, „Dunărea de Jos" University of Galati, Domnească Street, no. 47, Galați – 800008, Romania

2 MoRAS Center, 800008, Galaţi, Romania

[3] "REXDAN Center, „Dunărea de Jos" University of Galati, Domnească Street, no. 47, Galați – 800008, Romania

[*]Corresponding author*:* Isabelle.Metaxa@ugal.ro

Received on 13 October 2025
Accepted on 24 November 2025

Abstract

Climate change profoundly impacts aquatic ecosystems, both marine and freshwater, disrupting their ecological balance and functions. The rise in global temperature influences species distribution, alters the metabolism of aquatic organisms, and lowers dissolved oxygen levels, thereby promoting the development of hypoxic zones. A significant consequence is ocean acidification, driven by the excessive absorption of atmospheric CO_2. This process harms calcifying organisms such as corals and molluscs, weakening their structures and disrupting marine food chains. Coral reefs, vital ecosystems for biodiversity, are rapidly declining, impacting the human communities that rely on them. Accelerated glacier melting is changing salinity and ocean circulation patterns, affecting nutrient cycles and coastal marine habitats. Simultaneously, alterations in precipitation patterns and the increasing frequency of droughts affect freshwater systems, leading to reduced flow, eutrophication, and pollution, thereby negatively affecting biodiversity and water quality. Beyond ecological effects, climate change carries significant socio-economic repercussions, influencing fisheries, tourism, water supply, and food security. It is crucial to implement integrated adaptation and conservation strategies, grounded in scientific research, to protect these vulnerable ecosystems and the essential services they provide. Aquatic ecosystems provide vital services, including food, drinking water, climate regulation, and protection against natural disasters.

Keywords: climate change, impact, ecosystems, aquatic

Introduction

Climate change is one of the most pressing environmental issues of the present, with systemic effects on global ecospheres. Climate change occurs regularly on an annual and millennial time scale. A significant threat to the natural environment is the very high rates of this type of change observed in recent years. These changes threaten the freshwater environment when coupled with various other human pressures. All types of Earth's ecosystems are seriously threatened by climate change. Due to its global distribution, isolation, and physical deterioration, as well as its classification in the regulatory framework

for goods and services, freshwater is particularly susceptible to the effects of climate change (Woodward, 2009). Furthermore, only 0.8% of Earth's surface is covered by freshwater, which supports 6% of all species, endangering freshwater biodiversity worldwide (Dudgeon et al., 2006).

Aquatic ecosystems – including freshwater (rivers, lakes, wetlands) and marine (seas, oceans, coral reefs) – are among the most vulnerable to these transformations. Changes in physicochemical parameters, such as temperature, salinity, pH and dissolved oxygen levels, influence the ecological balance, trophic interactions, and resilience of aquatic biocenoses (Klein, S. G., 2024). In this context, an interdisciplinary analysis of the impacts of climate change on these ecosystems is vital to understanding the ecological risks and long-term socio-economic consequences. The direct effects of climate change include warming waters and their ecological and biological consequences, ocean acidification and the collapse of reef systems, melting ice caps, shifts in salinity and ocean currents, precipitation variability, freshwater scarcity, as well as socio-economic implications and the necessity of an integrated response. This review emphasises these significant climate change-induced disruptions to aquatic ecosystems, with complex ecological, economic, and societal implications.

Materials and methods

To conduct this review, a series of specialised articles in this field that address the mentioned subject were consulted. Most of the studies are recent, but some older ones, which are representative in this field, were also considered. The scientific works we discussed are indexed in the GS database; 55.15% of these works are also indexed in the Web of Science (WOS) database, and another 28.71% are indexed in Scopus. In the WOS database, there are the red zone, yellow zone, and white zone. According to our data, the percentages are: 43.21% in the red zone, 16.12% in the yellow zone, and 40.67% in the white zone.

We believe that the best results are achieved when multiple research methods, both electronic and manual, compete to reach the desired outcome. To provide a comprehensive answer, we considered an extended period from 2006 to 2025. The three areas (red, yellow, and white) were well visible before the articles were published. The articles were searched using keywords related to the topic. I focused on review articles and high-impact empirical studies (Nature, PNAS, Annual Review, IPCC syntheses) published since 2022, along with some widely cited empirical studies from 2023 to 2025 on marine heatwaves and coral responses.

Results and discussion

1. Warming waters and ecobiological consequences.

One of the most direct manifestations of climate change is the increase in global temperature, with apparent implications for water bodies (Perry, C. T., et al. 2025). Studies show that the average ocean temperature has increased significantly in recent decades, affecting:

- physiology and species distribution: high temperatures accelerate the metabolism of ectothermic organisms, influencing reproductive rate, oxygen consumption, and longevity.

- community structure: stenothermal species are gradually replaced by eurythermal ones, more tolerant to thermal variations, which alters interspecific relationships.
- thermal stress and hypoxia: the reduction in oxygen solubility in water particularly affects pelagic and benthic areas, leading to massive mortality among ichthyofauna.

2. Ocean acidification and the collapse of reef systems (fig.1)

The increase in atmospheric CO_2 concentration is directly correlated with ocean acidification, a phenomenon with a severe impact on biogeochemical processes and marine biodiversity (Dobson, K. L., et al., 2024).

- carbonation reactions are inhibited, affecting calcifying organisms (corals, bivalves, echinoderms), which lose their ability to form hard structures.
- coral reefs, key ecosystems in maintaining marine biodiversity, are threatened by the phenomenon of coral bleaching (Marcos, M., et al. (2025) and the reduction of their regeneration capacity.

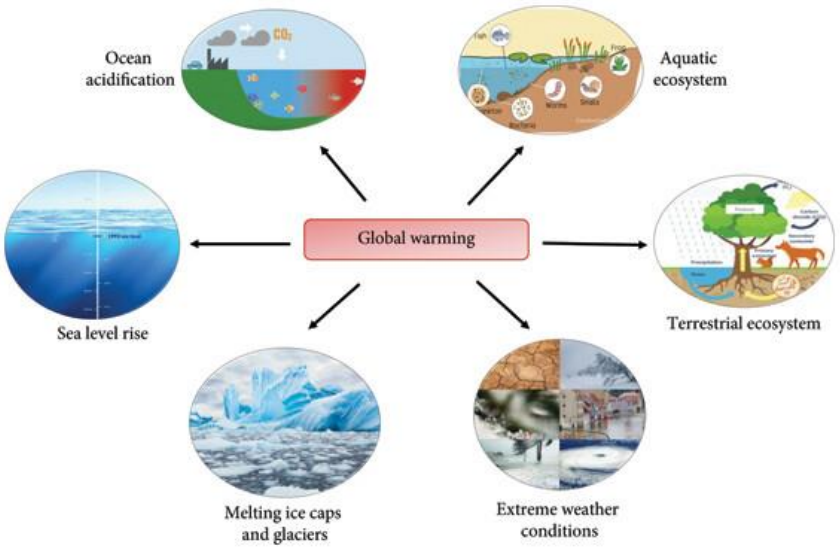

Figure 1. The effects of climate change on aquatic ecosystems (after Agarwal et al., 2024)

- marine food chains become unstable as the base organisms (calcifying phytoplankton) are directly affected (Olson, E. M., et al., 2025), and this impact propagates to higher trophic levels.

3. Melting ice caps, salinity and ocean currents.

The accelerated melting of glaciers and polar ice caps, driven by global warming, contributes significantly to sea level rise and hydrological changes (Trégarot, E., et al., 2024):

- Saline dilution causes changes in water density and, implicitly, in the structure of ocean currents, affecting the global thermohaline circulation.
- The entry of freshwater into estuarine systems abruptly alters the osmotic balance of organisms, endangering specialized species.
- The impact on thermal regime and nutrient cycles influences marine primary productivity, with cascading effects on the entire ecosystem.

4. Precipitation variability and freshwater stress

- Fluctuating river and lake flows lead to habitat fragmentation, loss of ecological connectivity, and the emergence of hypoxic zones.
- Eutrophication, accelerated by high nutrient input from agriculture combined with high temperatures, generates massive blooms of toxic algae (Thirukanthan, C.S., et al., 2023).
- Water quality is compromised, especially in regions where treatment infrastructure is deficient, amplifying risks to public health and aquatic ecosystems. Approximately 137 species of temperature-sensitive plants, animals, and invertebrates are disappearing daily due to global warming (Table 1).

Table 1. Aquatic species threatened with extinction.

No	Species	Type (animal/ plant)	Main Geographic Area	Effect of Climate Change	Current Status
1.	Staghorn coral (*Acropora cervicornis*)	Marine animal (coral)	Tropical Atlantic Ocean	Ocean warming – massive cora bleaching	Critically Endangered
2.	Brain coral (*Diploria labyrinthiformis*)	Marine animal (coral)	Caribbean Sea	Ocean acidification → loss of calcium skeleton	Vulnerable
3.	Emperor penguin (*Aptenodytes forsteri*)	Marine bird	Antarctica	Ice loss → loss of breeding habitat	Vulnerable
4.	Clownfish (*Amphiprion ocellaris*)	Marine fish	Indian and Pacific Oceans	Ocean acidification → loss of sea anemone habitat	Declining
5.	Green sea turtle (*Chelonia mydas*)	Marine reptile	Tropics, coral reefs	Rising sand temperature affects hatchling sex ratio	Endangered

6.	Ringed seal (*Pusa hispida*)	Marine mammal	Arctic Ocean	Melting ice → loss of birthing platforms	Vulnerable
7.	Atlantic cod (*Gadus morhua*)	Marine fish	North Atlantic	Warming waters → migration northward, population decline	Declining
8.	Short-snouted seahorse (*Hippocampus hippocampus*)	Marine fish	Mediterranean, Eastern Atlantic	Changing currents and habitat loss	Vulnerable
9.	Atlantic salmon (*Salmo salar*)	Freshwater / marine fish	North Atlantic, European rivers	Warmer water affects reproduction and migration	Declining
10.	Giant clam (*Tridacna gigas*)	Marine mollusk	Tropical Pacific Ocean	Coral bleaching → loss of symbiotic algae	Critically Endangered
11.	Leopard seal (*Hydrurga leptonyx*)	Marine mammal	Antarctica	Ice retreat → loss of hunting grounds	Vulnerable
12.	Amazon river dolphin (*Inia geoffrensis*)	Freshwater mammal	Amazon Basin	Lower water levels and thermal pollution	Endangered
13.	Golden jellyfish (*Mastigias papua etpisoni*)	Marine animal	Marine lakes of Palau	Changes in salinity and temperature	Declining
14.	Emperor angelfish (*Pomacanthus imperator*)	Marine fish	Tropical coral reefs	Habitat destruction due to coral loss	Declining
15.	Mediterranean monk seal (*Monachus monachus*)	Marine mammal	Mediterranean Sea	Rising sea temperature and coastal disturbance	Critically Endangered

5. Socio-economic implications and the need for an integrated response.

Aquatic ecosystems provide essential ecosystem services – from food and drinking water, to climate regulation and protection against natural disasters (Wernberg, T., et al. (2024). Their degradation has direct consequences:

- Food insecurity: Declining catches from commercial fisheries are affecting nutritional security in coastal regions.
- Climate migration: communities in low-lying or drought-affected areas may be forced to relocate, amplifying geopolitical and social tensions.

Conclusions

Climate change is generating profound disruptions to aquatic ecosystems, with complex implications at the ecological, economic and societal levels. Their degradation is not only an environmental problem, but also a global security problem. Coral reefs face severe, short-term risks from warming and acidification; systematic syntheses show large uncertainty in projections but consistent trends toward major decline unless warming is limited. Keystone species (seaweed, seagrass, corals, mangroves) are altered in abundance, distribution and function, with cascading effects on biodiversity and ecosystem services.

It is imperative to implement policies based on scientific evidence, integrating biodiversity conservation, climate change adaptation and sustainable use of aquatic resources. In the absence of coherent and immediate action, the risk of ecological collapse is becoming increasingly real.

Acknowledgments

This work was supported by the Centre for Scientific Research “Romania Centre for Modelling of Recirculating Aquaculture Systems” (MoRAS), from the University Dunărea de Jos, of Galați, which was established as a result of the implementation of the POSCCE project 622/ 11.03.2014.

1. Agarwal, Deepak, Shanmugam, Seerappalli Aran, Kathirvelpandian, Ayyathurai, Eswaran, Suresh, Rather, Mohd Ashraf, Rakkannan, Gowrimanohari, Unraveling the Impact of Climate Change on Fish Physiology: A Focus on Temperature and Salinity Dynamics, Journal of Applied Ichthyology, 2024, 5782274, 19 pages, 2024. https://doi.org/10.1155/2024/5782274.

2. Dudgeon D, Arthington AH, Gessner MO, Kawabata Z, Knowler DJ, Lévêque C, Naiman RJ, Prieur-Richard AH, Soto D, Stiassny ML, Sullivan CA. *Freshwater biodiversity: importance, threats, status and conservation challenges*. Biol Rev Camb Philos Soc. 2006 May;81(2):163-82. doi: 10.1017/S1464793105006950.

3. Dobson, K. L., et al. (2024). *Ocean acidification does not prolong recovery of coral after bleaching* (or related findings) Communications Earth & Environment (2024). (study on OA and coral recovery dynamics).

4. Klein, S. G., Roch, C., & Duarte, C. M. (2024). *Systematic review of the uncertainty of coral reef futures under climate change*. Nature Communications, 15, 2224. doi:10.1038/s41467-024-46255-2.

5. Marcos, M., et al. (2025). *Global warming drives a threefold increase in persistence of marine heatwaves*. PNAS, 2025. (marine heatwave persistence and trend analysis).

6. Olson, E. M., et al. (2025). *Potential for regional resilience to ocean warming and acidification extremes*. (open-access article / PMC) (2025). (analysis of future stress extremes under scenarios). (PMC)

7. Perry, C. T., et al. (2025). *Reduced Atlantic reef growth past 2 °C warming amplifies reef erosion projections*. Nature, 2025. (analysis of reef transitions under warming scenarios).

8. Thirukanthan, C. S., et al. (2023). *The evolution of coral reef under changing climate*. Frontiers / Scientific Reports / PMC review (2023). (comprehensive coral reef response synthesis). (PMC)

9. Trégarot, E., et al. (2024). *Effects of climate change on marine coastal ecosystems*. Biological Conservation / Global Change Biology (review, 2024). (coastal habitat responses across types). (ScienceDirect)

10. Wernberg, T., et al. (2024). *Impacts of Climate Change on Marine Foundation Species*. Annual Review of Marine Science, 2024. (review on kelp, seagrass, coral, mangrove responses and implications).

11. Woodward, G., Christensen, J. B., Olafsson, J. S., Gislason,G. M., Hannesdottir, E. R. & Friberg, N. *Sentinel systems on the razor's edge: effects of warmingon Arctic stream ecosystems*. Global Change Biol. (doi:10.1111/j.1365-2486.2009. 02052.x)