



Global Warming and Its Effects on Fisheries and Aquaculture: An Overview

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Human activities, including burning fossil fuels (coal, oil, and gas) and widespread deforestation, have dramatically impacted the climate since the industrial revolution (Houghton, 2005). These activities release about 7 billion metric tonnes of carbon, as carbon dioxide, into the atmosphere annually, along with substantial quantities of methane, nitrous oxide, and chlorofluorocarbons (CFCs). However, this results in an increase in atmospheric temperature, referred to as "global warming," and the gases contributing to it are called "greenhouse gases" (Houghton, 2005). Evidence of global warming is everywhere and cannot be ignored. Increasing global temperatures, wider thermal variation, and more frequent extreme heat waves negatively impact many aquatic ecosystems (Collins et al., 2019). Temperature is a crucial driving factor in aquatic species' growth and survival since it directly impacts their immunity, metabolic rate, and oxygen requirement. In addition to causing a high increase in oxygen requirement and metabolic disturbances, changes in external temperature above the organism's thermal threshold will also cause a decrease in feed intake (FI) and weaken its immunity (Dawood, 2020). Further, global warming contributes to the rise in anti-microbial resistance (MAR), which threatens human health by boosting the spread of drug-resistant microbes (Abbass et al., 2022).

However, this article's goal is to briefly review global warming, including its impacts and causes as well as potential solutions. More narrowly, this paper examines the implications of climate change for fisheries and aquaculture.

Sources of Global Warming

a) **Greenhouse Gases (GHGs):** GHGs are the significant contributors to global warming; their sources are listed in the following table 1

Table 1: Sources of greenhouse gases

S.No.	GHGs	Sources
01	Carbon dioxide	Burning of fossil fuels for generating electricity, power plants, respiration, and volcanic eruption.
02	Methane	Bovine flatulence, microbes in bogs, the production of fossil fuels, and rice fields.
03	Nitrous oxide	Nylon production (due to adipic acid), nitric acid production, cars with catalytic converters, use of fertilizers in agriculture, and the decomposition of organic matter

04	Chlorofluorocarbons (CFCs)	Refrigeration, Air-conditioning, blowing agents in foams, insulations and packing materials, propellants in aerosol cans, and solvents
05	Water vapor	Combustion, volcanic eruption, respiration, transpiration of plants, and evaporation from oceans, lakes, rivers, and moist lands

- b) **Deforestation:** One of the causes of greenhouse gas emissions is the clearing of forest land for agriculture and industrial use.
- c) **Permafrost:** It is the sub- or super-freezing layer of soil particles, water, and hazardous gases that lies beneath or above the earth's surface. When permafrost melts, it releases enormous amounts of greenhouse gases trapped underneath.
- d) **Fertilizers:** More heat can be stored by cropland when nitrogen-rich fertilizers are used in farming.
- e) **Garbage:** It is of two types: - Liquid and Solid waste. When the trash breaks down in landfills, it leads to the release of CH_4 and N_2O
- f) **Oil Drilling:** Carbon dioxide is released into the environment due to oil drilling's waste burn-off. Moreover, the extraction, transportation, and use of fossil fuels cause the release of greenhouse gases into the atmosphere, such as methane and carbon dioxide.

Effects of global warming on Fisheries and Aquaculture

The effects of global warming are not just limited to changes in temperature, but also include changes in water levels, flow patterns, eutrophication, acidification, reduced ice cover, ocean current changes, increased ultraviolet light penetration, and sediment runoff, all of which contribute to the demise of aquatic flora and fauna (Cochrane et al., 2009). The distribution of species will change, with the majority moving to the poles. Fish distribution, growth, and migration are all affected by long-term interannual thermal fluctuations due to the El Niño effect and global warming. However, the arctic regions are experiencing these impacts most acutely. The Arctic's vegetation and fauna are witnessing the effects of global warming. Loss of land and sea ice, risks to wildlife and traditional people's livelihoods, higher methane emissions, and more intense weather at lower latitudes are all consequences of Arctic warming. Researchers warn that the polar bears require assistance in obtaining food. Since the sea ice on which many polar bears have traditionally relied is becoming thinner and melting earlier, the bear's primary food source, i.e., seals, is also in danger because they rely on sea ice to give birth and rear their young. With the growing distance from their food source, the penguin population is also decreasing near the Antarctic region.

Nonetheless, coral reefs are also being destroyed because of global warming and rising sea levels. Warmer ocean temperatures cause thermal stress, which in turn aids in the transmission of illnesses and causes coral to bleach. In the case of reefs located near land-based sediment sources, rising sea levels may enhance sedimentation. Sediment discharge poses the threat of burying coral reefs. Upon being "bleached," coral takes on a white appearance. As a result, many marine creatures that rely on coral reefs may perish. Furthermore, El Niño is another consequence of global warming. For every 7–14 years ("the child"), there is a major disruption in the ocean and atmosphere. However, the warm surface waters prevent the cold, nutrient-rich Humboldt current from upwelling, leading to a decline in the plankton, which in turn disrupts the entire ocean food chain, demolishes the fishing sector, causes the monsoon to fail, and causes severe weather disturbances. Fish spawning and water temperatures in inland bodies of water have been affected by the reduction in average rainfall and the delay of the monsoon. The gonads of fish are aided in their

development by the endocrine glands, which are triggered by changes in temperature, precipitation, and photoperiod.

Responses to Global Warming

- Mitigation
- Adaptation
- Geoengineering
- UNFCCC (United Nations Framework Convention on Climate Change), 1994.
- The Kyoto Protocol, signed in 1997 in Kyoto, Japan, when industrialized nations committed to specified reduction targets for greenhouse gas emissions, aims to stabilize greenhouse gas concentrations in order to avoid "dangerous human interference."
- 194 nations had signed and approved the treaty as of November 2020.
- Algal biomass production as a tool for global warming mitigation.

Panchamrit strategy: As part of its "Panchamrit strategy," India recently declared new climate goals at COP26. It has made a significant step towards demonstrating its dedication to clean energy and informing the world of its plans to combat climate change. At the current COP26 meeting in Glasgow, the Indian Prime Minister proposed a five-fold strategy (Figure 1) to combat climate change called "Panchamrit". There is a set deadline (i.e., 2070) in the plan for achieving net zero.

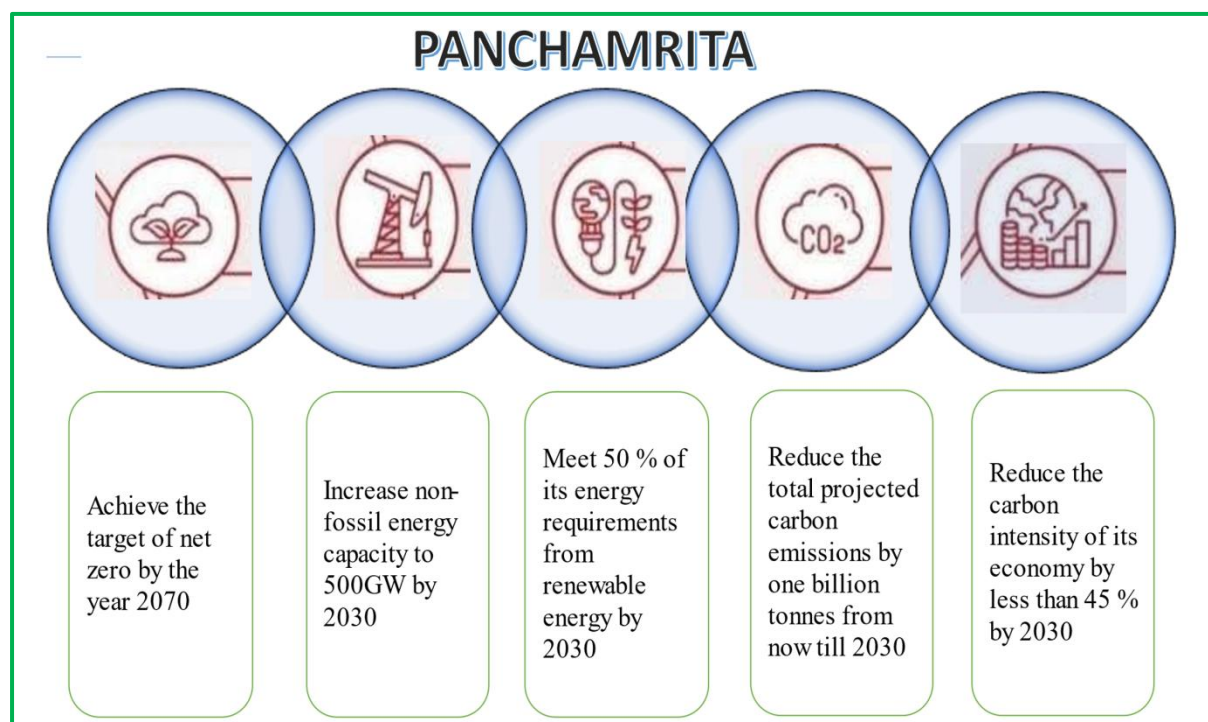


Figure 1: Five-fold strategies of Panchamrit

Conclusion and Future Strategies

One of the biggest challenges facing the aquaculture and fisheries industries today is global warming. It is essential for both developed and developing countries to work together to devise a plan to reduce emissions of greenhouse gases. Thus, nations that are experiencing rapid economic growth ought to seriously consider implementing a novel approach that is also relatively inexpensive for reducing the consequences of greenhouse gases. It is important to keep up with enormous and consistent reforestation initiatives. And also, a higher priority should be given to increasing the utilisation of renewable resources such as solar and wind energy.

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