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Climate Change and Its Impact on Aquatic Ecosystem

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Abstract

Climate change involves long-term shifts in global and regional climate patterns, mainly driven by human activities that release greenhouse gases from fossil fuel use, deforestation, agriculture, and industry. These emissions intensify the greenhouse effect and warm the planet, causing major impacts on aquatic ecosystems. Oceans are experiencing sea-level rise, acidification, altered carbonate chemistry, and frequent marine heatwaves, which reduce biodiversity and disrupt fish populations. Freshwater systems also face threats from rising temperatures, altered flow patterns, pollution, invasive species, and nutrient enrichment. Fisheries worldwide are affected by declining productivity, changing species distribution, and greater risks from extreme events and diseases. In India, climate variability has reduced the availability of key marine species, increasing pressure on fishing communities. Overall, climate change poses serious challenges to aquatic environments, fisheries, and human livelihoods.

Causes of Climate Change

The main cause is the burning of fossil fuels (coal, oil, and gas), which generates greenhouse gas (GHG) emissions like carbon dioxide CO_2 and methane CH_4. These gases trap the sun's heat, acting like a "blanket wrapped around the Earth" and raising global temperatures.

Sources of Emissions:

CO_2: Burning gasoline for transport, coal for heating, and clearing/cutting down forests (deforestation). CH_4: Major sources include agriculture and oil and gas operations. Contributing Sectors: Energy, industry, transport, buildings, agriculture, and land use.

Consequences and Impacts

The warming associated with climate change leads to severe and varied consequences globally:

1. **Rising Sea Levels:** Warming temperatures cause ocean waters to expand, and polar ice sheets and glaciers to melt at an accelerated rate. This rise damages coastlines through increased flooding and erosion.

2. **Extreme Weather:** The planet is experiencing more frequent and intense events, including Intense droughts and water scarcity, Severe fires, and Catastrophic storms (hurricanes, floods, downpours, winter storms).

3. **Ecological and Human Impact:** Declining biodiversity, Unpredictable weather patterns, making it difficult to maintain crops in farming-dependent regions, Threats to health, food security, housing, safety, and work, Increased vulnerability for people in developing countries and small island nations, leading to the rise of "climate refugees."

Climate refers to the seasonal averages of temperature, rainfall, and wind patterns in a specific area. Different places have distinct climates, such as arid (deserts, little rainfall), tropical (hot and humid), or temperate (warm summers and cool winters).

2. Impact of climate change on the aquatic ecosystem

1. **Reduced Total Carbonate alkalinity:** Total carbonate alkalinity of seawater will decrease CO_2 increases within the earth's atmosphere (Gattuso et al., 1998; kleypas et al., 1999). Doubling carbon dioxide concentrations in the atmosphere will decrease the aragonite saturation state in the tropics by 30% by 2050.
2. **Increased Sea level:** Sea level will rise as climate change pushes planetary temperature higher. The expected increase in sea level is approximately 9 - 29 cm over the next 40 years or 28 - 29 cm by 2090 (Church et al., 2001; IPPC 2001). According to Nichols and colleagues (1999), sea level rise could cause the loss of up to 22% of the world's coastal wetlands by 2080. Combined with other human impacts, this number is likely to climb to a loss of 70% of the world's coastal wetlands by the end of the 21st century.
3. **Sea temperature increase: A** Significant increase in heat content has not been distributed evenly. Sea temperature in turn influences the marine environment. Due to its direct effects on the density of seawater, changes in global temperatures can directly upon the rates and directions of ocean water movement.

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4. **Deep Sea biodiversity:** Marine biodiversity and ecosystem are threatened by pollution, shipping, military activities, and climate change, but today, fishing presents the greatest threat. The greatest threat to biodiversity in the deep sea is bottom trawling. This type of high-seas fishing is more damaging to seamounts and the cold-water corals they sustain. These habitats are home to several commercial bottom-dwelling fish species.
5. **Fish populations:** Coastal fisheries are critical resources for hundreds of millions of people. Many scientists now point to the dramatic overexploitation of fisheries and the subsequent decline in fish stocks as the major factor in ecosystem change over the past two centuries (Jackson et al., 2001).

Freshwater ecosystem: Most of the Earth Surface (around 70%) is covered with water, but not all the water is freshwater. Only 3.5% is freshwater, and the rest 96.5% is saltwater in the form of oceans. The Freshwater is found in the form of ponds, lakes, streams, frozen water, etc. other than oceans and seas. The freshwater ecosystem plays an important role in biodiversity. However, it is less extensive as compared to the saltwater ecosystem. A changing climate and increasing levels of UV light pose additional risks that superimpose upon existing threats.

Plastic Pollution in Oceans

Marine life is facing the dangers of plastic pollution and is under severe stress. The plastic bags float throughout the ocean; fishes, in small and big sizes, eat the plastics and feel full while they slowly starve to death. According to the United Nations, more than eight million tonnes of plastic waste is flooding our oceans every year, accounting for up to 80% of all the litter in the oceans.

Overfishing: Over-fishing exacerbates the effects of climate change by creating conditions that make a fishing population more sensitive to environmental changes. Fishing that is destructive and unsustainable affects biodiversity. Minimizing over-fishing and destructive fishing will increase Ocean resilience to climate change, hence mitigating climate change.

Climate Change and Fisheries Production in India

According to IPCC, the monsoon in India is expected to decline by 45%. Summers would get hotter and longer while monsoons would become shorter but more intense, both in India and elsewhere in the tropical belt. The Central Marine Fisheries Research Institute of India (CMFRI) has confirmed that there has been a decline in coastal marine fish production in India over the last few years. CMFRI data reveal a 9% decline in overall fish catch in 2018 as compared to 2017. The 2018 annual fish landing data showed a 54% decline of the Indian

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oil sardine (*Sardinella longiceps*), a pelagic fish found abundantly in the Arabian Sea, particularly the coastal waters that cover Karnataka, since 2017.

Conclusion

Climate change has emerged as a major global challenge, exerting profound and far-reaching impacts on both marine and freshwater ecosystems. Rising temperatures, ocean acidification, sea-level rise, and altered hydrological patterns are reshaping aquatic habitats, reducing biodiversity, and disrupting the stability of fish populations. Freshwater bodies face similar stress through pollution, invasive species, and changing nutrient levels, further threatening ecological balance. These environmental shifts directly affect fisheries, leading to declining catches, altered species distributions, and increased vulnerability of coastal and inland communities. Addressing climate change requires urgent mitigation and adaptation efforts to protect aquatic ecosystems, ensure sustainable fisheries, and safeguard the livelihoods that depend on them.

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