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Popular Article

Climate Change and Variability: Its Impacts on Fisheries and Aquaculture Sector

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Introduction

Climate change and climate variability are two of the most significant environmental challenges facing the world today. These phenomena have far-reaching impacts on various sectors, including fisheries and aquaculture. Climate change has been recognized as the foremost environmental problem of the twenty first century and has been a subject of considerable debate and controversy. It is predicted to lead to adverse, irreversible impacts on the earth and the ecosystem as a whole. Although it is difficult to connect specific weather events to climate change, increases in global temperature has been predicted to cause broader changes, including glacial retreat, arctic shrinkage and worldwide sea level rise. Climate change has been implicated in mass mortalities of several aquatic species including plants, fish, corals and mammals (Bimal and Sasmita, 2010). The Fish population variability and fisheries activities are closely linked to weather and climate dynamics. While weather at sea directly affects fishing, environmental variability determines the distribution, migration, and abundance of fish. Fishery science grew up during the last century by integrating knowledge from oceanography, fish biology, marine ecology, and fish population dynamics, largely focused on the great Northern Hemisphere fisheries. The observation that fish populations fluctuate at decadal time scales and show patterns of synchrony while being geographically separated drew attention to oceanographic processes driven by low-frequency signals, as reflected by indices tracking large-scale climate patterns such as the Pacific decadal oscillation (PDO) and the North Atlantic Oscillation (NAO). This low-frequency variability was first

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observed in catch fluctuations of small pelagic fish (anchovies and sardines), but similar effects soon emerged for larger fish such as salmon, various ground fish species, and some tuna species. Today, the availability of long time series of observations combined with major scientific advances in sampling and modelling the oceans ecosystems allows fisheries science to investigate processes generating variability in abundance, distribution, and dynamics of fish species at daily, decadal, and even centennial scales. (Lehodey, 2006).

The fisheries sector plays a significant role in the Indian economy. It contributes to the national income, exports, food and nutritional security and in employment generation. This sector is also a principal source of livelihood for a large section of the economically underprivileged population of the country, especially in the coastal areas. India has become the 3rd largest fish producer, and the 4th largest exporter of fish and fisheries products taking brand India from Local to Global, and also 2nd largest aquaculture producing nation in the world. The Blue Revolution in India demonstrated importance of Fisheries and Aquaculture sector. To improve the quality of life and economic well-being of people in rural areas and to create more livelihood opportunities, a holistic approach has been adopted by the Government of India to meet Sustainable Development Goals (Anon, 2023).

The fisheries and aquaculture sector has a important contribution to make within the four betters, that are Better Production, Better Nutrition, Better Environment and Better Life. The fisheries sector in the country continues to be among the most crucial and fastest growing agriculture and allied sectors in the country. The sector has exhibited strong growth of about 8% per year on average with aquaculture growing at an annual average of more than 10%. The fisheries sector has been recognized as a Sunrise Sector and has demonstrated an outstanding double-digit average annual growth of 10.87% since 2014-15, with record fish production of 161.87 lakh tons (provisional) during 2021-22. In terms of employment, the sector supports the livelihood of over 28 million people in India especially the marginalized and vulnerable communities. Export earnings from the fisheries sector was ₹46,662.85 crore during 2019-20. The share of fisheries in agricultural GDP/GVA has impressively increased during the period from a mere 0.84 per cent in 1950-51 to 7.28 per cent in 2018-19. The contribution of fisheries and aquaculture sector to the GDP/GVA has gone down from 0.46 per cent in 1950-51 to 0.22 per cent in 2020-21(at current prices) (Anon, 2022 & 2022a). However, climate change and climate variability pose significant threats to aquaculture productivity, food security, and rural livelihoods. This article explores the impact of climate change

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and climate variability on fisheries and aquaculture and the measures that can be taken to mitigate these impacts.

Climate Change and Variability on Fisheries / Aquaculture

Climate change is causing changes in temperature, precipitation, and weather patterns, which are affecting aquaculture productivity. Fisheries are affected by climate change in various ways: marine aquatic ecosystems are being affected by rising ocean temperatures, ocean acidification and ocean deoxygenation, while freshwater ecosystems are being impacted by changes in water temperature, water flow, and fish habitat loss. Climate changes directly affect fishery production. Fish reproduction, growth and migration patterns are all affected by temperature, rainfall and hydrology. It is likely to adversely affect both the fresh water and marine fisheries in India.

Nature of the climate change threat: Fisheries and aquaculture are threatened by changes in temperature and, in freshwater ecosystems, precipitation. Storms may become more frequent and extreme, imperilling habitats, stocks, infrastructure and livelihoods.

The need to adapt to climate change: better climate variability and ncertainty complicate the task of identifying impact pathways and area of infirmity, requiring research to devise and pursue coping strategies and improve the adaptability of fishers and aqua culturists.

Strategies for coping with climate change: Fish can provide opportunities to climate change by, for example, integrating aquaculture and agriculture, which can help farmers cope with drought while boosting profits and household nutrition. Fisheries management must move from seeking to maximize yield to increasing adaptive capacity.

Impacts of Climate Change and Climate Variability on Fisheries and Aquaculture

Climate changes and variability may affect fisheries and aquaculture directly by influencing fish stocks and the global supply of fish for consumption, or indirectly by influencing fish prices or the cost of goods and services required by fishers and fish farmers. An outline of the variety of possible generators of climate change impacts in Aquaculture (Fig.1).

In the current scenario, there is an increase in the demand for fish due to the increase in population. However, the capture fishery production has reached its maximum potential, and there is only a little scope is left to increase the production. Thus the focus is on aquaculture productions as there is vast scope for increasing the production. Nevertheless, increasing climate change brings many challenges to the aquaculture sector.

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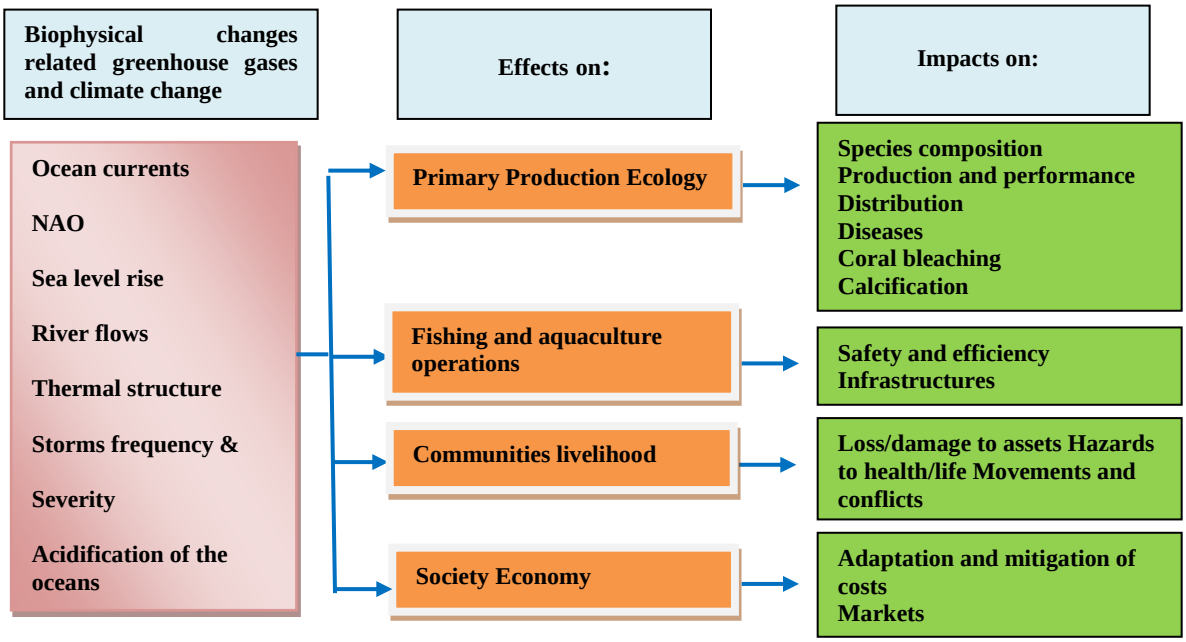

Fig. 1. Major climate change impacts on fisheries and aquaculture

Coastal ecosystems, inland aquaculture and offshore marine aquaculture (Mariculture) are being affected due to long term climate change. Sea-level upsurge can contribute to coastal erosion, impacting coastal geomorphology and hydrodynamics, which can positively and negatively alter the appropriate areas for shellfish cultivation (Filgueira et al., 2016). The some of the important ways in which major climate change may directly affect production from fisheries and aquaculture (Table.1).

Table 1. Ways in which climate change may directly affect production from fisheries and aquaculture

Climate driver (trend)	Biophysical Effects	Implication for fisheries and aquaculture
Sea surface temperature	1. Change in the local and size of suitable range for particular species.	1. Aquaculture opportunities both lost and gained. Potential species loss and altered species composition for capture fisheries.
	2. More frequent harmful algal blooms; less dissolved oxygen; increased incidence of disease and parasites; altered local ecosystems with changes in competitors, predators and invasive species; changes in plankton composition.	2. For capture fisheries, impacts on the abundance and species composition of fish stocks. For aquaculture, change in infrastructure and operating costs from worsened infestations of fouling organisms, nuisance species and predators.
	3. Change in timings and success of migrations, spawning and peak abundance, as well as in sex rations.	3. Potential loss of species or shift in composition in capture fisheries; impacts on sees availability for aquaculture.

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	4. Enhanced primary productivity.	4. Potential benefits for aquaculture and fisheries but perhaps offset by changed species composition.
	5. Longer growing seasons; lower natural mortality in winter; enhanced metabolic and growth rates.	5. Potential for increased production and profit, especially for aquaculture.
El Niño-Southern Oscillation	1. Changed ocean temperature and bleached coral	1. Reduced productivity of reef fisheries.
	2. Damage to coral reefs that serve as breeding habitats and may help protect the shore from wave action.	2. Reduced recruitment of fishery species. Worsened wave damage to infrastructure or flooding from storm surges.
	3. Altered rainfall patterns bring flood and drought.	3. See impacts for precipitation trends, drought and flooding above.
Rising Sea level	1. Loss of land.	1. Reduced are available for aquaculture. Loss of freshwater fisheries.
	2. Salt water infusion into groundwater.	2. Damage to freshwater capture fisheries. Reduced freshwater availability for aquaculture and a shift to brackish water species.
	3. Changes to estuary systems.	3. Shifts in species abundance, distribution and composition of fish stocks and aquaculture seed.
	4. Loss of costal ecosystems such as mangrove forests.	4. Reduced recruitment and stocks for capture fisheries and seed for aquaculture.
Higher inland water temperature	1. Increased stratification and reduced mising of water in llakes, resucing primary productivity and ultimately food supplies for fish species.	1. Reductions in fish stocks.
	2. Shift in the locations and size of the potential range for a given species.	2. Aquaculture opportunities both lost and gained. Potential loss of species and alteration of species composition for capture fisheries.
Increase in Frequency	1. Large waves and storm surges. 2. Inland flooding from intense precipitation. 3. Salinity changes	1. Loss of aquaculture stock and damage or loss of aquaculture facilities and fishing gear. 2. Impacts on wild fish recruitment and stocks.
Drought	1. Changes in lake water levels and river flows	1. Reduced wild fish stocks, intensified competition for fishing areas and more migration by fisherfolk.
	2. Lower water quality and availability for aquaculture salinity changes.	2. Loss of wild and cultured stock. 3. Increased production costs. 4. Loss of opportunity as production is limited.

Major challenges to fishing communities posed by climate change

- Relocation of resources and replacement with less commercially valuable species requires diversification of fishing operation and markets.

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- In areas where production is already limited by temperature traditional productive areas may be reduced. Dependent communities will need to diversify their livelihoods.
- Changes in the timing of fish spawning and recruitment will need adjustments to management interventions.
- The impact of ocean acidification may be locally significant, for example in activities dependent on coral reefs.
- Increases in the frequency and severity of storms may affect infrastructure, both at sea and on shore.

Conclusion

Climate change and climate variability are significant challenges facing aquaculture and fisheries. However, by implementing measures to mitigate their impacts, such as developing Climate-resilient aquaculture adaptations are necessitated to sustain production and to uphold socio-economic conditions, improving water management, promoting sustainable land use practices, enhancing early warning systems, the aquaculture sector can adapt to these challenges and continue to provide food, nutrition, Jobs across the world and other essential products to the world's population.

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