Warming Oceans and Changing Fisheries: Impacts and Global Initiatives

Prathyusha Voma[1]* and Bhukya Manikanta Rathod[2]

[1]College of Fisheries, Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Mangalore, Karnataka, India-575002
[2]P.V. Narsimha Rao Telangana Veterinary University, College of Fishery Science, Pebbair-509104

Corresponding Author
Prathyusha Voma
Email: prathyusha.voma@gmail.com

OPEN ACCESS

Keywords

Climate change, Fisheries, Aquaculture, Ocean acidification, Marine biodiversity

How to cite this article:

Voma, P. and Rathod, B. M. 2026. Warming Oceans and Changing Fisheries: Impacts and Global Initiatives. *Vigyan Varta* 7 (05): 72-79.

ABSTRACT

Climate change serves as a significant international environmental problem which affects both freshwater systems and commercial fishery operations and aquaculture farming. Fish functions as an essential food source which contributes to worldwide nutritional needs through its provision of animal protein especially in developing nations. The combination of rising greenhouse gas emissions and increasing global temperatures has caused changes in both oceanographic and climatic systems which produce phenomena such as sea level rise and ocean acidification and monsoon pattern changes. Fish species use these changes to adapt their body functions and movement patterns and their reproduction processes and their ability to produce fish. The decline of marine species and coral reefs and coastal areas which include mangroves and wetlands through climate change destruction creates additional challenges for maintaining sustainable fishing. Climate change has begun to alter fishery stocks through its effect on catch patterns and species composition and stock distribution for different fish species. This article presents the causes and effects of climate change on fishery resources while it shows how international agreements will solve these problems through sustainable management methods and adaptive strategies which protect ecosystem health and food production for the future.

INTRODUCTION

Fisheries and aquaculture serve as fundamental food sources which fulfil food security requirements for both local and regional and global economic growth. The climate of a specific area represents its extended weather patterns which include temperature and rainfall and humidity and wind and other weather elements that scientists measure over periods of 30 years or longer. Climate change has become the main environmental problem which humanity must tackle during the 21st century; this situation has led to fierce arguments and debates. The main elements of climate change that could potentially impact on aquaculture production are sea level raise in temperature rise, change in monsoonal rain patterns, extreme climatic events and water stress. The most notable and significant changes associated with climate change are the gradual rise of global mean temperature and a gradual increase in atmospheric greenhouse gases, both of which have been aptly synthesized and documented. However, the world's fisheries and aquaculture sectors are largely impacted by anthropogenic climate change, one of the greatest environmental challenges the world faces today (Barange *et al*., 2018). Climate change has already begun to alter ocean conditions, most notably water temperature and biogeochemistry, and is expected to have an effect on marine fisheries productivity (Holdsworth *et al*., 2021). Studies also estimate that climate change will result in economic losses in many regions although some countries and/or regions may benefit from increased fisheries production (Guerra *et al*., 2021).

Causes of climate change

The earth's temperature and climate change are influenced by both natural processes and human-made activities. The global warming phenomenon occurs due to the substantial rise in human-generated greenhouse gas (GHG) emissions which have increased during each passing decade. However, for the past few thousand's years earth has been in an interglacial period with a constant temperature. Conversely since the industrial revolution in the 1850s, the global temperature has increased as alarming and much faster rate (1 to 100 years) it leads to sixth mass extinction or the Holocene extinction at very faster rate

Natural processes affecting the earth's temperature

The Earth experiences natural temperature changes through its various environmental processes. The sun functions as the primary energy source for Earth because it produces energy at a constant rate although its output undergoes minor fluctuations during extended time frames. The climate undergoes changes because of natural processes which include orbital forcing and volcanic eruptions and atmospheric greenhouse gas changes. The Earth encounters energy balance disruptions from greenhouse gas changes and aerosol modifications and land cover transformations and solar radiation variations. Volcanic eruptions release gases which contain sulfur dioxide (SO_2) that produces sulfate aerosols in the atmosphere, leading to additional climate effects.

Greenhouse gases

Greenhouse gases create a thermal blanket which prevents heat from escaping Earth to maintain essential temperatures for life on our planet. Natural gases consist of water vapour and carbon dioxide and methane and nitrous oxide and ozone, while industrial gases result from human production of halocarbons and chlorofluorocarbons. Human activities that included fossil fuel combustion and deforestation which decreased carbon storage capacity led to climate change through carbon

dioxide emissions. The current atmospheric CO_2 level of approximately 370 ppm represents the highest point in hundreds of thousands of years; scientists predict that it will increase substantially until the 21st century terminates.

Impacts of Climate Change

Sea level rise

The local sea level rise at a particular site does not match the worldwide sea level rise because it experiences different local determining elements which include land sinking and flood control systems and coastal land erosion and ocean current behaviour and land height variations and the slow process of land restoration which started after the Ice Age. Tide stations combined with satellite altimeters measure sea level by recording water height measurements from permanent land markers. The global sea level reached 97 mm above the 1993 baseline in 2021 because of accelerated glacier and ice sheet melting which increased its height. Glaciers and ice sheets naturally undergo summer melting and winter reconstruction but the current rate of melting exceeds the pace of replenishment which results in ongoing ocean level increases. The rising ocean levels result from two factors which include seawater expansion due to increased ocean temperatures and additional water from melting glaciers. The transformations produce permanent changes that affect ocean ecosystems.

Ocean Acidification

The oceans can absorb approximately 75 percent of the CO^2 emissions produced by human activities according to research conducted by Caldeira and Wickett (2003). The water dissolves CO^2 which then transforms into carbonic acid through a reversible chemical process. Although increased acidity from dissolved CO^2 in seawater benefits the planet by reducing global warming, it creates detrimental effects on ocean ecosystems. The authors Le Quesne and Pinnegar (2011) state that direct effects include modifications to physiological functions which include diminished growth of calcified structures and otolith development along with decreased fertilization success. These factors produce direct effects that affect organism growth and reproduction while they also increase predation risks and mortality rates and change feeding patterns and behaviours and decrease immune function and thermal resistance. The indirect effects lead to changes in predator and prey populations which affect biogenic habitats including coral reefs and they also result in nutrient recycling processes being disrupted.

Loss of Marine Biodiversity

Rising atmospheric CO_2 increase the risk of loss of marine and coastal ecosystems. The coral reef acts as an important habitat which provides protection to 25% of all oceanic species. Coral reefs must face three distinct challenges which stem from the increasing levels of atmospheric CO_2. The ocean experiences bleaching events because of sustained warmer-than-average sea surface temperatures. Corals maintain a symbiotic partnership with zooxanthellae which are photosynthetic algae that deliver nutrients to coral polyps while also giving them their vibrant colours. The process of coral bleaching occurs when reefs experience stress that leads to the loss of their essential tiny algae. Corals react to heat stress by rejecting zooxanthellae which results in their skeletons acquiring a bleached appearance. Ocean acidification leads to decreased calcium mineral availability which affects the skeleton development and maintenance processes. The present global temperature of 1.1°C has caused 60% of marine ecosystems worldwide to experience degradation or continue to be used in unsustainable ways. The warming of 1.5°C will lead to the extinction of 70 to 90% of

coral reefs while a 2°C increase results in a total loss of coral reefs (IPCC, 2018)

Loss of Coastal Ecosystems

Coastal wetlands function as natural flood protection systems while their ecosystems deliver superior carbon storage performance to other ecosystems during designated time intervals. Forested wetlands function as essential climate change protection systems. Wetland ecosystems face complete destruction because of increasing sea levels. Mangrove ecosystems function as natural fish breeding areas which sustain 80% of global fish populations during their breeding season. Environmental destruction occurs at a severe level through ecosystem destruction. Wetlands will experience up to 22% loss by 2080 because of advancing sea levels. Coastal wetlands serve as native habitats for native animal and plant species who now face extinction risk because of climate change and their native ecosystems sustain marine ecosystem damage which affects the fishing sector

Clouds to Go Extinct

Clouds work as natural surfaces which reflect light from Earth back into space after reflecting sunlight. The general public can see stratocumulus clouds in the sky because they represent an essential atmospheric component. The extinction of stratocumulus clouds will begin because of climate change. The new climate models predict that rising atmospheric carbon dioxide levels will interfere with cloud development which will result in major temperature increases throughout the forthcoming years. Higher temperatures cause the atmosphere above the ground to become drier which leads to higher cloud bases and decreased cloud thickness. The primary heat emission function of stratocumulus clouds enables them to maintain their structure through energy loss to the upper atmosphere. The warm air prevents them from performing this function which results in their disintegration.

Affecting the Monsoon Circulations

Climate change results in increased ocean water vaporization which moves from ocean areas into land regions, thereby causing alterations in major atmospheric teleconnection systems. The higher temperatures have resulted in more frequent atmospheric teleconnections which include El Nino-Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) and Madden-Julian Oscillation (MJO) which directly affect monsoon patterns. The El Nino-Southern Oscillation (ENSO) describes the unpredictable shifts in winds and ocean temperature patterns which occur in the eastern tropical Pacific during El-Nino and La-Nina episodes that repeat every few years. Indian summer monsoon rainfall increases because El-Nino combines with extreme positive IOD events, while El-Nino along with extreme negative IOD results in lower precipitation rates. As global temperatures rise, the frequency of extreme positive IOD events is expected to increase, leading to more intense Indian summer monsoon rainfall occurrences. The Madden-Julian Oscillation (MJO) generates areas which produce increased rainfall, which travel eastward along the Equator every 40-50 days, impacting tropical and high-latitude winds and altering extreme weather patterns such as floods and hurricanes and heat waves. MJO influences the Indian monsoon through its cyclical system.

Effects in Fisheries

Climate change impacts fisheries through its effects on catch and landing patterns and fish stock distribution and species dominance. The fish population parameters of fish abundance and recruitment and growth are controlled by temperature changes and oceanographic

factors and environmental conditions. The catch data shows fish population trends which result from both environmental factors and fishing activities and market demand and technological advancements and fishing effort. Climate-driven changes in ecosystems result in species dominance transitions which scientists observe in sardine–anchovy and herring–blue whiting ecosystems that demonstrate temperature and upwelling and predation and competition as causes of population cycles which maintain total biomass. Climate change causes species distribution changes by altering habitat conditions and reproductive patterns and the life behaviour of species. Warming waters let certain species expand their territories while other species lose their territories because of oceanic front changes and seasonal weather patterns which create new feeding areas and migration routes that impact fishery resources.

Global Initiatives Liability in Tackling Climate Change

Food and Agriculture Organization

The United Nations established the Food and Agriculture Organization (FAO) in 1945 as an international organization. The organization headquarters located in Rome, Italy. The FAO has three main objectives which include ending global hunger and removing food insecurity and treating malnutrition and eliminating poverty while helping people to grow socially and economically and developing sustainable methods for managing all natural resources from land and water to air and climate and genetic resources which will benefit both present and future generations. The FAO conducts its plan to fight climate change through agricultural techniques which help both climate adaptation and climate impact reduction. The system improves its operational activities because it provides better coordination between its two different operational processes.

World Wide Fund for Nature

The World-Wide Fund (WWF) started operations in 1961, in Morges, Switzerland. it changed its name to World Wide Fund for Nature in 1986 to better reflect the scope of boarding. The outdated name continues to be used in both the United States and Canada. The WWF organization has a mission which involves stopping all forms of natural environmental destruction while establishing a future world where humans live in peaceful coexistence with nature. The organization protects endangered species and their habitats while fighting against global environmental problems which include pollution and overfishing and climate change. The Living Planet Report has been published biannually since 1998 based on Living Planet Index data and ecological footprint calculations. The organization operates its current activities through six primary domains which include food and climate and freshwater and wildlife and forests and oceans.

RAMSAR Convention

The Ramsar Convention, or Wetland Convention, is an international agreement which was signed on 2 February 1971 in Ramsar, Iran. The convention became effective from 21 December 1975. The convention has reached its current status with 172 countries participating as treaty members. Wetlands are ecosystems that exist in water-covered areas throughout different times of the year. Wetlands occupy only 6% of the Earth but they provide essential wildlife habitat areas which serve as breeding sites for almost 40% of all animal species and plant species. Ramsar sites stand as vital protected regions which possess global significance. 2500 sites have been designated by 172 countries. India currently has 98 Ramsar sites which occupy 257 million hectares of land area. Tamil Nadu has highest number (20) and West Bengal

Sundarbans being the largest and Renuka being smallest.

The United Nations Environment Programme (UNEP)

The United Nations Environment Programme (UNEP) was established during the Stockholm conference. The organization handles environmental problems by managing the coordination of different environmental activities which occur throughout the United Nations system. Maurice Strong established the organization on 5th June 1972 in Nairobi Kenya. The organization provides leadership and scientific expertise to develop solutions for climate change and terrestrial and marine ecosystem management and green economic development. UNEP focuses on climate change issues and post-conflict disaster management and ecosystems management and environmental governance and harmful substances while promoting sustainable resource efficiency and consumption and production practices.

The Green Belt Movement

The Green Belt Movement (GBM) is an indigenous grassroots organization in Kenya that empowers women through the planting of trees. The most effective and well-known grassroots organization which operates to stop deforestation exists as this organization. The National Council of Women of Kenya (NCWK) established the organization through Prof. Wangari Maathai in 1977. The mission of GBM is "to mobilize community consciousness for self-determination, justice, equity, reduction of poverty, and environmental conservation, using trees as the entry point." The Green Belt Movement which Maathai established combines women empowerment and eco-tourism activities with economic development efforts. Africa Environment and Wangari Maathai Day are celebrated every year on 3rd March. The organization GBM has achieved global recognition through its success in educational programs and forest protection efforts and women's economic empowerment initiatives.

The Vienna Convention

The Vienna Convention operates as the first international agreement which focuses on protecting the ozone layer. The Convention for the Protection of the Ozone Layer opened its signature process on 22 March 1985 at Vienna and continued to accept signatures until 21 March 1986. The treaty became active in 1988. The Montreal Protocol established regulatory frameworks which the treaty provided between parties who signed it.

The Inter-governmental Panel on Climate Change (IPCC)

The Inter-governmental Panel on Climate Change (IPCC) operates as a United Nations inter-governmental organization which leads global research efforts on climate change because its findings receive backing from major climate scientists and government bodies. The IPCC established itself as an organization in 1988 when the WMO and UNEP established its founding document. The organization provides scientific assessments of climate change impacts. The United Nations General Assembly later recognized it as an official body. The organization operates from its headquarters in Geneva Switzerland which includes 195 member countries. The IPCC provides comprehensive climate change scientific evidence which includes natural environmental variations and political and economic developments alongside the identification of potential solutions to climate change. The organization has three working groups which contain Working Group I for scientific assessments and Working Group II for impacts and adaptation and mitigation and Working Group III for socio-economic dimensions of climate change.

The United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) established an environmental treaty to protect the climate system from dangerous human interference through its framework that regulates greenhouse gases through atmospheric stabilization methods. UNFCCC is an international treaty that was adopted in 1992 at the Earth Summit in Rio de Janeiro to achieve atmospheric greenhouse gas concentration stabilization. The UNFCCC treaty established its foundation through the IPCC first report published in 1990. The organization established its Secretariat in Bonn Germany which began operation on 21 March 1994 and created the Conference of Parties (COP) as its highest decision-making assembly, which holds annual meetings. The UNFCCC gained 198 parties by the year 2022.

The Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD) is a multilateral treaty which started to accept signatures at the Rio Earth Summit on 5 June 1992 and began its legal operation on 29 December 1993. The treaty establishes a comprehensive international legal framework to protect biodiversity while promoting sustainable resource management and equitable resource benefit sharing. The CBD treaty requires countries to create national plans that protect biodiversity while enabling sustainable resource management. The Conferences of the Parties (COP) serve as official gatherings that unite all Convention signatories for their formal meetings. The first COP took place in Nassau Bahamas in 1994 while COP 15 occurred in 2021 and 2022 between Kunming China and Montreal Canada.

Mitigation and Adaptation

The term adaptation refers to the process of planning for future changes which people will use to guide their immediate and extended future choices. People create active adaptation strategies when they need to deal with current changes or prepare for future changes which will help them maintain their well-being. The practices of adaptation consist of continuous activities which people execute through their daily decisions and their remaining social standards and social behaviour patterns (Daw *et al.*, 2009). The political difficulties which people experience when they try to decrease climate change impact constitute the main problem which people have about climate change. Innovative solutions will be necessary to achieve carbon footprint reduction in Fisheries and Aquaculture operations through mitigation methods. The recent addition of Mangrove conservation as a method to reduce emissions from deforestation and forest degradation in developing countries demonstrates its potential to protect catchment forest areas. The research should investigate two areas which involve discovering new approaches for carbon capture through aquatic ecosystems and creating aquaculture production systems which emit low carbon emissions.

CONCLUSION

Climate change alterations create hazardous situations which damage water ecosystems and produce risks for both fishing and aquaculture operations that sustain global food supply and support local communities. The combination of rising temperatures and ocean acidification and sea level increase and changed weather patterns has created disruptions to fish populations and ecosystem diversity and coastal ecological systems. The biological changes lead to social and economic relationships which create waves of impact on fishing communities. Human activities have

caused climate changes which surpass the boundaries of natural climate variability. The growing threat to marine and coastal ecosystems requires immediate protection through effective environmental protection measures. Local communities must implement climate change solutions whereas international organizations and climate change initiatives require stronger enforcement measures and policy integration to continue their operations. The combination of sustainable fisheries management and climate-resilient practices which protect critical habitats leads to reduced environmental impacts while maintaining fisheries resources in their climate-adaptive state.

REFERENCES

Barange, M., Bahri, T., Beveridge, M. C., Cochrane, K. L., Funge-Smith, S., & Poulain, F. (2018). Impacts of climate change on fisheries and aquaculture. *United Nations' Food and Agriculture Organization*, *12*(4), 628-635.

Caldeira, K., & Wickett, M. E. (2003). Anthropogenic carbon and ocean pH. *Nature*, *425*(6956), 365-365.

Daw, T. (2009). Climate change and capture fisheries: potential impacts, adaptation and mitigation. ... *change implications for*….

Guerra, T. P., dos Santos, J. M. F. F., Pennino, M. G., & Lopes, P. F. M. (2021). Damage or benefit? How future scenarios of climate change may affect the distribution of small pelagic fishes in the coastal seas of the Americas. *Fisheries Research*, *234*, 105815.

Holdsworth, A. M., Zhai, L., Lu, Y., & Christian, J. R. (2021). Future changes in oceanography and biogeochemistry along the Canadian Pacific continental margin. *Frontiers in Marine Science*, *8*, 602991.

IPCC (2018). Global warming of 1.5° C: an IPCC special report on the impacts of global warming of 1.5° C above pre industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Intergovernmental Panel on Climate Change.