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Carbon Footprint in Marine Capture Fisheries

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Fishing is an energy intensive activity and the amount of fuel used during fishing operations is one of the major sources of greenhouse gas emissions. The carbon footprint of marine fisheries is determined by a number of factors like operation of fishing gear, vessel characteristics, fishing ground scouting and other related activities. Life Cycle Assessment (LCA) is an approach known to assess the amount of emissions generated in different phases of fishing. This is expressed as carbon dioxide equivalent (CO₂e). The average emissions in India were estimated to be 1.52 kg CO₂e per kg of fish caught. This is approximately 30% lower than the global estimated figure. However, there are considerable variation in emission levels in different fishing regions and methods. The carbon footprint of marine fisheries can be reduced by improving fuel efficiency, use of renewable energy sources, adopting appropriate technologies and strengthening fisheries management

Keywords: Carbon footprint, greenhouse gases, marine fisheries, carbon dioxide equivalent

Introduction

We often value a fish catch from the sea for its nutritional, economic and ecological importance. But every catch has a story beyond the fish itself—a story of fuel, energy and emissions associated with the process. Marine capture fisheries depend heavily on fuel consumption. From powering vessels and fishing gear to travelling to and from fishing grounds, every fishing trip comes with an energy cost. Burning of this fuel releases greenhouse gases into the atmosphere. These emissions add to the greenhouse gases that are already driving changes in the global climate.

The global fishing fleets have been estimated to consume around 42.4 million tons of fossil fuel annually. This accounts for about 1.2% of the total world oil consumption and releases approximately 130 million tons of CO₂ into the atmosphere. This corresponds to 1.7 tons of CO₂ per ton of fish landed (Tyedmers et al., 2005). A more recent estimates suggest an average of 2.2 kg of CO₂-equivalent emissions on catching one kilogram of fish. This value might differ significantly depending on the amount of fuel used and fishing technique (Parker et al., 2018).

As fishing become increasingly mechanized and reliant on diesel, vessels travel farther, stay longer at sea, and use a wider variety of fishing gears. But this causes increased emissions into the atmosphere (Jha and Edwin, 2019). The consequences of these emissions are already evident in the ocean. Rising temperatures causes fish to migrate to cooler waters. While ocean acidification and lower oxygen levels add stress to marine life. Frequent and extreme weather conditions disrupt fishing operations, damage vessels, landing centres and other coastal infrastructure. Thus, understanding and reducing these emissions is an important part of building more sustainable and climate-resilient fisheries.

Concept of Carbon Footprint

There are no labels on seafood informing us about the cost of the catch in terms of carbon emissions. We usually judge fish by the taste, texture, freshness and nutritional value and often overlook the long journey it took from the sea to reach us. Capturing the fish involves a

series of activities each requiring energy that contributing to greenhouse gas emissions. In order to evaluate the environmental cost of fishing process, it is necessary to take into account the emissions generated along the process. The sum of all greenhouse gase emissions released during the fishing process like catching, processing, transporting etc is known as carbon footprint.

The carbon footprint is the total greenhouse gas emissions generated during a process or activity. It is usually expressed as carbon dioxide equivalent (CO_2e). The carbon footprint of fishing process is not limited to a single greenhouse gas, CO_2 . Fishing also emits smaller amounts of methane and nitrous oxide. These gases have greater capacity to trap heat than CO_2 . Since different greenhouse gases have different capacities to warm the atmosphere, their impacts are converted into a common measure based on their Global Warming Potential (GWP). Carbon dioxide is used as the reference gas, with a GWP of 1. The warming effects of other gases are expressed in relation to CO_2 .

Measuring carbon footprint in marine fisheries

A wide range of fishing methods are used in Indian marine capture fishes, each with a specific energy requirement. The amount of energy used during the fishing process depends on a number of factors such as fishing methods, the distance to the fishing ground, type of craft and gears etc. The carbon footprint of fishing begins even before the fishing process begins. The construction and preparation of the fishing vessels, engines and gear emit greenhouse gases. Energy is also needed to preserve, process and transport the landed catch. The carbon footprint of seafood displays not only what happens at sea, but the entire chain of activities involved in bringing fish from the fishing ground to consumer.

The measurement of the carbon footprint of fishing involves the accounting of the greenhouse gas emissions generated during the fishing process. The most common technique for estimating the carbon footprint is Life Cycle Assessment (LCA). LCA is the method used to estimate the carbon footprint of a product, process or activity by taking into account the greenhouse gas emissions generated during its life cycle. The information gathered from different stages of the process is used to estimate the total greenhouse gas emissions, which are expressed as carbon dioxide equivalent (CO_2e).

Before the fishing begins

The first stage is the preparation required to undertake fishing. Fishing vessels need to be built and maintained. Based on the requirements, different types of fishing gear are constructed for different fishing methods. The construction and repair of fishing boats require wood, steel, fibre-reinforced plastic and other materials. Similarly, fishing nets, ropes and other gear are made from materials such as polyethylene, polypropylene, polyamide or natural fibres. Production of these materials requires energy which in turn generates greenhouse gas emissions. Electricity and fossil fuels may also be used during the construction and repair of fishing vessels and gear. Although these emissions occur before the vessel goes to sea, they form part of the environmental cost associated with fishing.

During the fishing operation

In this phase, the fuel use becomes quite visible. Fishing vessels consume fuel during the trip from the landing centre to the fishing grounds and vice-versa. Fuel is used in operating fishing gear and carrying out fishing activities onboard. The amount of fuel consumed can vary greatly depending on the type and size of the vessel, fishing gears used, the distance to the fishing ground, fishing trip duration and conditions of sea. The combustion of fuel, mainly diesel, releases carbon dioxide and other greenhouse gases, making it one of the major contributors to the carbon footprint of fishing.

After the fish are caught

The energy demand does not end with catching of fish in sea. Maintaining the fish fresh is important, especially when vessels stay at sea for long period of time. Ice is widely used to cool and preserve fish, but producing it requires energy. Additional energy is required to freeze, store or process the at shore-based facilities. Transportation also contributes to energy use and emissions, as fish, ice, fuel, fishing gear and other supplies are transported by road or

other means at different stages of the supply chain. The energy used for transport depends on the distance travelled and the type of transport.

Carbon footprint of India's marine fisheries

Indian fisheries have always been less intensive and used less energy per unit of fish catch. Over the past five decades, there was an increase in fishing intensity and efficiency due to substantial rise in diesel consumption. According to Vivekanandan et al. (2013), fisheries related CO₂e emissions increased from 0.30 to 3.60 million tons from 1961 to 2010. At the same time period, emissions per kg of fish catch increased from 0.50 to 1.02 CO₂e.

The carbon footprint of India's marine fisheries is relatively low compared to the global average. Across India's fishing operations, including the mechanized, motorized and indigenous sectors, the average emission is 1.52 kg CO₂e for per kg of fish caught. This is approximately 30% lower than the global average (Dineshababu et al., 2024). When only mechanized fishing sector is taken into consideration, the average emission was estimated at 1.47 kg CO₂e for every kg of fish landed, against global estimate of around 2.2 kg CO₂e per kilogram of marine fish (Parker et al., 2018). However, these national averages hide considerable differences in emissions between regions and fishing methods.

Along the Indian coast, the average emissions ranged from 1.34 kg CO₂e/kg of fish in the northwest to 1.76 kg CO₂e/kg in the northeast. The southwest and southeast recorded intermediate values of 1.61 and 1.51 kg CO₂e/kg, respectively (Fig 1). These regional differences reflect variations in the fishing gears used, catch rates and the amount of fuel required to harvest the catch

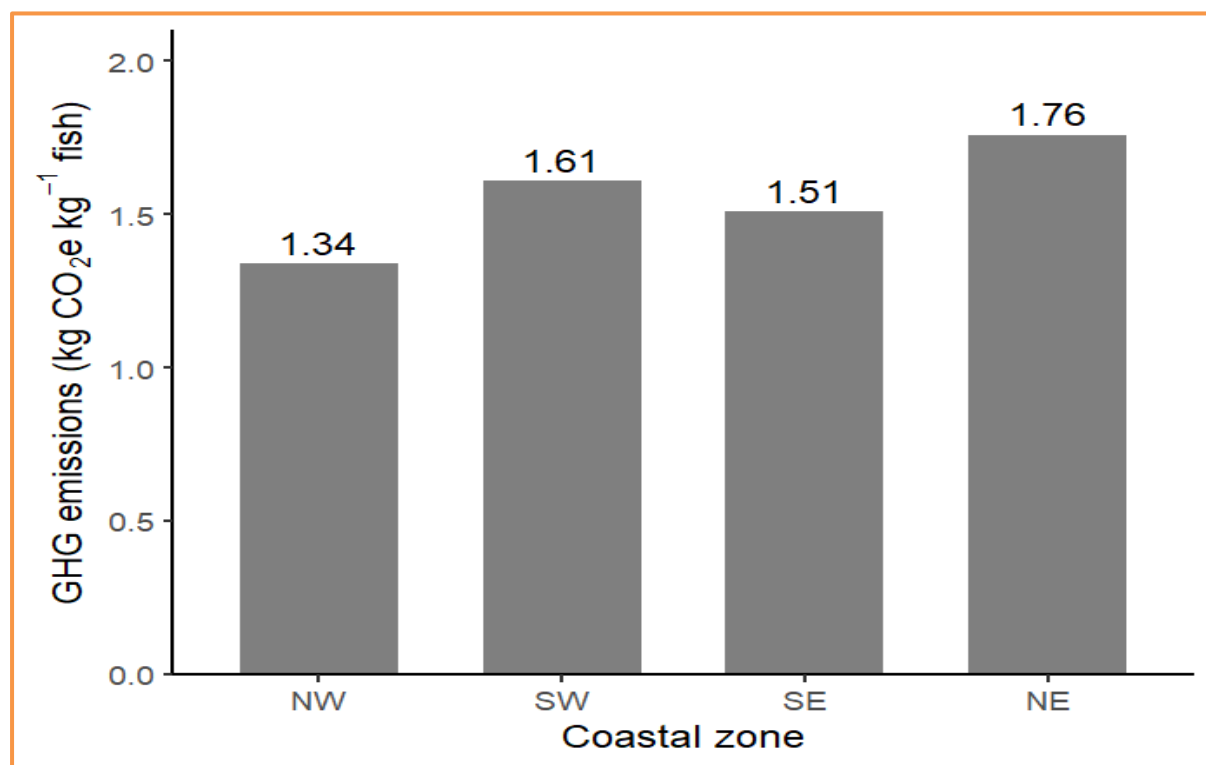


Figure 1. Greenhouse gas emissions across different coastal zones. NW: Northwest, SW: Southwest, SE: Southeast, NE: Northeast. (Source: Dineshababu et al., 2024)

The type of fishing gear used makes an even clearer difference. The emissions of trawlers that target non-shoaling species recorded an average of 1.81 kg CO₂e/kg of fish nationwide. In contrast, gears targeting fish that occur in large shoals were much more fuel-efficient. Mechanized ring seines in Kerala emitted about 0.93 kg CO₂e/kg, while purse seines in Karnataka emitted around 0.68 kg CO₂e/kg. Dolnet fishing showed an even smaller footprint, with emissions of only 0.34 kg CO₂e/kg in Gujarat and 0.39 kg CO₂e/kg in Maharashtra. These large differences are mainly due to amount of fuel used and quantity of fish caught. Fishing methods capable of catching large quantities of shoaling fish with relatively little fuel

tend to have a smaller footprint. In contrast, searching for scattered resources can require greater fishing effort and fuel for every kg of fish.

Towards low carbon fishing

Reducing emissions from marine fisheries will require a combination of better fuel efficiency, advanced fishing practices and renewable energy sources. As fuel use during the fishing operations is the primary source of emissions (~90%), improvement of engine and vessel efficiency can make a big contribution. Regular engine maintenance, efficient vessel operation, careful trip planning and avoiding unnecessary fuel use can help reduce consumption. Selecting fuel-efficient fishing gear can also reduce fuel consumption without decreasing catch efficiency. The use of renewable energy can also become an alternative way to low-carbon fishing. The solar energy can be used for lighting, refrigeration and other electrical equipment on fishing vessels and at landing centres. Other renewable energy sources can also be used by modifying according to the needs of local conditions and the scale of fishing operations. The aim to decrease the carbon footprint of fisheries does not necessarily mean reducing fishing activity. Instead, it calls for better fuel efficiency, appropriate fishing practices, advanced technologies and informed management of fishing operations. By making fisheries more energy efficient, we can move towards a seafood sector that is both productive and environmentally responsible.

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