Chapter 20

Environmental impacts of fishing

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General ecological impacts due to fishing

Fishing can have a significant impact on ecological processes on a large scale, and badly managed fisheries develop excessive fishing capacity, leading to overfishing with social and economic consequences. An ecosystem that was originally stable, mature, and efficient becomes stressed and immature as a result of overfishing. By targeting and reducing the abundance of high-value predators, fisheries deeply modify the trophic chain and the flows of energy across the ecosystem. Fishing also alters habitats by destroying and disturbing bottom topography and the associated habitats including seagrass, seaweed, mangrove, algal beds, coral reefs, and benthic communities. The alteration of the habitat by various fishing activities may be physical like the introduction of artificial structures or mechanical such as the use of bottom trawls, or chemical such as the leaching of pesticides, heavy metals, drugs, hormones, etc to the marine environment result in changes in productivity. Some aspects of fishing can have significant and long-lasting effects, e.g. destructive fishing techniques or inadequate fishing practices; pollution, use of ozone-depleting refrigerants, dumping at sea of plastic debris that can entangle marine animals or be swallowed by turtles; loss of fishing gear, possibly leading to ghost fishing; lack of selectivity, affecting associated and dependent species, resulting in wasteful discarding practices, juvenile mortality, added threat to endangered species, etc. Poorly-managed fishing practices can damage coastal ecosystems and contribute to ecosystem contamination with food residues, waste, antibiotics, hormones, diseases, and alien species.

Fishing involves the construction of the fishing vessel, gear & other accessories which channelled the harvest process. Both of these processes cause many environmental impacts. During the last 50 years, the introduction of synthetics in construction/fabrication gradually replaced natural materials such as wood for fishing boat construction and natural fibres such as cotton, manila, sisal, jute, coir, etc in the fabrication of fishing gears due to their high breaking strength, high resistance to weathering, low maintenance cost, long service life and better uniformity in characteristics also affect the marine ecosystems.

Environmental impacts of major boat building materials in aquatic system

Several technologies evolved over the years in the fishing industry which have improved the fish catch as well as the effort and the related inadequate practices leading to damage to the ecosystem and these ecological impacts were well explained in much of the literature. Hence, this chapter mainly dealt with the environmental impacts of boatbuilding materials and emissions from fishing.

In fishing boat construction, the common materials used in India include wood, glass/fiber reinforced plastic (FRP/GRP), aluminium, steel, plywood, ferrocement, etc. While selecting a material for boat construction some basic factors to be considered are type, size, speed, the shape of the vessel, availability and suitability of the material, and economic and environmental viability. The performance and efficiency of a boat are directly dependent on the choice of the boat-building material which also has a direct impact on the environment. By taking these facts into account, a boat designer can select the best possible alternative for building a boat of high efficiency and durability. A fishing boat is made up of different components and their construction is a complex process. Certain quantities of greenhouse gases (GHGs) are produced in the process of manufacture, transportation, and utilization of these components, which can be converted in terms of equivalent CO2. Every ocean has marine debris, and more than 60% of it is plastic that comes from the fishing industry, offshore platforms, recreational shipping, etc (Cheshire et al., 2009; Eriksen et al., 2014; Pham et al., 2014., Richardson et al., 2019).

At present, the larger class of fishing vessels are made of steel while vessels belonging to the medium and lower categories mostly use wood for construction. Fiberglass, ferrocement, and aluminium are the new substitutes for conventional boat building materials as these can improve the lifespan of the boats. However, traditional fishing boats still play a vital role in this era. Despite its obvious advantages, all boat-building materials are susceptible to the effects of the marine environment, for example, glass fibres are the most selected material for boat construction, which are vulnerable to the effects of sunlight in marine conditions. Fiberglass-reinforced plastic (FRP) is a polyester resin-based composite, reinforced with fine strands of glass filaments. Glass fiber is prone to osmosis, and gelcoat gets faded in sunlight resulting in the attack of UV radiation. FRP fragments have a higher density than seawater and will tend to concentrate nearshore. The polyester resins or epoxy resins in the FRP undergoing physical &

chemical degradation lead to the release of microplastics which affects the environment. Marine organisms consume these plastic particles and end up in the human food chain causing severe health issues. Additionally, the deteriorating and peeling paint with high concentrations of tributyltin and lead from the abandoned boats may provide a long-term environmental issue

Aluminium alloys are prone to corrosion if untreated or damaged. When new alloys are exposed, an oxide layer is formed on their surface but this oxide layer does not protect the alloy in the long term when exposed to marine environments. Periodically the paint system will need to be removed in areas of stress and the corrosion treated. Careful inspection on an annual basis of all weld seams helps in early identification of the occurrence of this problem. Aluminium reacts with some copper-based antifouling paints causing serious corrosion in environmental conditions. Therefore, antifouling containing metallic copper or cuprous oxide should never be used on aluminium, whilst copper thiocyanate-based antifouling can be used if the aluminium is primed properly.

The most common form of corrosion in steel is rust. Such a reaction will take place only in the presence of water. A marine environment is therefore an ideal place for rust to occur. Due to the high flexibility and strength of steel, it is hard to break, but impact damage may well result in a dent owing to the metal stretching and deforming locally. This can present problems for a protective coating, which may not be so flexible.

The fibrous nature of timber means that it has a tendency to absorb moisture from the atmosphere, and swell and contract to varying degrees depending on the type of construction. For a varnish or paint coating to stay intact it has to be quite flexible in nature. Moisture content in wood allows the growth of fungal spores, which leads to rotting and decay. Wood can also be subjected to the attack of marine borers, which eat the wood fibers. Therefore, it needs to be protected by good-quality preservatives and coatings. Many different kinds of wood can be used, which can differ immensely.

A comparative table giving the carbon consumption in the production of these materials

Material	Net carbon emissions (kg C/metric) [1]	Net Carbon emissions including Carbon storage within material (kg C/ metric ton)[2]
Framing Lumber	33	-457
Medium density fibre board	60	-382
Steel	694	694
Aluminium	4532	4532
Plastics	2502	2502

Net carbon emissions in producing 01 ton of material (OECD, 2010)

While considering the environmental and economic sustainability of different boat building material, wood is an ideal material still preferred for marine boat construction. Wood is a functionally efficient material which reduce carbon footprint thereby reducing the environmental impact and simultaneously balance the cost objective. Environmental impact of any material can be evaluated through Life cycle assessment procedure or LCA. The environmental impact of wood from the very first state of harvesting to the end of the product was studied and compared with other materials and found that wood as a material for boat construction contributes less pollution to the environment compared to concrete, steel, aluminium, etc.

Studies have found that wood products have less embodied energy and are more environmentally friendly as they are involved in less carbon footprint as well as air and water pollution. Furthermore, residues of wood industries are utilized in either by-product manufacturing or fuel and clean bio-energy. As forests act as a carbon sink and prevent climate change and greenhouse gas, increasing wood use ensures sustainable development by reducing emissions, increasing renewable wood use, and thus helping the national economy.

Fishing Vs Energy use

Commercial fishing operation mainly utilizes fossil fuels which result in the emission of greenhouse gases. The active cost of fishing is less understood and consequently receives less attention to GHG emissions than the direct impact on fishery stock and marine ecosystem. Similarly, in the harvest process, several reoccurring inputs are required for every fishing operation, viz. fuel, lubricant, ice, freshwater, etc. These inputs have their own carbon footprint value for construction/extraction/process, especially fuel contributes more than 95% out of all the components. Despite the fact that the prevailing pre-harvest phase of marine capture fisheries lacks general detail and standardization about LCA/carbon footprint studies; such studies and their findings can be useful in formulating constructional/operational recommendations to improve the environmental performance of fisheries, under the context of an ecosystem approach to fisheries along with future certification and different eco-labeling of fisheries. Studies related to pre-harvest, harvest, and post-harvest fisheries LCA/carbon footprint analysis would be more appreciated by policymakers for the regulation of fishing boat yards and other related fishing ventures.

Based on behaviour and habitat, there are different methods of fish harvest and on the basis of their operation, the quantum of fuel and energy requirement also varies. As per the study by Parker et al., 2018, the world fishing fleet burned about 40 billion liters of fuel and emitted 179 million tonnes of CO_2 equivalent and other GHGs to the atmosphere. Overcapacity and irresponsible use of fossil fuels leads to increased levels of fuel consumption in fishing contributing to climate change in the long run. India contributes 134 million metric tonnes (2.7%) of CO_2 emission due to total marine capture fisheries, against 90 million metric tonnes (3.9% of global production) of fish production. The emissions due to fishing were not given importance as compared to other sectors for emission in India, however, the contribution of the fisheries sector is negligible which roughly may be $<1\%$ of global GHG emission. The other associated important environmental parameters by which the health of the environment, humans, and resources can be evaluated due to the fishing process are; terrestrial acidification, formation of fine particulate matter, Water consumption, Ionizing radiation, ozone formation, human carcinogenic toxicity, fossil resource scarcity, mineral resource scarcity environment deterioration, human health, resource depletion, and stratospheric ozone depletion, etc.

Different types of vessel and gear combinations are used for fishing to exploit various fish stocks. The important fishing practices are trawling, gillnetting, longlining, dol netting, purse seining, etc. One major reason for the substantial increase in eq. CO_2 emission by the construction process is the increase in the number and efficiency of fishing boats otherwise called overcapacity, which need more inputs and equipment, resulting in more eq. CO_2 emission.

In modern fisheries, the major direct and indirect energy inputs can be systematically analyzed using process analysis and input-output techniques. Mostly direct fuel inputs are used primarily for vessel propulsion. On average direct fuel energy inputs account for between 75 and 90% of the total energy inputs, irrespective of the fishing gear used or the species targeted. The remaining 10 to 25% generally depends on vessel construction and maintenance, and the provision of labour, fishing gear, bait, and ice if used which depends on the character of the fishery and the scope of the analysis conducted. The secondary energy-consuming activities, which include onboard processing and storage are negligible compared to primary energy consumption in terms of fuel burned. The study of environmental burden is important in relative resource-use analysis and greenhouse gas (GHG) impacts in climate change mitigation. It has got emphasis due to the high instability in fossil fuel costs which has potentially lasting impacts on the economic performance of various fishing systems.

The effects of fishing and its implications on ecosystems, especially from the boat-building sector or the usage of energy, fuel, and emissions, were not particularly addressed and are anticipated to have significant effects on ecological sustainability and food security globally.