

### 3.3 Environmental challenges in aquaculture

A significant environmental challenge is the discharge of aquaculture effluents, which contain dissolved nutrients like nitrogen that contribute to eutrophication, particularly in cage culture systems. High-density culture environments can stress aquatic species, increasing susceptibility to disease and leading to a reliance on antibiotics, which further deteriorates water quality (Noor et al., 2019). Furthermore, the transition from traditional rotational cropping to intensify shrimp culture has occasionally resulted in poor water quality and reduced growth rates. A critical ecological risk is the escape of farmed fish, as interbreeding with wild populations can lead to high mortality rates and reduced genetic fitness in offspring.

### 3.4 Freshwater aquaculture in India

Freshwater aquaculture development in India continues to expand, though it faces constraints related to input availability and environmental management (Jayasankar, 2018). Cage aquaculture has been introduced as a viable method for ecosystem-based management, showing success with species such as cyprinids, perches, and catfishes (Radhakrishnan et al., 2010). When managed correctly, these systems leverage natural productivity (phytoplankton and zooplankton) to provide economic opportunities for rural communities. Currently, India is the second-largest fish producer globally, contributing approximately 8% of total production. The country continues to leverage its vast inland resources-including rivers, reservoirs, and tanks through strategic development programs aimed at enhancing sustainable productivity (Table 1, Table 2).

Table 1 Marine resources and statistics

Parameter	Value	Unit	Source
Total Coastline Length	8,118	km	Government of India / FAO (2022-2024)
Exclusive Economic Zone (EEZ)	2.02	million km <sup>2</sup>	FAO (2022-2024)
Continental Shelf Area	0.42	million km <sup>2</sup>	FAO (2022-2024)
Fish Landing Centers	1,376	Number	National Marine Fisheries Census (2005)
Fishing Villages	3,322	Number	National Marine Fisheries Census (2005)
Fishermen Families	764,868	Number	National Marine Fisheries Census (2005)
Total Fisher folk Population	3,574,704	Number	National Marine Fisheries Census (2005)

Table 2 Inland resources

Parameter	Value	Unit
Rivers and Canals	195,210	km
Reservoirs	3.15	million hectares
Tanks and Ponds	2.414	million hectares
Flood Plains / Derelict Water Bodies	0.8-1.2	million hectares
Brackishwater Area	1.24	million hectares
Saline / Alkaline Affected Area	1.20	million hectares

### 3.5 Brackish water aquaculture in India

India has contributed remarkable aquaculture producer, contributing significantly to both domestic and international markets. The country leverages vast inland resources like ponds and tanks, along with brackish/saline areas, for a variety of fish like carps, catfish, and tilapia, and has expanded into saline water aquaculture using inland saline groundwater. This is exemplified by the commercial farming of the Pacific white leg shrimp (*Litopenaeus vannamei*) in states like Haryana, Punjab, Rajasthan, and Uttar Pradesh. India is the second-largest producer of aquaculture in the world. The emphasis on brackishwater aquaculture invited large number of private companies and multi-nationals in intensive aquaculture resulted detrimental impact and serious environmental and health issues among the coastal community due to large conversion of thousands of hectares of coastal lands for intensive shrimp farming. The mangroves were cleared, wetlands were encroached and drained, and aquaculture tanks were built into freshwater lakes. Apart from saltwater intrusion into freshwater bodies, including aquifers, and aquaculture practices led to the release of contaminants into water sources.