major drivers of biodiversity loss (Peay et al., 2019). Historical intensification of shrimp farming, for instance, has been linked to soil salinization, reduced agricultural yields, and the degradation of mangrove wetlands.

Ensuring environmental protection at an acceptable level is mandatory given the rising global food demand. Transitioning toward resource-efficient and technologically advanced systems-such as Recirculating Aquaculture Systems (RAS), Integrated Multi-Trophic Aquaculture (IMTA), and well-managed offshore cage farming-can address the challenges associated with conventional methods (Brugere and Ridler, 2004). Ultimately, the effective protection of the marine environment supports the creation of high-value products, including new pharmaceuticals, renewable energy, and sustainable protein sources.

2 Methods Adopted

This review was conducted using a systematic literature search strategy to ensure rigor, transparency, and relevance. Scientific databases including Scopus, Web of Science, PubMed, Science Direct, and Google Scholar were searched to collect peer-reviewed literature related to sustainable aquaculture practices in India and globally. The time window for literature selection covered publications from 1988 to 2024, with greater emphasis on studies published after 2010 to ensure contemporary relevance.

The primary keywords used for the search included: sustainable aquaculture, biosecurity in aquaculture, integrated multi-trophic aquaculture, recirculatory aquaculture systems, shrimp farming sustainability, climate change and aquaculture, inland fisheries management, and biodiversity conservation in aquaculture. Boolean operators (AND, OR) were applied to refine search combinations and improve specificity.

Inclusion criteria comprised peer-reviewed journal articles, review papers, official reports (e.g., FAO and national fisheries agencies), and research studies directly addressing sustainability, ecological management, disease control, productivity enhancement, and environmental impacts in freshwater, brackishwater, and marine aquaculture systems. Exclusion criteria involved non-scientific opinion articles, duplicated studies, papers lacking methodological clarity, and publications not directly related to aquaculture sustainability.

The selected studies were screened initially based on title and abstract relevance, followed by full-text evaluation for methodological robustness and data reliability. Extracted data were categorized into thematic areas including ecological aspects, natural resource management, biodiversity conservation, biosecurity, climate resilience, and socio-economic sustainability. A qualitative descriptive synthesis approach was adopted to compare findings, identify common trends, highlight gaps, and draw integrative conclusions regarding sustainable aquaculture development. This structured methodology ensures that the review is comprehensive, evidence-based, and aligned with contemporary academic standards for systematic review articles.

3 Sustainable Aquaculture Production

3.1 Overview of sustainable aquaculture

Sustainable aquaculture systems are engineered to maximize socio-economic benefits while mitigating adverse environmental impacts. Despite economic fluctuations, aquaculture remains a cornerstone of rural livelihoods and food security, particularly in Indian states like Andhra Pradesh. In regions such as West Godavari, the sector has transitioned into high-density farming zones. However, the intensification of commercial practices-including integrated rice-fish farming-faces challenges regarding long-term ecological resilience. Transitioning toward moderate stocking densities and optimized feed application is essential to satisfy international market demands while maintaining ecosystem health (Betala and Betala, 2025).

3.2 Traditional aquaculture systems and their challenges

In Southeast Asia, traditional systems like rice-cum-fish and carp polyculture are being refined through Environmental Impact Assessments (EIA) to eliminate the misuse of aqua chemicals and promote natural resource conservation. Sustainability in these systems is achieved by managing biomass and waste through strategic site selection and the determination of carrying capacity (Wurts, 2000). Comprehensive hazard assessments are vital to prevent disease transmission and ensure food safety for human consumption.