

5 Evaluation of the Application Effects of Green *Porphyra* Farming Models

5.1 Impact on farming yield and product quality

Green *Porphyra* farming models tend to improve yield stability by aligning cultivation intensity and harvest timing with environmental conditions that control growth. Field-based and mechanistic evidence shows that *Porphyra* biomass accumulation is strongly shaped by temperature, nutrient availability, irradiance, and stage-specific growth dynamics, so management that responds to these variables is better positioned to sustain production across the culture cycle (Lin et al., 2025). This effect is practical rather than theoretical, because seasonal thresholds for sustainable biomass and growth have already been identified in cultivation models, allowing managers to reduce overstocking and better match harvest schedules to peak biomass formation (Lin et al., 2025).

Product quality also appears to benefit when green models reduce environmental stress and improve farm management precision. In the Maine case, organically certified nori was successfully produced and marketed, showing that environmentally oriented production can support differentiated, higher-value product pathways. At the same time, unstable site conditions, disease, farming inexperience, and drought-related nitrogen depletion caused inconsistent production, indicating that green production only supports quality advantages when site selection and environmental management are robust.

5.2 Impact on resource utilization efficiency and environmental load

Green *Porphyra* farming models improve resource utilization efficiency mainly through nutrient recovery and ecosystem-based purification. Large-scale *P. yezoensis* cultivation in Jiangsu significantly reduced ambient inorganic nutrient concentrations, with ammonium, nitrite, nitrate, and phosphate all lower in the cultivation season than in non-cultivation periods, confirming that the crop efficiently converts dissolved nutrients into harvestable biomass (He et al., 2008). Harvested biomass also removed substantial amounts of nitrogen and phosphorus from the water, directly linking production output to nutrient extraction rather than to feed or fertilizer input (He et al., 2008).

These environmental gains extend beyond nutrient removal to broader reductions in coastal environmental load. At the national scale, seaweed aquaculture in China removed 75,563 t of nitrogen and 9,592 t of phosphate from coastal waters in 2015, while also sequestering carbon and reducing the need for chemical fertilizers and pesticides compared with land-based vegetable production. *Porphyra* cultivation also appears to support carbon-focused resource efficiency, because cultivation zones showed higher dissolved organic carbon and a 169% higher estuarine addition of microbially sourced humic-like C3 during the farming period, consistent with enhanced transformation of organic matter into more refractory carbon pools (Wang et al., 2025).

5.3 Impact on farming profitability and industrial competitiveness

Green *Porphyra* farming models can strengthen profitability when environmental services are translated into lower input intensity, improved market positioning, or greater resilience. Resource-use analysis in southeastern China found that *Porphyra* production had a mean exergy demand of 0.98 GJ eq. per live-weight ton, much lower than major animal mariculture products, suggesting an inherent efficiency advantage that can support competitive production if farm operations and fuel use are well managed. However, 83%-99% of seaweed-production impacts were linked to fuel used in operation and maintenance, so green competitiveness depends heavily on farm design, logistics, and spatial planning rather than on biology alone.

Industrial competitiveness also improves when green *Porphyra* farming is embedded in broader blue-economy value creation. China's seaweed cultivation has been framed as a sustainable mariculture model with ecological and economic benefits, including major contributions to carbon sequestration and blue-carbon development, which can expand the industry's strategic value beyond food production alone (Wang et al., 2025). Even so, evidence remains mixed on how easily environmental benefits convert into farm-level profits, because regional water quality, species selection, and management intensity still require spatial adjustment, and poorly matched farming layouts can reduce both ecological and economic performance.