



## CREATING A BLUE REVOLUTION: SEAWEED CULTIVATION UNLEASHES POTENTIAL IN INDIA

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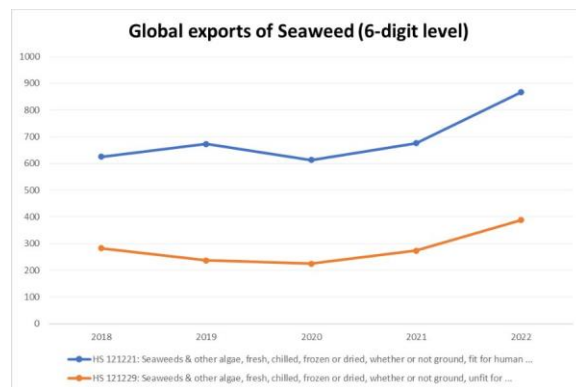
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### Introduction

Seaweeds, often seen as microscopic algae, have diverse applications in food, energy, chemicals, and medicine, significantly impacting agriculture, biomedicine, and personal care. This study explores seaweed applications, market status, and business opportunities in India, focusing on the contributions of CSIR-Central Salt and Marine Chemicals Research Institute. Concurrently, seaweed cultivation, especially in coastal states like Tamil Nadu, Gujarat, and Maharashtra, aligns with the sustainable Blue Revolution, meeting the demand for seaweed products and boosting the economy. This growth emphasizes research in cultivation techniques, product development, and seaweeds' potential in pharmaceuticals, bioplastics, and wastewater treatment. Beyond economic benefits, seaweed cultivation aids marine ecosystems, absorbing carbon dioxide, providing habitat, and contributing to coastal protection. As India's Blue Revolution progresses, responsible and sustainable seaweed cultivation, involving government, academia, industry, and coastal communities, is crucial for a harmonious sector. This transformation not only impacts the coastal landscape but also holds global potential for sustainable solutions, integrating seaweed cultivation with innovations in pharmaceuticals, bioplastics, and wastewater treatment, making it

an exciting time for India to harness this marine resource's full potential.

### Current Status of Global Seaweed Production



The global seaweed market has experienced substantial growth, averaging a 9% annual increase, according to the World Bank in 2023. The State of World Fisheries and Aquaculture (SOFIA) report by the Food and Agriculture Organization revealed that global algae production, including seaweed and microalgae, reached 36 million tons wet weight in 2020. Valued at US\$ 7.5 billion in 2022, the seaweed market is projected to grow at a Compound Annual Growth Rate (CAGR) of 11.64% from 2023 to 2028, owing to seaweed's versatility and sustainable nature. Chile dominates industrial seaweed exports, reaching US\$ 177.3 million in 2022 with a remarkable YoY growth of 41.7%. In contrast, India ranks 40th, emphasizing the need for strategic measures to enhance its position.

For seaweed intended for human consumption, Indonesia leads with exports at US\$ 374.4 million in 2022, showing a significant YoY growth of 78%. India ranks 37th in this category, with exports valued at US\$ 646,000, facing a negative YoY growth of 42%.

The global demand for seaweed for human consumption presents an opportunity for India to explore avenues for growth and competitiveness. Chile's success is attributed to the production of 18 different species, supported by a workforce of at least 35,000 fishermen and gatherers. The evolving consumer landscape, driven by increased environmental awareness, favors macro algae for its role in carbon absorption and oxygen release, aligning with sustainability goals. The rise in veganism and plant-based products further fuels interest in macro algae production.

As the seaweed market continues to expand globally, India, with its extensive coastline and diverse marine ecosystem, has the opportunity to leverage strategic initiatives and sustainable practices for seaweed cultivation. By tapping into its untapped potential, India can emerge as a significant player in the seaweed market, catering to both industrial and human consumption. The convergence of consumer trends and environmental consciousness presents a promising avenue for India to contribute to and benefit from the ongoing seaweed revolution.

Top Seaweed Importing Countries	Import Size in US\$ million	
	2021	2022
China	155,717	254,508
France	25,718	48,452
United States of America	38,074	48,094

Spain	16,156	21,815
Japan	13,715	20,395
Ireland	12,550	12,909
United Kingdom	12,232	12,272
Germany	5,279	6,881
Australia	4,428	6,140
Chile	4,733	5,783

### Export Potential in India

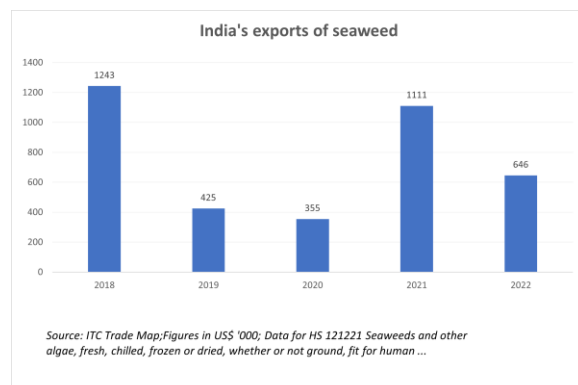
India's current performance in seaweed exports is characterized as weak and erratic, but promising developments, such as the establishment of new hubs in states like Tamil Nadu and Lakshwadeep, suggest a bright future for the sector. These emerging hubs have the potential to strengthen India's position in the global seaweed market, which is undergoing significant transformation. Seaweeds, once underestimated, are proving to be a dynamic force with the potential to revolutionize various industries and contribute to sustainable practices. With a vast coastline of over 7,500 kilometers, India is uncovering a hidden treasure beneath its waves – seaweed. Referred to as the "wonder plants of the sea," seaweeds are emerging as a sustainable powerhouse for industries spanning from food to energy, chemicals, and medicines. They are a renewable source with diverse applications in agriculture, biomedicine, and personal care.

Seaweeds, often called the "Medical Food of the 21st Century," are utilized in the production of laxatives, medicinal capsules, and treatments for conditions such as goiter, cancer, and bone-replacement therapy. Industrial applications include agar, agarose, and carrageenan, essential components in labs, medicines, cosmetics, cardboard, paper, paint, and processed meals. In India, 46 seaweed-based

industries, 21 focusing on agar, and 25 on alginate, contribute to various sectors. However, their full potential remains untapped due to challenges in the supply of raw materials.

Traditionally, seaweed seed stock is gathered from the seabed in shallow waters along the southeastern coast of Tamil Nadu. Cultivating seaweeds proves to be a lucrative venture, characterized by simple, low-cost, and low-maintenance technology with a short grow-out cycle. However, unregulated harvesting practices have led to the depletion of natural resources, urging a shift towards sustainable cultivation. While seaweeds have been a staple in Asian cuisines, including Japanese, Chinese, and Korean dishes, India's diverse marine ecosystem provides an ideal environment for seaweed cultivation. Coastal states like Tamil Nadu, Gujarat, Maharashtra, Andhra Pradesh, and Kerala are spearheading efforts to explore the vast potential of seaweed farming.

The economic impact of India's seaweed industry is significant, estimated at approximately US \$600 million, providing employment for over 200,000 individuals. As the nation taps into this aquatic resource, seaweeds are poised to redefine sustainable practices, offering a plethora of benefits to the economy, the environment, and the well-being of its people. The seaweed revolution is underway, transforming the coastline into a source of prosperity and innovation.



## Agricultural Industry: Plant Growth Regulators

The agricultural industry confronts challenges from a growing global population, diminishing cultivable land, and adverse climatic conditions affecting yields. Seaweed-based plant biostimulants offer a natural complement to traditional fertilizers, addressing abiotic stress, especially heat and drought stress, and substantially contributing to increased agricultural yields. The global seaweed biostimulants industry, currently valued at USD 1 billion, is projected to reach USD 1.8 billion by 2030, maintaining a 30% market share. In the Indian market, seaweed extract biostimulants dominate, holding a 37.4% market share with a total value of USD 57.2 million in 2022. The Indian biostimulants market is anticipated to grow at a CAGR of 10.51% from 2023 to 2029, underscoring the growing importance of seaweed-based solutions in sustainable agriculture practices.

The growth of seaweed-based biostimulants is fueled by environmental concerns and an increasing shift towards organic foods. Global implementation of organic regulations has further boosted biostimulant growth. Favorably, low entry barriers for manufacturing seaweed-based biostimulants provide opportunities for numerous Micro, Small, and Medium Enterprises (MSMEs) to enter the business. The recent introduction of registration policies in India signals a regulatory framework, promoting a more structured industry. Manufacturers benefit from utilizing byproducts from the biostimulant extraction process as raw materials for other products, creating a sustainable production cycle.

Despite increasing interest in seaweed-based biostimulants, challenges persist in convincing efficacy due to complex interaction mechanisms in different soil types, resulting in

inconsistent performances. Lack of evidence and understanding of these interactions remains a major hurdle. The novelty of biostimulants poses challenges for stakeholders and end-users unfamiliar with their benefits. While entry barriers are low, small and medium-scale enterprises face difficulties competing with established large companies operating under existing business models. Many seaweed biostimulant producers adopt a Business-to-Business (B2B) model, complicating the market landscape for smaller players. Additionally, the absence of standardized certifications for nutrient requirements and efficacy of seaweed biostimulants globally is a significant challenge, impacting the industry's growth.

### **Food Industry**

Global challenges stemming from climate issues, shrinking land areas, and the pursuit of sustainable agriculture are critical considerations for global food production. The escalating demand for food requires more sustainable and nutritious solutions, with estimates suggesting a need for a 50-70% increase in food production by 2050 to sustain current consumption trends. As consumers become more conscious of the nutritional value of food and gravitate towards healthier choices, the culinary industry is exploring seaweeds as a valuable food source or ingredient. Seaweeds, renowned for their nutritional properties, offer a sustainable supplement to address the growing demand for food. They are already consumed directly in various dishes like salads and sushi, particularly in southeast Asian countries such as Japan, China, and Indonesia.

Seaweeds are generally low in fat and rich in carbohydrates, minerals, vitamins, dietary fiber, and essential micronutrients, including antioxidants. India, blessed with an extensive coastline of 8100 km and a vast exclusive

economic zone of 2.17 million km<sup>2</sup>, harbors diverse seaweed resources, including almost 700 species. Despite this abundance, the utilization of Indian seaweed in food and nutraceutical applications is significantly limited. The rising demand for vegetarian-based nutritious food is a key factor fueling interest in seaweed-based foods, influenced by exposure to and the popularity of international cuisines, especially within the hotel industry.

However, challenges persist in meeting the demands of the hotel industry, notably the year-round availability of raw materials (seaweed materials). Ensuring a consistent supply and maintaining uniform quality of raw materials are critical issues that need to be addressed to fully leverage the potential of seaweed-based foods in the culinary landscape.

### **Food Processing Industry**

Alginate, the predominant polysaccharide in brown algae, constitutes up to 40 percent of the dry weight of brown seaweed. Alginates serve as crucial components in various industries, functioning as gelling agents in the food industry and stabilizing and thickening substrates in sectors such as beverages, cosmetics, paper, pharmaceuticals, printing, and textiles. Agar, a polysaccharide mixture, is another significant component with versatile applications in the pharmaceutical, food, and cosmetic sectors. Extracted from red seaweeds, carrageenan acts as a structuring agent with diverse applications, including its use as a functional ingredient in yogurt and a thickening agent in ice cream.

As qualitative research advances and the demand for processed food grows, along with changing lifestyles, there is an increasing need for sustainable and nutritious materials as core ingredients. Over the past decade, leading agar production industries have focused on producing more food-grade agar than bacteriological grade

agar due to a scarcity of good-quality raw materials. Identifying other suitable algae can play a crucial role in meeting domestic demands for these valuable seaweed-derived products.

### Animal and Pet Feed Industry

Seaweed is already contributing to the production of feed additives and feed ingredients, playing a crucial role in addressing the challenges posed by the growing global population and increasing reliance on animal-based food systems. The seaweed-based animal feed additive market is projected to reach USD 1.122 billion by 2030, reflecting its significant potential. Preliminary studies also indicate that incorporating seaweed-based animal feed could contribute to reducing methane emissions from animals. Several factors contribute to the advantageous position of seaweed-based feed additives. Increasing consumer concerns about meat quality and food safety align with the economic gains and conversion efficiency offered by these additives. The high cost margin of seaweed-based feed additives positions them competitively against existing feeds in the market. However, it's important to note that the production of seaweed-based animal feed requires a substantial volume of raw materials. Without a consistent and adequate supply, the potential for optimum production and maintaining a price advantage over other competitive feed additives may be compromised. Ensuring a reliable and sustainable supply chain for raw materials is crucial for the continued success and growth of the seaweed-based animal feed industry.

### Conclusion

India, with its extensive coastline, holds significant potential for seaweed cultivation. As market demands evolve in various aspects of life, the use of seaweed and its applications becomes inevitable. The scientific advancements made by

CSIR-CSMCRI in seaweed cultivation and value processing contribute to strengthening the Indian markets. There is a substantial entrepreneurial opportunity in the cultivation and processing of seaweeds, reflecting the broader potential for sustainable and innovative solutions.

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