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Rapid market analysis of the seaweed value chain in Cox's Bazar, Bangladesh

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Rapid market analysis of the seaweed value chain in Cox's Bazar, Bangladesh

▶ Acknowledgements

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▶ Executive summary

Seaweed is a highly versatile product, offering potential not only as a nutritious food source but also as a key component of a variety of consumer and agricultural goods. With various environmental benefits on top of its commercial potential, the crop presents an important opportunity for boosting incomes and generating entrepreneurship opportunities for vulnerable populations in Cox's Bazar.

As part of the project "Leaving No One Behind: Improving Skills and Economic Opportunities for the Bangladeshi Community and Rohingya Women & Youth in Cox's Bazar", the ILO has sought to better understand the challenges and opportunities within the seaweed value chain by conducting a rapid market system assessment. The assessment used a blend of desk and field research to map the seaweed value chain, identify the key market actors, and shed light on the challenges and potential market solutions to address them, with women and vulnerable groups maintained at the centre of focus.

The enormous potential of seaweed, both globally and domestically in Bangladesh, owes largely to growing demand driven by its diverse applications and markets. Seaweed can be used as a nutritious source of vitamins and protein on its own, or used as a thickening agent in a wide range of food products. Seaweed by-products are also widely used in pharmaceutical and cosmetic products, in addition to agricultural goods such as animal feed and fertilizers. Although Bangladesh's seaweed industry is in its nascent stages, the country – especially the district of Cox's Bazar – is well situated, with ideal geographic and climactic conditions for seaweed production.

In Cox's Bazar, seaweed is harvested and cultivated at a small scale by households in coastal communities and by local fishermen. For most, it serves as a source of supplementary income to complement other economic activities. Seaweed traders are also primarily individuals from these local communities. Nevertheless, seaweed and its processed goods remain a niche within local and domestic markets in Bangladesh.

There is, however, a lack of technical knowledge at the production and processing levels, an absence of value-added products, and a lack of existing industrial facilities for extracting high potential seaweed by-products. Other key challenges within the sector include the absence of nurseries for providing seaweed seeds for cultivation; untapped access to markets in the animal feed, hospitality, and other industries; and a non-conducive policy environment with, for example, a lack of coordinated efforts to advance the industry and a lack of relevant product certifications.

To address these problems, the report outlines a number of potential areas for market-based interventions, centred around:

- **Increasing production and productivity,** for example, through interventions that aim to support the establishment of nursery infrastructure and technology for seaweed production or that foster consensus on improved cultivation methods.
- **Supporting sector development and coordination,** including by strengthening the social marketing of seaweed and its commercial applications.
- **Developing value addition opportunities,** which could be done through interventions that establish pilot-scale industrial level agar extraction facilities and promote high-value seaweed species cultivation.

By focusing on these intervention areas, the project holds the potential to foster the development of Bangladesh's nascent seaweed sector while simultaneously contributing to the socioeconomic development of local communities in Cox's Bazar.

▶ 1. Introduction

▶ 1.1. Project introduction

This rapid market assessment was conducted under the project "Leaving no one Behind: Improving skills and economic opportunities for the Bangladeshi Community and Rohingya Women & Youths in Cox's Bazar," a joint initiative by the International Labour Organization (ILO), the UN Refugee Agency (UNHCR), and BRAC, with financial support from Global Affairs Canada. The project pursues the economic empowerment of the Bangladeshi host community and the Rohingya refugees in the Cox's Bazar district of Bangladesh. It leverages a gender-sensitive and market-relevant skills development approach linked to (a) to self-reliance activities in the camps and (b) employment and self-employment in growth sectors for the host communities.

The market systems approach is one which aims to address the root causes of why markets may not be meeting the needs of certain subsets of the population, including people living in poverty, youth, women and other disadvantaged people. The approach builds on the capacities and incentives of market actors – both private and public – to increase the likelihood that positive results are sustained and even scaled up after intervention.

Box 1. What is a market system?

A **market system** refers to the inter-connected network of actors and factors that interact to shape the outcomes of an economic exchange. These exchanges are governed by a range of:

- **Supporting functions:** The context- and sector-specific functions that inform, support and shape the quality of exchange, such as information, skills, infrastructure, finance and access to markets.
- **Rules and norms:** The legislative and regulatory environment, including policies, voluntary standards and social norms that guide day-to-day attitudes and conduct.

Supporting functions and rules are carried out by a wide range of market actors, from businesses to financial institutions, trade associations, regulators and government agencies. When certain rules or functions do not operate well, a market system constraint is created that reduces the effectiveness of the system and reduces the value captured by the people and market actors involved in the transaction.

Market systems development programmes aim to create positive systemic changes. A systemic change takes place when there is a lasting improvement in one or more market system constraints that leads to improved outcomes for target groups, be they workers suffering from poor safety and health conditions, or young people excluded from the labour force. such programmes discover why market actors have not addressed these constraints themselves, and then work on improving these actors' incentive and capacity to perform new or improved roles.

Source: Ripley 2016.

▶ 1.2. Study purpose and objectives

This rapid market systems analysis was conducted to identify the key constraints in the seaweed value chain, along with the corresponding root causes that limit functionality within this market. For this study, the analysis looks into understanding the market around the project's target group: the Bangladeshi community, particularly women, in Cox's Bazar, with a focus on boosting income and generating entrepreneurship and self-employment opportunities as a contribution towards poverty reduction.

▶ 1.3. Study methods

The research was carried out in two phases:

- **Desk research:** Available literature was gathered to provide a framework for the primary data collection process. This included a review of national laws, sector data and market trends as well as studies conducted by other development agencies.
- **Field research:** Primary research was conducted in Cox's Bazar during two weeks in July 2023. During this stage, a total of 30 businesses and organizations were interviewed. The interviews were semi-structured and conducted with government officials, producer associations, formal and informal business owners, community groups, non-governmental organizations, and key industry informants. The interviews provided an in-depth picture of the sector from a diverse set of actors and opinions. A detailed list of all the interviewed stakeholder organizations is included in Annex A.

The research is based on the methods of the *ILO's Value Chain Development for Decent Work guide* and the Springfield Centre's *Operational Guide on the M4P Approach*. Results were validated through triangulation of data and methodologies. This means the research uses different types of data (both primary, and secondary) and multiple methods (such as, observation and surveys).

The project validated the study findings at a validation workshop attended by the ILO's tripartite partners and relevant stakeholders. Here, more than 35 participants, including industry stakeholders, research organizations, and representatives from workers' and employers' organizations discussed the findings and suggested changes, which have been taken into consideration in the final revision of this report.

▶ 1.4. Report structure

The report first provides an overview of the seaweed value chain, how the sector has developed over time, and how the various interactions along the value chain impact the target group of the programme (Section 2). It then looks at the seaweed market system, including its key constraints and their possible root causes (Section 3). The analysis findings are then used to develop a project strategy, which includes an assessment of the incentives and capacity of market actors to intervene in the market and identification of potential interventions that could help address the identified root causes in a sustainable way (Section 4).

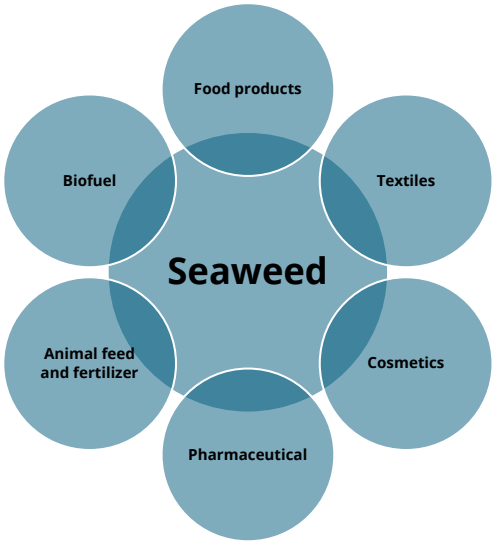
▶ 2. Sector overview

Seaweed is a highly versatile product. In addition to being an important food source for a wide range of marine life, it is also highly used for human consumption, animal feed, cosmetics, pharmaceuticals, fertilizers, and biofuels. The sector also presents a number of environmental benefits, including coastal protection via wave reduction, supporting marine biodiversity, enhancing fish production, and carbon capture.

Seaweed is typically categorized into three main varieties. **Red** seaweed is the most dominant in the global market. High in vitamins and protein, it is most commonly used in foods and as a source of hydrocolloids (such as agar and carrageenan). **Green** seaweed contains high levels of beta-carotene, which has shown to be effective in cancer prevention and has other medical uses. Finally, **brown** seaweeds are widely used in agriculture, animal feed, and food and beverages.

Agar and carrageenan are two popular hydrocolloids that are derived from red seaweed. Agar is a gelatinous substance extracted from certain species of seaweed. It is a common ingredient in the food industry, where it is used as a vegetarian alternative to gelatine, and it is often used in desserts, confectionery, jellies, and as a bacterial culture media in microbiology. Carrageenan is another extract obtained from red seaweeds, and is used in food products and cosmetics.

Figure 1. Overview of product areas relevant to seaweed cultivation



▶ 2.1. Market trends

The global seaweed market is estimated to be between US$6.5 and US$15 billion annually[1]. Found throughout the world's oceans, demand for seaweed has grown steadily in recent years, with forecasts predicting the trend to continue with a compound annual growth rate of between 2.3 and 8.7 per cent over the next decade. This strong growth in worldwide demand can be attributed to a number of factors:

- Rising popularity of vegan and vegetarian diets, as well as the importance of environmentally friendly products, as seaweed is increasingly used to develop plant-based protein alternatives.
- General increase in popularity of seaweed food products and use in the cosmetics and pharmaceutical industries.
- Growing demand for seaweed by-products used to add nutritional value to food and as gelling, stabilizing, emulsifying and thickening agents in products like ice cream, jams and bakery products.

[1] Figures as of 2021 based on data from Grand View Research, Allied Market Research, and Fortune Business Insights.

▶ 2.2. Production

Based on estimates from the Food and Agriculture Organization, global production has risen by over three times since 2000 (FAO 2021b). In 2019, the global cultivation of seaweed reached 34.7 million tons, catering to both food and non-food purposes and generating a significant first-sale value of US$14.7 billion. The major contributors to this growth were *Laminaria/Saccharina* (US$4.6 billion), *Porphyra* (US$2.7 billion), *Kappaphycus/ Eucheuma* (US$2.4 billion), *Gracilaria* (US$2 billion) and *Undaria* (US$1.9 billion) (FAO 2021a).[2]

Before the introduction of large-scale farm operations, seaweed was harvested primarily by coastal communities in Asia. Today, the largest producing countries are China, Indonesia, the Republic of Korea and the Philippines. Europe and the Americas have also joined the ranks, contributing 0.8 per cent and 1.4 per cent of global production in 2019, respectively. The shift from traditional practices to more industrialized methods has led to a noteworthy increase in output.

The transition to aquaculture has become the dominant mode of seaweed production, accounting for an overwhelming 97 per cent of global seaweed production in 2019. The shift away from wild collection has been driven by the scalability and efficiency of aquaculture methods. However, it is worth noting that in some parts of Asia, seaweed production still relies on relatively low-tech and labour-intensive techniques.

There is a growing consensus that wild resources will not be able to supply enough seaweed to satisfy future demand, despite the robust management strategies in many areas (Steen et al. 2016; Monagail et al. 2017; and Lauzon-Guay et al. 2021, as cited in FAO 2021a). Consequently, the sustainable cultivation of seaweed through aquaculture has become a crucial aspect of meeting future demand while ensuring the conservation of this marine resource.

▶ 2.3. Cox's Bazar district

The seaweed industry in Bangladesh is still at an initial stage of development. Bangladesh is home to 117 different seaweed species[3] , 19 of which are commercially important (Sarak et al. 2016; Siddiqui et al. 2019). Despite having a 710-km coastal zone and a 25,000-km^2 coastal area with sandy and muddy beaches, estuaries, and mangrove swamps, Bangladesh is still lagging behind in terms of commercial seaweed production and market penetration.

With approximately 8,500[4] km^2 of exploitable coastal area, geographically Bangladesh is well suited for developing the seaweed sector. Approximately, 5,000 metric tons of seaweed biomass is annually available throughout the whole Bangladeshi coast from October to April, when conditions are favourable (Siddiqui et al. 2019). However, the highest quantities are found between January and March. Cox's Bazar is one of the 64 districts of Bangladesh, and is home to the world's longest natural sea beach (120 kms long, including mud flats)

The highest quantities of seaweed in Cox's Bazar district are found around St. Martin's Island, due to the natural conditions of the island – such as greater light intensity, water quality and salinity levels, among others – supporting high levels of seaweed growth. In Teknaf, Inani, Bakkhali and Sonadia, a lower diversity of seaweed is found due to the high turbidity of the water, and the sandy to muddy bottom, among other factors.

[2] The italicized words in this sentence refer to the genus of these seaweed varieties. In scientific taxonomy each species is given a two-part name – for example, Homo sapiens – with the first, capitalized word being the genus name and the second, lower-case word being the species name. Most of the scientific names used in this report refer to the genus only, as they are meant to cover a range of similar species that are all closely related to each other and have similar uses.

[3] According to the BFRI (Islam et al. 2019), a total of 117 seaweed species were reported from the south-eastern and south-western coasts of Bangladesh. According to research such as Sarkar et al. (2016), and Siddiqui et al. (2019), the number is even higher, at 193 species.

[4] According to Hossain, Ghose, and Begum (2022), there is 25,000 square km of coastal areas favourable for seaweed production.

Within the Nuniarchara region, prevalent seaweed varieties include *Ulva* and *Gracilaria*; while around St. Martin's Island, *Caulerpa*, *Sargassum*, *Hypnea*, *Gracilaria* and *Padina* can be observed. In the mangrove ecosystems, *Catenella* and *Ulva* are commonly encountered.

The potential applications of the naturally occurring seaweed found in coastal Bangladesh is shown in table 1. However, at present a variety of environmental technological and socio-economic constraints limit the scale of what can be cultivated.

Figure 2. Map of Cox's Bazar

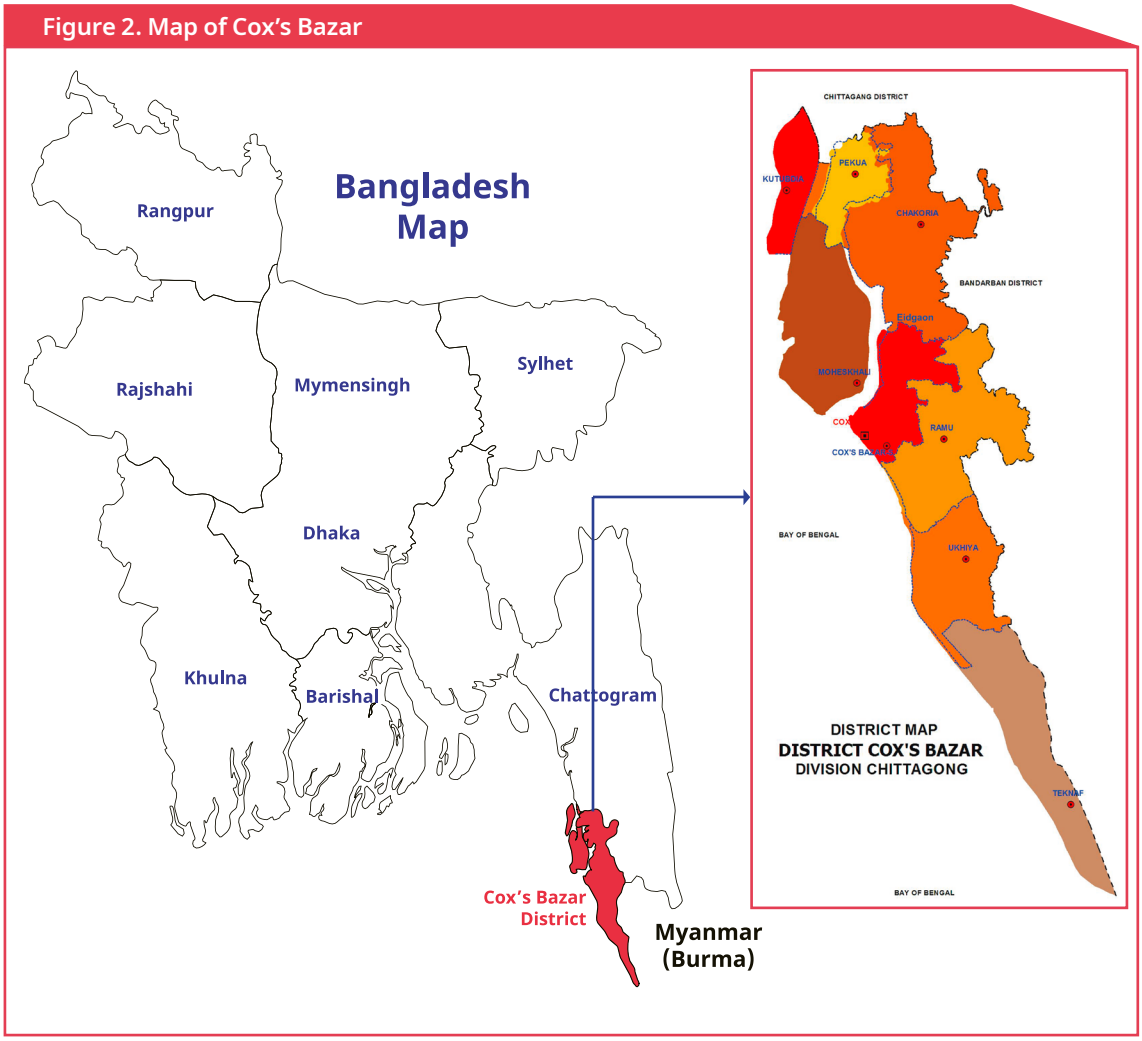


Table 1. Potential application of seaweeds naturally grown on the coasts of Bangladesh

Application	Types of seaweed
Edible	*Cladophora prolifera, Caulerpa sp., Codium geppei, Dictyota atomaria, Dictyopteris australis, Gracilaria sp., Hypnea musciformis, Hydroclathrus sp., Halymenia sp., Padina sp., Ulva lactuca*
Medicinal/pharmaceutical (anti-bacterial, anti-fungal, anti-tumor properties)	*Caulerpa taxifolia, Codium geppei, Dictyota atomaria, Hydroclathrus sp., Halimeda sp., Gracilaria sp., Padina sp., Sargassum sp., Ulva lactuca*
Industrial (agar, alginate)	*Gracilaria spinuligera, Sargassum sp.*
Agriculture (animal feed and fertilizer)	*Cladophora sp., Codium geppei, Dictyota atomaria, Gracilaria sp., Hydroclathrus sp., Hypnea sp., Halimeda sp., Halymenia sp., Padina sp., Sargassum sp., Ulva lactuca*

Note: The abbreviation "sp." refers to there being multiple relevant species within the genus provided.
Source: Islam and Haroon 2016; Shaika et al. 2022.

▶ 2.4. Market trends

It has been documented that Bangladesh's territorial waters hold an annual traceable stock of about 5,000 metric tons of seaweed biomass (Sarkar et al. 2016). Within the coastal waters of Bangladesh, the estimated annual seaweed production comes to 97.5 tons in dry weight, and is mostly composed of *Hypnea*, *Gracilaria* and *Ulva* (Hossain et al. 2021). The majority of this biomass is sold within the local market, primarily to tribal individuals and traders residing in the nearby hill district of Bandarban. This district, with a 37 per cent tribal population and bordered by Myanmar to the south, serves as a hub for distribution to local ethnic/tribal wholesalers. These traders then retail the seaweed to tribal consumers at marked-up prices.

However, there is a lack of substantial sector-specific information or data concerning the local seaweed market, which presents a challenge when seeking to identify market trends. The Government's Export Promotion Bureau (EPB) has reported no instances of seaweed exports from Bangladesh in dried or powdered forms[5].

Notably, while seaweed itself is not being exported or imported, there is an import trend involving seaweed that has been transformed into agar.

Data from the International Trade Centre's Trade Map provides valuable insights into the patterns around agar imports. In 2022, importers allocated US$475,000 to acquire roughly 33 tons of agar. It is noteworthy that the bulk of Bangladesh's agar imports originate from China, although there are supplementary contributions from India, Taiwan (China) , the Netherlands and Singapore. Agar imports displayed consistent growth from 2018 to 2022, with an annual rise of 6 per cent in the total imported value and a corresponding 10 per cent increase in the quantity imported. Bangladesh's utilization of agar extends across three major sectors: research laboratories, pharmaceuticals, and the confectionery industry.

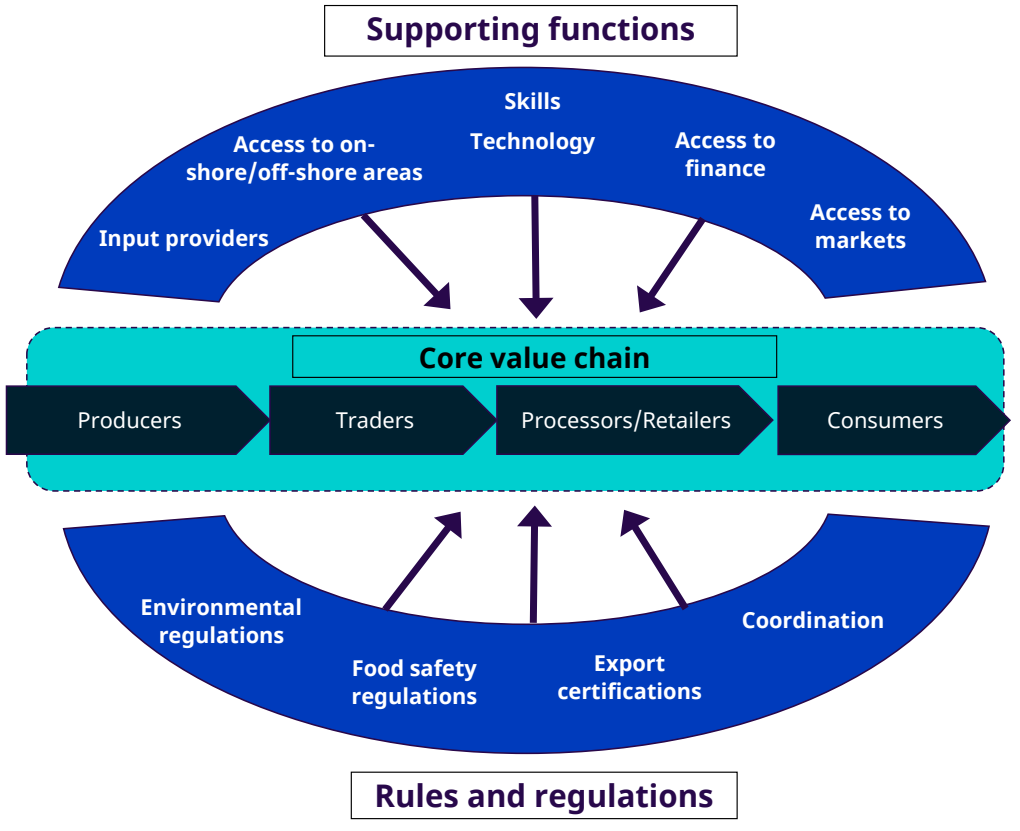
[5] Harmonized System (HS) Codes 12122910 and 31010099.

▶ 3. The market system

The market system is the overall picture of how a sector operates. The market system includes the supply–demand transactions in the core value chain – from producer to retailer to end consumer – as well as the "supporting functions" and "rules and norms" that shape the way in which businesses and employees work across this core chain. A market system approach therefore covers a broad scope, because the various actors in the value chain do not operate in a vacuum. The commercial success and well-being of the target group are influenced – directly and indirectly – by what happens in their surroundings. For example, access to financial services, which is a supporting function, does not directly operate within the seaweed value chain, but strongly influences how businesses set up, grow and operate.

Figure 3 provides an illustration of the market system for seaweed in Cox's Bazar district, which includes a simplified value chain surrounded by the supporting functions and rules/regulations that strongly influence and constrain market performance. Going forward, the analysis (Section 3) and opportunities (Section 4) sharpen their focus onto the local community, particularly women, in Cox's Bazar – the target beneficiaries of the programme – with a view to boosting income and generating entrepreneurship and self-employment opportunities as a contribution towards poverty reduction.

Figure 3. Seaweed market system

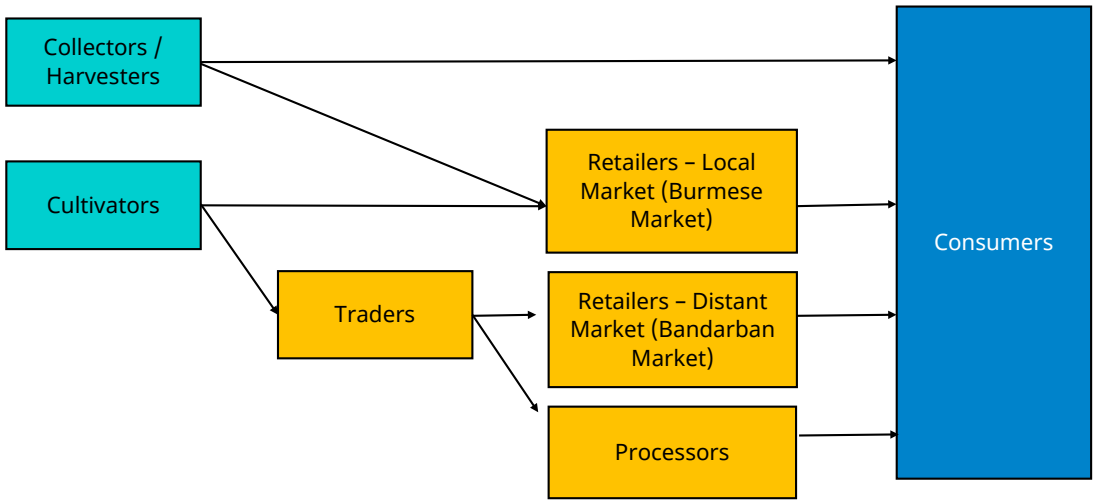


▶ 3.1. Core market

The discussion in the core market looks at each step along the value chain from producer to end consumer. Figure 4 below provides a simple representation of that productive chain, and the following subsections detail how each step functions and how it is constrained.

3.1.1. Farmers

Figure 4. Value chain map for seaweed in Cox's Bazar



In Cox's Bazar seaweed is either harvested or cultivated by households in coastal communities and by local fishermen. The latter are reportedly becoming increasingly interested in cultivating seaweed using local materials and low-cost methods (ICAB 2022). This is due in part to a Bangladesh government ban on fishing in the Naf River of Cox's Bazar district as part of efforts to prevent "illegal infiltration and drug trafficking". Following the enactment of this ban in 2017, fishermen in the surrounding communities were left without a stable source of income. Because of the simple growing process, inexpensive equipment, and limited need for inputs, some turned to seaweed cultivation. In general, the coastal communities in the district are already commonly involved in fishing, agriculture and livestock. For the local communities, seaweed typically serves as a supplementary source of income. Based on market actors' estimations, around 200–300 households are involved in seaweed collection/farming along the Cox's Bazar coast.

Generally, seaweed collection or cultivation is carried out by all members of a family, for instance, with a farmers' wives and children also participating in the collection of seaweed or the planting of seaweed seedlings. Women, who are commonly active in the seaweed sector, are mainly involved with preparation for seeding, harvesting and sun drying, and a few are also involved in marketing. Men in the sector typically come from fishing backgrounds or work as occasional labourers. The men usually handle seedling collection and cultivation, harvesting, and marketing. It is worth noting that seaweed currently does not serve as the primary source of livelihood for these households. Instead, it functions as an additional source of income during the production season.

Seaweed in the Cox's Bazar area is primarily collected from wild stocks by individuals or local communities. There are, however, some small groups of cultivators that use dedicated seaweed farms to grow seaweed in controlled environments. However, such small-scale cultivators are limited, and their initiatives are often supported by projects like a USAID-funded initiative implemented by WorldFish and an IFAD project (later continuing through core agriculture sector funding) implemented by the Palli Karma Sahayak Foundation (PKSF) and its partner NGOs (IDF, n.d.), wherein farmers receive training and support for seaweed cultivation.

Large-scale seaweed farming operations that employ wage workers have not been found in Cox's Bazar. So there is no wage rate established in the farming or harvesting of seaweed.

The prevalent variety of seaweed produced by local communities is *Gracilaria*, which is mainly used in its dried form for human consumption. Additionally, smaller amounts of *Ulva* and *Hypnea* are also collected, but on a lesser scale. Although about 14 types of seaweed varieties found in Cox's Bazar are commercially viable, most farmers in the region **lack knowledge concerning the viability of cultivating these different seaweed varieties**, and consequently, only four types are currently being produced in the region.

3.1.2. Local production methods

There are two main ways of producing seaweed in Bangladesh: (i) naturally (that is, the collection of wild seaweed) or (ii) cultivation (that is, farming). Households who practice natural harvesting collect wild seaweed from the coastline, after which they wash, dry, cool, and store the seaweed before selling it directly in the market.

By contrast, seaweed cultivation farmers obtain seedlings from their natural habitat and plant them at the beginning of a farming cycle (October–April). The most dominant method[6] among seaweed farmers in Cox's Bazar is the long-line method , as revealed by a baseline study (Akhtar et al. 2022). This method involves collecting wild seaweed seedlings for vegetative propagation, washing them with seawater, and cutting them into pieces. Within three days of collection, the resulting "seeds" are planted along twisted ropes (long-lines) that are 25–30 meters long, with a distance of 25 cm between each seed along the rope. These ropes are then tied to bamboo poles in the low-tide zone, where they can be submerged during high tide (Akhtar et al. 2022).

Some research programmes are also exploring the use of a bottom net system to reduce seaweed losses caused by water flow. For example, under the ECOFISH II Project, additional research has been conducted on floating seaweed farming in Nuniarchora, Khurushkul Rastarpara, and various locations along the Moheshkhali Channel (such as Ahamdiakata). Preliminary findings have shown positive results regarding the volume and quality of seaweed produced (Banik et al. 2023). Finally, additional research has also been carried out by the Bangladesh Oceanographic Research Institute (BORI) on a multi-layer seaweed farming method in Rezu Khal, and WorldFish has also explored multi-layer seaweed cultivation in the area. Nevertheless, there is still an **absence of consensus on improved cultivation methods specifically tailored to the region.**

The success of seaweed growth is significantly influenced by the salinity of the seawater. Research indicates that seaweed exhibits low growth below 24 parts per thousand (ppt) salinity, but its growth improves when the salinity increases to more than 30 ppt (Islam et al. 2019). As a result, the choice of location for seaweed cultivation is crucial, and farmers cannot cultivate it in places where seawater mixes with fresh water, as this affects the level of salinity. To address this, some programmes are testing the cultivation of seaweeds in ponds and rivers where the intrusion of saline water exists. However, there is a **lack of technical knowledge** among some groups of seaweed farmers, particularly **in regard to site assessment and farm suitability.**

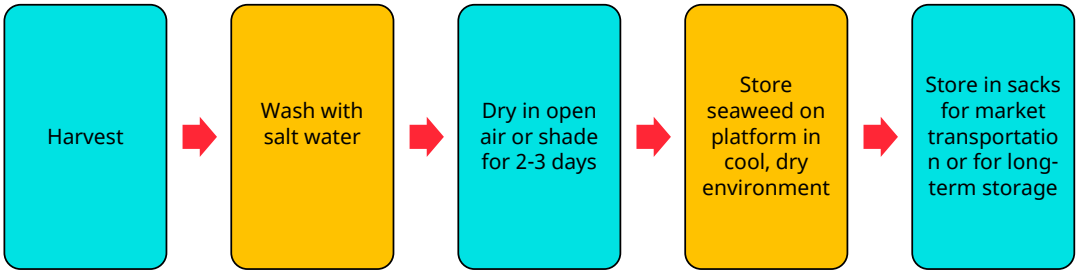
The typical cultivation period for seaweed farming is from October to April (9 months). However, this varies according to the seaweed type, and some farmers stated that their **cultivation period is**

[6] Another method for seaweed cultivation is the net method (floating or submerged): a square frame made of coir or nylon ropes – usually measuring 5×5 m^2 – with a mesh size of 25 cm is placed in the lower intertidal zone using the support of bamboo poles. The wild seeds are planted between the twists of the net ropes with the same distance interval maintained in long-line practices. (Akhtar et al. 2022).

usually of only 5 months' duration. During this cultivation period, farmers are typically engaged in other economic activities, as seaweed farming involves a low level of labour intensity and only requires efforts every 15–20 days for harvesting. Outside of the farming period, some farmers store the seaweed, but the amounts produced and stored are not sufficient to provide a reliable income. Improved storage could help address this to an extent, but a **lack of proper propagation methods and incubation of seeds** remain the underlying factors that limit production, and thereby increase the impact of seasonality on farmers' incomes. Another important challenge is the lack of seed availability, which can result in a late start to farming.

Despite the potential for successful cultivation, farming operations may be vulnerable to environmental and climate factors that will likely only be exacerbated over time. These include **damage to farming structures by cyclones, turbid and polluted waters**, and heavy waves, all of which have led to economic losses and decreased production for seaweed farmers (Ahmed et al. 2022).

Figure 5. Seaweed harvesting and post-harvest steps



After between 6 and 8 weeks of cultivation the seaweed is harvested. Alternatively, it may be harvested as early as 2 weeks after seeding, after which it will be regularly harvested every 15–20 days. The harvest is generally done by hand, or occasionally with knives or sickles. In one unit of 30 feet x 15 feet area about 50 kg of wet seaweed can be produced every 15 days. One household can generally manage between 30 to 50 units, which in one season amounts to a production between 12,000–20,000 kg of fresh seaweed.

The product is first brought to drying yards where the farmers cull the seaweed and prepare it to be dried and packaged for sale. Natural drying is done primarily by spreading the fresh seaweed across concrete or bamboo platforms/racks and repeatedly turning them over. Depending on the intended use of the seaweed, this process is carried out under full sun exposure or in shaded conditions.

Full sun or shaded drying are susceptible to weather conditions, presenting challenges during cloudy or rainy days. Although **more efficient air drying methods exist, they are not practiced due to the higher costs involved**. The moisture content is then assessed by eye (with around 15 per cent being the ideal range for selling). The preservation of dry seaweed is ensured through careful packaging in sealed packs.

Overall, seaweed farmers in Cox's Bazar typically rely on low-cost and locally sourced materials for their farm development. Among the inputs and supplies used, the main cost sources are bamboo poles, ropes, weights, seeds and labour.

Distribution channels

Following the harvesting process, seaweed enters the market in two forms: dried seaweed for local consumption and raw seaweed intended for human consumption or animal feed.

Local farmers have two primary options to sell their seaweed products. First, they can sell raw or dried seaweed directly in local markets. Alternatively, some farmers choose to sell their dried seaweed to traders who offer better prices. While a few traders provide upfront payment, most opt for payment upon delivery of goods.

Traders set the price based on the quality of the dried seaweed, incentivizing farmers to maintain

product quality. During the harvesting season, traders purchase dried seaweed at 120–150 taka/kg, and during the off-season the purchase price jumps to 200–250 taka/kg. Traders try to stock up during periods of lower prices.

Farmers frequently face the **challenge of retaining more of the profits generated within the sector**. Farmers who cultivate seaweed typically resist selling dry seaweed below 200–250 taka/kg regardless of the season due to production costs of approximately 150 taka/kg (Hossain et al. 2020). By contrast, seaweed collectors tend to engage in frequent price negotiations. Fresh seaweed is sold at even lower prices, ranging from 30–60 taka/kg.

Generally, most traders sell dried seaweed directly to markets at a price ranging from 200 to 350 taka/kg, depending on the quality. Certain traders sometimes supply to small-scale processors, mostly on a need basis or for research purposes, allowing them to market a diverse range of processed seaweed products, including powders, soups, juice, face scrubs and extracts.

The main consumers of the seaweed produced in Cox's Bazar are members of the Mog, Rakhine, Chakma and Marma tribal communities, who primarily consume it as a fresh salad. While research labs do occasionally source seaweed from local communities to extract agar, this practice remains limited in scale and is not carried out on a commercial level.

Local traders also noted that sometimes seaweed is sent into Myanmar. These are largely as parcels rather than proper exports due to tensions at the border. Moreover, there are accounts of seaweed being exported to countries like China and Singapore (Shafiuddin 2019). However, there is no concrete official evidence of these exports. Instead, some businesses sporadically send one or two samples through courier services to other countries, though this does not occur through official trade channels.

The main challenges around the distribution channels are **low local demand** and an **absence of value-added products**.

Processing into food or cosmetics products

A few entrepreneurs and small-scale enterprises have ventured into the realm of processing seaweed, harnessing its potential for creating food and cosmetic products. These businesses have established informal relationships with seaweed collectors to receive either fresh or dried seaweed. In some cases, these businesses have also set up informal pre-financing arrangements with collectors, securing more favorable rates by providing upfront payment for the seaweed's cost. For instance, while the standard rate for dried seaweed may be 200 taka/kg, these entrepreneurs secure it at a reduced rate of 100 taka/kg. It is worth noting that this practice is limited in scope, and only a handful of entrepreneurs operate within Cox Bazar's district.

Figure 6. Small business' seaweed-based products

One entrepreneur is processing seaweed into a powdered extract. This extract finds a market among tourists, predominantly hailing from Japan and China, who purchase it at 3,500 taka/kg. This entrepreneur is promoting her business through social media and by informal referrals from local hotel staff. This is a secondary activity of her family business.

Another small business is processing seaweed into food products such as soup and juice, along with cosmetics products like facial masks.

Despite these modest efforts, it is crucial to recognize that **seaweed-based processed items remain a niche market** within Cox's Bazar and Bangladesh as a whole. Capitalizing this market will require a product quality certification from the Bangladesh Standard and Testing Institution (BSTI). The BSTI to date has not defined product standards for seaweed and its derivatives in Bangladesh.

Traders and trading

The traders are mostly individuals from local communities. Their prime consumers are tribal communities, mostly in the hill tracts. Discussion with some traders revealed that nearly 40 per cent of dried seaweeds are marketed in Bandarban for consumption. Other markets include the Burmese Market in downtown Cox's Bazar and weekly local markets often known as *haat bazars*. People of ethnic minority origins are both vendors and consumers of seaweed products. Most of traders also trade dried fish together with the seaweed.

Regarding seaweed quality, local traders stated that sometimes the seaweed is not adequately cleaned before drying, with sand particles remaining among the seaweed, which reduces the price of seaweed both at the buyer's and seller's end. Overall though, traders are optimistic about sales increasing given that their products are generally of good quality and have a lengthy shelf-life. As noted above, the few local processors of seaweed tend to procure directly from the farmers through their representatives. However, hotels – based on demand from hotel residents – procure dried seaweed from the traders. Some traders from other parts of the country also procure dried seaweed from Cox's Bazar for use in cosmetic products, owing to its antioxidant properties.

Processing into agar

Agar, a gelatinous substance derived from seaweed, is a valuable product used in various industries, including food, pharmaceuticals and research. To explore and optimize the extraction process of agar from the red seaweed *Gracilaria*, three research laboratories have been established, including at the Bangladesh Oceanographic Research Institute (BORI) and the Institute of Marine Sciences at the University of Chittagong.

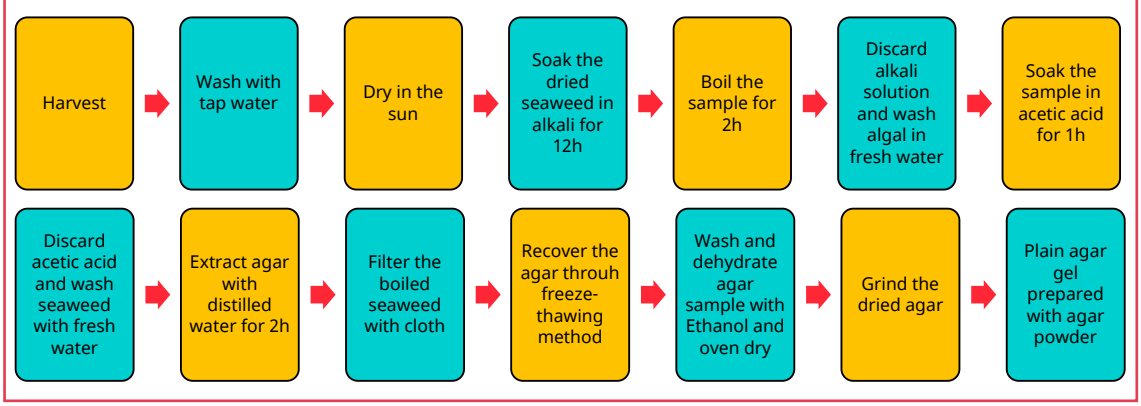
However, there are significant challenges that hinder the widespread industrial-level production of agar from *Gracilaria* seaweed. One major issue is the **lack of existing industrial facilities for agar extraction** in Bangladesh. While research laboratories are conducting valuable studies, the transition to large-scale production remains unexplored.

Another challenge is the **lack of farmers who have been trained in the specific preparations required for agar extraction**. The process demands meticulous washing of the seaweed in tap water to remove impurities like sand, excess salt and debris, thereby ensuring the purity of the seaweed. Subsequently, the seaweed must undergo a specific drying method involving sunlight exposure to eliminate pigments effectively.

Furthermore, once the preliminary washing and drying steps are complete, the subsequent stages of agar extraction demand a laboratory setting. While not exceedingly complex, the involvement of certain chemical processes, such as acidification, necessitates a controlled environment, rendering household-level extraction impractical.

Finally, ensuring a high level of seaweed production is essential for industrial-level agar production, as 100 kg of dried seaweed is needed to produce 15 kg of agar.

Figure 7. Process for extracting agar from seaweed



Box 2. List of seaweed productions with market potential

1. **Agar**	:	Extracted from red seaweed and used as a vegetarian gelatine or thickener in cooking and desserts. Used in the cosmetics, food and pharmaceutical industries.
2. **Seaweed snacks/ chips**	:	Crispy snacks made from roasted seaweed.
3. **Sushi wraps**	:	Edible seaweed wraps are used to prepare various types of sushi.
4. **Seaweed fertilizer**	:	A natural fertilizer made from processed seaweed, used to nourish plants and improve soil health.
5. **Wakame**	:	A type of edible brown seaweed commonly used in salads and miso soup, either in dried or fresh form.
6. **Seaweed extract supplements**	:	Dietary supplements derived from seaweed are known for potential health benefits/nutritional value.
7. **Seaweed face masks:**		Skincare masks infused with seaweed extracts for their purported skin-rejuvenating properties.
8. **Seaweed soap**	:	Soap made with seaweed extracts, believed to offer benefits for the skin.
9. **Seaweed powder**	:	Crushed seaweed used as a seasoning or ingredient in soups, sauces and stews.
10. **Alginate**	:	A substance derived from brown seaweed, used in the food industry for thickening, stabilizing and creating gels.
11. **Kombu**	:	Dried kelp often used to make dashi, a fundamental Japanese soup stock.
12. **Dulse**	:	Red algae usually used for cooking or snacks.
13. **Seaweed salad**	:	A mix of various seaweeds, usually marinated in a flavourful dressing.
14. **Sea lettuce**	:	Green seaweed used in salads and soups and as a garnish.

▶ 3.2. Supporting functions

Technology adoption

Despite the production potential of multiple varieties of seaweed, feasibility in regard to commercial production of agar, the most widely used seaweed derivative, is yet to be established. The organization WorldFish is working with local think tanks, universities and government research institutions to undertake assessments aimed at developing such capacity.

However, there are already some local innovations in terms of the diversification of seaweed into food products for human consumption, livestock feed and cosmetic products. Although at the infancy stage in Bangladesh, technologies for such a diversification are well-developed and have been adopted in various East Asian countries like the Philippines and Indonesia, which may offer potential models for how to adopt such technologies in the domestic context.

If introduced properly, today's small-scale industry could benefit from these technologies and processes to improve production, local processing, product diversification and so on.

Skills development

Currently, no formal training institutions offer guidance on seaweed cultivation and processing in Cox's Bazar. Training opportunities are mainly project-based, such as the aforementioned WorldFish project and PKSF-funded initiatives through its partner NGOs (IDF, n.d.) that provided training on seaweed cultivation techniques, harvesting, and marketing to local communities. However, the **lack of sustainability in training initiatives** is a concern.

Similarly, the lack of **processing methods for seaweed presents another challenge**. For instance, the drying process should be adjusted based on the intended use of the seaweed. Seaweed meant for food production requires drying in the shade to retain its colour, whereas seaweed intended for agar production needs to be dried in the sun to lose its colour. Proper drying techniques are crucial to minimize moisture content, thereby ensuring longer preservation of the seaweed and enabling farmers to sell their products at higher prices.

Inputs

One of the key constraints for seaweed production is the **absence of nurseries for seaweed seeds**. While local communities can currently collect seaweed for local food consumption and seaweed seeds for cultivation purposes, the scale of these activities remains restricted. Moreover, conducting such activities on a larger scale poses environmental risks. Farmers are facing challenges in sourcing seeds from the wild and are compelled to travel to less utilized sea areas by boat to find the required seeds.

Certain research institutions, such as the Bangladesh Fisheries Research Institute (BFRI) and the Bangladesh Oceanographic Research Institute (BORI), conduct experimental cultivation of seaweed and have established experimental tissue culture laboratories for seaweed. However, more research and investment are needed to be able to establish a method to produce seaweed seeds via tissue culture.

Access to other inputs needed for seaweed cultivation, such as bamboo, ropes and floating drums, is not a major issue. These materials are readily available in local markets at a low cost, with farmers estimating a total investment of approximately 10,000 taka (approximately US$92) per season for inputs.

Access to finance

In Bangladesh, financial services are provided through an array of providers, although there are no financial services institutions that have a specific focus on seaweed. Some microfinance institutions, such as the Integrated Development Foundation (IDF), provide credits to groups of seaweed farmers. Although generally the credits are not exclusively for seaweed farming, but rather focused on fishery or livestock activities, and seaweed represents just a small part of the planned activities. Projects working on seaweed also provide access to finance, but the support is not sustainable.

Some scattered support to promote access to finance in the seaweed industry has been ongoing. The Palli Karma Sahayak Foundation (PKSF), a specialized institution of the Government of Bangladesh that aims to secure poverty alleviation through employment generation, has also come forward to promote seaweed cultivation through the Learning and Innovation Fund to Test New Ideas (LIFT) programme.

As part of this initiative, the microfinance institution IDF was allocated 65 lakh taka (US$65,000) as credit support for seaweed cultivation and 35 lakh taka (US$35,000) as a grant for a three-year period to bolster seaweed cultivation. IDF obtained the loan at a 5 per cent service charge through the LIFT programme. Subsequently, IDF extended the credit amount to seaweed farmers at a 24 per cent interest rate, calculated on a declining balance.[7] Although the project concluded in December 2022, IDF continues to provide credit and technical support to the group of families engaged in seaweed cultivation.

Access to Bangladesh Bank funds is limited to commercial, private and public banks following provided guidelines. In 2023–24, the Government has earmarked 35,000 crore taka (US$3.5 billion) for agriculture and rural credit. A recent circular[8]

[7] The Micro-credit Regulatory Authority (MRA) under the Bangladesh Bank has capped the declining balance interest rate at 24 per cent for all microfinance institutions across the country.

[8] Banking and Regulation Policy Department Circular No. 32, dated 13 August 2023.

caps the interest rate at 5 per cent for Export Facilitation Pre-financing Fund (EFPF) loans. Participating banks must pay 2 per cent interest against pre-financing funds from Bangladesh Bank, with these funds intended to benefit priority sector items. However, seaweed is not a priority item for export or cultivation. Consequently, seaweed entrepreneurs will not get loans at the 5 per cent rate from banks, forcing them to face higher general interest rates.

Access to markets

This remains the key issue in expanding the seaweed industry in Cox's Bazar. Local tribal communities occasionally consume seaweed; however, the market structures, key players, size and nature of demand are not yet clear. In addition, **access to markets for seaweed at an industrial level, including the animal feed industry, the hospitality sector and other consumption markets, is yet to be capitalized**. In a way, the seaweed market in Bangladesh, despite all of its potential, is still very much in its infancy.

Access to information

There is a general lack of information flows among the seaweed producers, traders, and existing and potential users of the seaweed varieties. There is also a general lack of use of and little recognition of the benefits of seaweed and seaweed-based products among potential consumers, including the growing hospitality industry in Cox's Bazar. Similarly, representatives from most potential industries – like the animal feed, food processing and pharmaceutical industries – mentioned that they have heard of seaweed being used, but are not that aware of its use in Bangladesh or confident of its benefits.

▶ 3.3. Rules and regulations

Environmental regulations

In the coastal region of Bangladesh, regulations regarding the collection and trade of wild seaweed are currently lacking (Akhtar et al. 2022).

However, specific areas have been declared as Ecologically Critical Areas (ECAs) under the 1999 Environmental Conservation Act. These ECAs function as environmental protection zones, imposing restrictions on development activities that could endanger the environment. St. Martins Island, a renowned hub of seaweed biodiversity, falls within the scope of an ECA, rendering it inaccessible for exploration and exploitation (Hossain et al. 2020).

Furthermore, the St. Martin's Marine Reserve has obtained the status of a Marine Protected Area under the Wildlife Act of 2012, and therefore the exploitation of resources in that area has been banned. Only researchers/research institutions are allowed to harvest/cultivate seaweed for research purposes with prior permission from the Government. Despite this, vulnerable communities on St. Martin's Island do continue to collect seaweed on a limited scale.

By contrast, other regions remain in a regulatory grey area, lacking specific guidelines or regulations pertaining to seaweed collection or extraction.

Food safety regulations

In Bangladesh, the Bangladesh Standard Testing Institution (BSTI) is the exclusive authority responsible for product certification. Having BSTI certification is obligatory for the sale of any product in the market. Upon obtaining this certification, enterprises gain the privilege of displaying the BSTI logo on their products, which enhances consumer confidence in their purchase. Among the 239 items subjected to BSTI testing, seaweed is conspicuously absent.

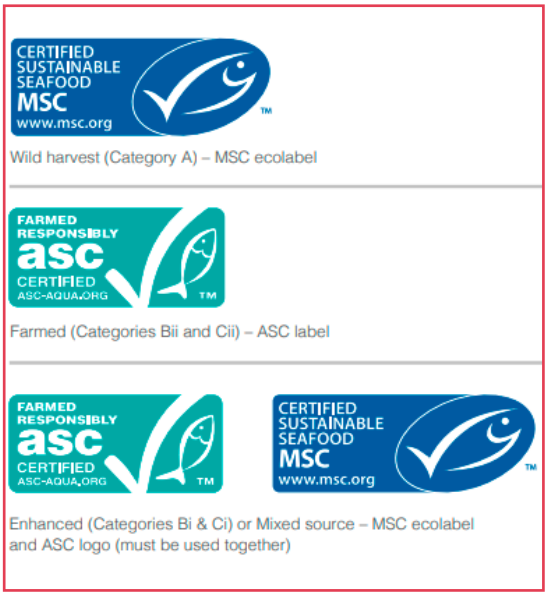
The absence of seaweed from the testing list can be attributed to the fact that it has not garnered the attention of policymakers. This is largely because seaweed is not a part of the regular diet of most people in Bangladesh, with the exception

of tribal communities. Despite numerous research findings, policymakers have yet to recognize the economic potential associated with seaweed, a gap that can be attributed to insufficient advocacy and a lack of awareness within policymaking circles.

Export certifications

For international exports of seaweed, food safety certifications are required, but buyers are also increasingly demanding sustainability certifications (although they are not yet widely required). The ASC-MSC Seaweed Standard is the most well-known standard, and it covers all scales of operations, including both wild harvest and farmed seaweed. The standard assesses indicators related to environmental impacts but also social responsibility, among others. Bangladesh **does not have any ASC-MSC Seaweed Standard-certified companies.**

Regarding food safety certifications for international export of seaweed, should exporters wish to send their seaweed products to the European Union (EU), for example, they would need to comply with the:



- General Food Law, which establishes a traceability system throughout the supply chain;
- Regulation (EC) 1333/2008, which sets the rules on food additives; and
- Regulation (EC) 852/2004, which requires a Hazard Analysis and Critical Control Point (HAACP) system for food processors of seaweed extracts.

In addition, the EU also establishes maximum residue levels (MRLs) for pesticides (EC Regulation 396/2005) and heavy metals (EC Regulation 1881/2006).[9] These regulations showcase the level of quality control and compliance that will be needed in the seaweed value chain in Bangladesh if the sector ever hopes to engage in any substantial degree of exportation.

Access to on-shore/off-shore areas

Seaweed cultivation can take place either onshore, using seawater in places close to the sea, or offshore, within bays or the open sea. No specific regulatory framework exists for either offshore or onshore cultivation, given that all relevant land is owned by the Government. Despite the abundance of available land for seaweed farming due to its modest demand, potential complications arise when governmental land requisition occurs. A case in point is the expansion of Cox's Bazar airport, leading to the takeover of areas once dedicated to seaweed cultivation.

In addition, the potential expansion of seaweed farming is **limited by the availability of suitable areas** and the **competition for these areas** with other farmers. This scenario has prompted certain research cultivation sites to experiment with offshore cultivation. Yet, these endeavors have encountered difficulties primarily linked to the vulnerability of floating structures in the open sea, which were susceptible to damage from boats during nighttime. These challenges prompted a return to onshore cultivation.

Coordination

In Bangladesh, there is no dedicated government body tasked with overseeing the coordination of the seaweed industry. However, the country's policy landscape and research institutions demonstrate a commitment to advancing this sector.

The last two versions of the Government's Five Year Plan (that is, do 2016–20 and 2020–25) both highlight the need to promote seaweed cultivation (Bangladesh, GED 2015; Bangladesh, GED 2020). In addition, the Ministry of Foreign

[9] For more information, see: https://www.cbi.eu/market-information/natural-food-additives/seaweed-extracts-food/market-entry and https://www.cbi.eu/market-information/fish-seafood/seaweed/market-entry.

Affairs (2020) has published a Blue Economy Development Action Plan in which they establish seaweed mariculture as a priority initiative and allocate a budget of 34 crore taka (US$4 million) from 2020 to 2030 to implement this initiative. The Maritime Affairs Unit under this Ministry is now in discussions with one local industry concerning agar production.

The National Agricultural Policy of 2018, prepared by the Ministry of Agriculture, also highlights the need to:

i. undertake programmes on selecting suitable areas for seaweed cultivation, variety development, production/ harvesting technique, and increased production;

ii. enhance the capacity-building of related institutions in strengthening seaweed agriculture research; and

iii. promote seaweed agriculture by strengthening local and export market linkages through providing incentives to entrepreneurs for extension.

Parallel to these policies, certain government research institutions, such as the BFRI and BORI, actively contribute to the advancement of seaweed-related knowledge by conducting research and investigations aligned with government policy objectives.

However, despite the existence of these policy blueprints and active research institutions, there remains an **absence of coordinated efforts** to fully advance the industry or deal with ongoing challenges.

▶ 3.4. Crosscutting issues

3.4.1. Gender

In the context of the seaweed industry in Cox's Bazar, women play a crucial role within the entire value chain. The majority of people involved with seaweed collection and cultivation in Cox's Bazar are women. Women participate actively in vital tasks like seaweed collection, cultivation, harvesting, and drying. And although men typically take on roles related to processing and marketing, there is a noticeable and increasing involvement of women in these aspects as well. In addition, nowadays women have direct access to credit for seaweed cultivation and other economic activities. In fact, a number of women are venturing into entrepreneurial activities centred around products derived from seaweed. As a result, the seaweed sector offers promising opportunities for advancing women's economic development in Cox's Bazar.

3.4.2. Environmental

There is growing evidence of the **environmental benefits of seaweed cultivation** , such as:

- **Carbon sequestration:** Seaweeds are highly efficient at capturing and storing carbon dioxide from the atmosphere. The photosynthetic process of seaweeds can also reduce ocean acidification caused by the uptake of carbon dioxide. Cultivating seaweed on a large scale can contribute to mitigating climate change by sequestering significant amounts of carbon.
- **Improved water quality:** Seaweed cultivation can help improve water quality by absorbing excess nutrients, such as nitrogen and phosphorus, which are responsible for causing harmful algal blooms and eutrophication.
- **Coastal protection and biodiversity support:** Seaweed farms can serve as artificial reefs, providing habitats and shelter for a wide range of marine species. This can lead to increased biodiversity in the area and

contribute to the conservation of marine life. Seaweed cultivation along coastlines can act as a natural barrier against strong wave action to protect the shoreline.

- **Sustainable feed source:** Seaweed is rich in nutrients, minerals and vitamins, making it a valuable source of feed for animals. Methane emissions from cattle farming can even be reduced if certain seaweeds are used as feed supplements.
- **Bioenergy production:** Seaweed can be used as a feedstock for bioenergy production, such as biofuels or biogas, reducing dependence on fossil fuels and contributing to a more sustainable energy mix.
- **Eco-friendly materials:** Seaweeds can be used to produce a variety of eco-friendly products, including biodegradable plastics, fertilizers and cosmetic ingredients.

But the **impacts of seaweed farming** in local ecosystems should still be considered when establishing seaweed farms. Impacts associated with seaweed culture can include (Phillips 1990):

- **Habitat alteration:** Seaweed cultivation can lead to the modification of natural habitats, which can disrupt the existing marine ecosystem and affect the biodiversity of the region.
- **Introduction of non-native species:** The introduction of non-native seaweed species for cultivation can lead to invasive species issues. If these non-native species escape from cultivation areas, they can outcompete native species and disrupt the balance of the ecosystem.
- **Loss of natural ecosystems:** Converting natural coastal areas into seaweed farms can lead to the loss of critical habitats, such as mangroves or seagrass beds, which provide essential ecological functions and services.
- **Netting and debris entanglement:** Seaweed farming sometimes involves the use of nets and structures that can entangle and trap marine animals, including fish, turtles and marine mammals.
- **Nutrient pollution:** If seaweed cultivation involves the addition of fertilizers, excess nutrients from fertilizers can cause nutrient pollution and impact marine life.
- **Deoxygenation:** Seaweed cultivation can lead to increased biomass in a localized area. When this biomass decays, it can consume oxygen during the decomposition process, leading to localized deoxygenation, which is harmful to marine life.

▶ 3.5. Constraints summary

Table 2. Summary of constraints in the seaweed value chain and their underlying causes

Constraint area	Underlying causes
Core market	
Production	▶ Production of seaweed is still considered as a casual activity. No organized work arrangements – such as wages, working hours and methodologies – have been established. ▶ Surplus labour from the households is engaged in production activity. ▶ Lack of technical knowledge, particularly in areas like site assessment and farm suitability. ▶ Absence of consensus on improved cultivation methods specifically tailored to the region. ▶ Reduced production season. ▶ Production is largely the harvesting of wild seaweed; aquaculture practice is yet to be established.
Distribution channels	▶ No organized distribution channel owing to the lack of a formal market for the product. ▶ Products use is largely confined to ethnic minority groups, and mostly producers are also the consumers. ▶ Absence of value-added products and industrial consumption.
Processors	▶ Potential industrial consumers (hospitality sector, animal feed, food processing) are largely unaware of the use and benefits of seaweed in their production value chains. ▶ Industrial processing to extract agar is still in the testing phase to establish commercial and technical feasibility. ▶ Local processors lack effective market demand for their products.
Supporting functions	
Technology adoption	▶ No effort to explore available technologies for the production, processing and use of seaweed. ▶ Potential commercial users are unaware and uninterested in the use of seaweed in their production process. ▶ Commercial viability of the seaweed and its products' market not yet established in Bangladesh, constraining the investment in technology development, replication and dissemination
Skills development	▶ Training focused on researching and testing of the product, and not on commercial production and processing. ▶ Lack of sustainability in training initiatives, as initiatives are project-based.

Constraint area	Underlying causes
Inputs	▶ Absence of nurseries for seaweed seeds, as technical level knowledge to establish these centres is still at the early stages of development in the country. ▶ Lack of interest/confidence among market players in investing in the necessary inputs, including seedlings, production facilities and other associated inputs.
Access to markets	▶ Absence of an effective market intermediary to bridge the gap between producers and industrial consumers. ▶ Local demand and traders associated with seaweed are casual in nature, making it difficult to access the local market effectively. ▶ Lack of year-round production to supply hotel chains, feed producers, and so on.
Information	▶ Lack of information on the use and benefit of seaweed for commercial and food purposes. ▶ Lack of information among producers and users on the production and use of seaweed-based products
Rules and regulations	
Environmental regulations	▶ Unclear and restrictive environmental regulations for wild seaweed collection from coastal regions. ▶ Subjective interpretation of the environmental guidelines by authorities.
Food and safety regulations	▶ Absence of seaweed from the list of items subjected to testing by the BSTI. ▶ Insufficient advocacy and a lack of awareness within policymaking circles to include seaweed in the testing list.
Export certifications	▶ No lead companies that see potential in the sector to apply for certification standards to export seaweed. ▶ Not included in the priority export item list like other similar items. As a result, it lacks government privileges.
Access to land	▶ Limited availability of suitable areas and competition with other farmers in seaweed cultivation areas. ▶ Lack of demarcation of suitable farming zones.
Coordination	▶ Only limited coordination efforts are in place to streamline the industry's development and address existing challenges.

▶ 4. Opportunities

The market systems approach aims to identify and address constraints at the systemic level that hinder the growth of more inclusive markets. Within this framework, projects execute diverse pilot interventions, expecting some to drive systemic shifts while acknowledging that others may not yield substantial effects due to external factors. Once pilot interventions have undergone thorough testing and have demonstrated their effectiveness in achieving the project's specific objectives for the designated target group, the next step involves exploring avenues to upscale these approaches for greater impact.

Emphasis is placed on sustainability and scalability, ensuring both business and intervention models can be adopted and replicated by market participants, thereby further amplifying their long-term effects. In this way, market-based approaches create opportunities for market actors within the system to develop their own business-oriented solutions, allowing for systemic change that can outlast the project's duration.

Box 3. Facilitating market system interventions

Traditional value chain development projects tend to orient their interventions towards the question of "what problems do value chains have and how can the project solve them?" rather than focusing on "why isn't the market environment providing solutions to these?" and "how can the project address the constraints that prevent it from effectively doing so?"

A market systems approach opts for a "light touch" way of intervening, running a temporary package of activities designed to stimulate lasting behaviour change among public or private market players. The facilitation approach encourages market actors to take on new or improved roles that will lead to systemic change in the market system.

Anything is possible with facilitation: from "hard" tactics like cost-sharing and technical advice, to "softer" tactics like brokering relationships – as long as the facilitation stays true to the market systems approach principles on developing a more efficient and inclusive system that benefits the poor and that does not have to rely on continued external support. There is no "correct" single way to do facilitation, and decisions must always be contextual.

Some general "rules of thumb" are outlined in the ILO brief Market Systems Facilitation: How Good Are You? (Ripley, Hartrich and Martinez 2017).

▶ 4.1. Key market actors

For sustainability purposes, it is recommended that the project be implemented with existing market actors taking the lead in delivering interventions. To help ensure the partners have the right incentives and abilities to take initiatives forward, table 3 below summarizes perceived organizational motivation and human and financial resource capacity to drive change in such initiatives.

Table 3. Key stakeholders in the seaweed sector

Organization	Relevant information	Motivation and capacity[10]
Bangladesh Fisheries Research institute (BFRI)	▶ Autonomous government research institution for fisheries and related research. ▶ Has a research laboratory on tissue culture of seaweed seed, experimenting with Ulva and Gracilaria. ▶ Have established laboratory that successfully extracted agar and carrageenan, and is trying to link up with commercial enterprises for further advancement.	Motivation: High Capacity: Medium/Low
Bangladesh Oceanographic Research institute (BORI)	▶ Bangladesh government research institute under the Ministry of Science and Technology that engages in oceanographic research. ▶ BORI has been researching the extraction of agar and carrageenan, which are commercially important. To date, they have found six types of seaweed for agar extraction and five types for carrageenan. ▶ BORI is also experimenting with culturing seaweed in ponds and rivers.	Motivation: High Capacity: Medium/Low
Department of Agricultural Extension	▶ The DAE is part of the Ministry of Agriculture. ▶ They are not delivering extension services on seaweed cultivation.	Motivation: Low Capacity: Low
Cox's Bazar Chamber of Commerce and Industry (CCCI)	▶ CCCI comprises individuals and entities engaged in various economic activities. ▶ No substantial work has been done in the past on seaweed.	Motivation: Low Capacity: High
National Association of Small and Cottage Industries of Bangladesh (NASCIB)	▶ NASCIB is a trade association formed to highlight issues related to micro-, small- and medium-sized enterprises (MSMEs) and cottage industries, and works for the development of the MSME sector of the country. ▶ Some of the Women Council members are associated with the seaweed business.	Motivation: High Capacity: Medium

[10] The term "motivation" indicates the perceived organizational motivation to drive change in the sector. "Capacity" is related to human resource capacity to drive change in the sector. Both of these were gauged by the team based on the semi-structured interviews that took place during the field research.

Organization	Relevant information	Motivation and capacity
Project-based initiatives/ NGOs delivering seaweed training	▶ Project-based initiatives directly deliver training in seaweed cultivation, such as the USAID-funded project implemented by WorldFish, or the PKSF-funded project implemented by IDF.	Motivation: High Capacity: Low/Medium
Remark HB	▶ Newly established company in Bangladesh, as an affiliated partner in Asia of the US-based Remark LLC to manufacture about 400 to 500 products belonging to 40 bands of colour cosmetics, skincare, home care and personal care (Noman and Noyon 2022). ▶ Remark HB is planning to buy seaweed locally, but they are struggling with a lack of facilities in Bangladesh capable of testing for heavy metals. At the moment they would need to send their materials to be tested in Malaysia or Indonesia. ▶ They expect to start working in the seaweed industry in Bangladesh in 2024–25.	Motivation: High Capacity: Low
Hotels and restaurants in CXB	▶ Hotels and restaurants are not preparing items with seaweeds, either dry or wet. ▶ If customers request seaweed to eat, they pre-order it and prepare it.	Motivation: Low Capacity: Low
Sagar Fish Exports	▶ Exporter of fish and other seafood products. ▶ Not working on seaweed currently.	Motivation: Medium/ Low Capacity: High
Mega Feed & Spectra Hexa Feeds LTD (Fish, Poultry and Cattle Feed)	▶ Prime manufacturer of fish feed. ▶ Seaweed can be used as protein substitution for the fish meal/feed.	Motivation: Medium Capacity: High
Nourish Poultry and Fish feed Limited	▶ Manufacturer of fish and poultry feed. ▶ Used 200 kg of dried seaweed (Gracilaria) for poultry.	Motivation: Medium/ Low Capacity: Medium
Quality Feeds (Poultry, Fish, Shrimp and Cattle)	▶ Manufacturer of standard feeds for poultry, fish, shrimp and cattle. ▶ Foreign experts are working for Quality Feeds as nutritionists.	Motivation: High Capacity: High

▶ 4.2. Potential areas of intervention

Based on the findings of the constraints analysis and given the assessment of the key market stakeholders, several potential areas for intervention have been identified. These interventions are focused on addressing the underlying causes to key constraints. They also have a sustainability and scalability focus, such that businesses and organizations can continue, scale-up or replicate interventions beyond the life of the project.

The proposed interventions can be summarized into an intervention strategy, based on three key areas:

Increase production and productivity

1. **Promote aquaculture practices for seaweed by establishing nursery infrastructure and technology for seaweed seed production.** The initiative could build on the existing research-oriented initiative together with the existing producers. The initiative could work with a commercial company like Remark HB and use the technical expertise of the BORI and BFRI, as relevant.

2. **Foster exchanges and technical visits** with countries that are successfully producing and harvesting seaweed, like the Philippines and Indonesia. This can be complemented by training and capacity-building activities on topics such as nursery management (spore collection, maintenance, and so on) and water management.

3. Considering the infancy stage of the sector, **promoting cooperative-led production, harvesting and marketing arrangements** could yield better organization among producers and enable social marketing initiatives for their products.

4. **Foster consensus on improved cultivation methods.** Establish a collaborative research programme with BORI, BFRI and others that involves seaweed farmers, experts and researchers to develop region-specific cultivation methods that optimize yield and extend the production season. Organize workshops and knowledge-sharing sessions that bring together farmers to exchange successful practices and collectively identify solutions for extended production.

5. **Increase productivity by enhancing post-harvest processing techniques.** Immediate efforts could be directed towards collaborating with appropriate organizations, likely private sector or research institutions, to provide extension services. The project's role could therefore be focused on developing the capacity and plan for this organization to deliver the training.

   This collaboration would seek to elevate the quality of dried seaweed that Remark HB or other leading companies procure on a regular basis. In the medium to long term, the intervention aligns with the establishment of agar laboratories (see the recommendations on developing value addition opportunities below). This will ensure that seaweed processing adheres to laboratory standards, contributing to industry-wide quality improvement. Here, the project will work to support better farm-level skills and the use of basic technology to improve production quality, which will drive up farmer incomes.

Support sector development and coordination

1. **Strengthen social marketing of seaweed and its commercial applications.** Support seaweed producers' cooperatives to undertake social marketing campaigns that target the hospitality, livestock feed and food processing industries.

2. Support BSTI in developing/adopting product standards for various seaweed products.

3. Profile seaweed products as a signature product of Cox's Bazar through various promotional initiatives, including trade fairs, public programmes and so on.

4. Profile and support the intermediaries in the sector to upscale their processing and marketing activities related to seaweed and its derivatives.

Develop value addition opportunities

1. **Promote high-value seaweed cultivation species in the region.** By partnering with interested lead companies and the BORI and BFRI, a pilot initiative can be initiated to introduce novel seaweed species for cultivation that hold significant commercial promise in the region. It is important to note that a great deal of care needs to be taken to determine and consider the environmental impacts of introducing such novel varieties to the Cox's Bazar region, including potential damage to habitats and local marine life.

2. **Establish pilot-scale industrial-level agar extraction facilities.** Establish pilot-scale agar extraction facilities in collaboration with relevant institutions or companies. This initiative would involve:

    a. developing market research on the potential of establishing an agar extraction facility in Cox's Bazar;

    b. disseminating market research among international companies interested in establishing an agar factory;

    c. providing training programmes, in partnership with interested companies, to farmers on the specific preparations required for successful agar extraction; and

    d. encouraging the company to collaborate with research institutions to develop efficient and cost-effective agar extraction technologies.

3. **Incorporation of seaweed in the production of livestock and aquaculture feed.** Once a nursery facility is successfully established and bulk production is established, the project can facilitate strategic collaborations between seaweed producers and feed manufacturers. In the long term, arrangements can potentially be negotiated between feed manufacturers/suppliers and farmers/farmers' groups, whereby the latter sell a steady supply of high-quality seaweed to the former in exchange for training on productive farming techniques (supported by the project).

▶ 5. Conclusion

The project has the opportunity to develop Cox's Bazar's seaweed sector in a way that generates more self-employment and entrepreneurship opportunities for the local community – particularly for women. The promotion of seaweed cultivation among coastal communities can also be a critical alternative livelihood for communities that have been traditionally dependent on marine/seawater-based economic activities, such as fishing, dry-fish processing, salt production and shrimp cultivation – all of which are extremely vulnerable to climatic change and abrupt weather fluctuations during peak production seasons (that is, winter and spring). This study provides the project with a starting point to drive change in the sector, and has identified potential interventions to do so.

The findings of this study serve as a pivotal starting point for strategic interventions aimed at reshaping the nascent sector. The proposed interventions encompass a range of strategies, from improving productivity to enhancing market opportunities for women farmers and industry stakeholders, including fostering the creation of new market actors. Furthermore, the project demonstrates substantial potential in enhancing sector-wide coordination, including by effectively bridging the gap with research and development initiatives by linking them to market opportunities for seaweed farmers. The aim of these initiatives is to facilitate value addition, but also to unlock avenues for job creation, notably to benefit the women of Cox's Bazar.

Considering these interventions, the project holds the promise of fostering the seaweed sector while simultaneously contributing to the socioeconomic development of the local community. Furthermore, it offers a pathway to empower women in the region, ultimately fostering sustainable growth and prosperity in Cox's Bazar.

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▶ Annex. Research interview list

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Bangladesh Bank

Bangladesh Fisheries Research Institute (BFRI)

Bangladesh Small and Cottage Industries Corporation (BSCIC)

Bangladesh Standard Testing Institution (BSTI)

Bangladesh Oceanographic Research Institute (BORI)

Cox's Bazar Chamber of Commerce and Industry (CCCI)

Cox's Bazar Women Chamber of Commerce & Industry

Department of Agriculture Extension Cox's Bazar (DAE)

Export Promotion Bureau

Food and Agriculture Organization (FAO)

Innovision Consulting

Institute of Marine Sciences at the University of Chittagong

Integrated Development Foundation (IDF)

Long Beach Hotel

Maritime Affairs Unit, Ministry of Foreign Affairs

Mermaid Restaurant

Ministry of Commerce

Ocean Paradise Hotel

Palli Karma Sahayak Foundation (PKSF)

Remark HB

Sagar Fish Exports

Seaweed consumers

Seaweed small businesses

Seaweed smallholder farmers' groups

Seaweed traders

Women's National Association of Small and Cottage Industries of Bangladesh (NASCIB) for Cox's Bazar District

WorldFish

World Food Programme (WFP)

Zahanara Green Agro, Cox's Bazar

Rapid market analysis of the seaweed value chain in Cox's Bazar, Bangladesh

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